WORKSHOP ON THE OCCURRENCE OF VMES (VULNERABLE MARINE ECOSYSTEMS) AND FISHING ACTIVITIES IN EU WATERS OF THE OUTERMOST REGIONS (WKOUTVME)

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ICES
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Contents

i Executive summary

ICES received a special request for information on the list of areas where Vulnerable Marine Ecosystems (VMEs) are known to occur, or are likely to occur, and on the existing deep-sea fishing areas in EU waters of the Outermost Regions subject to the EU deep-sea access regulation (Regulation (EU) 2016/2336). The nine Outermost Regions of the EU (French Guiana, Guadeloupe, Martinique, Mayotte, Réunion Island, and Saint-Martin (France), Azores and Madeira (Portugal), and the Canary Islands (Spain)) have not previously been part of ICES deliveries. ICES has responded to this request by offering step-wise deliverables, with the first phase a scoping technical service (review) in the form of this workshop (Workshop on the Occurrence of VMEs (Vulnerable Marine Ecosystems) and Fishing Activities in EU waters of the Outermost Regions; WKOUTVME). WKOUTVME has laid the foundations for subsequent work which could deliver the coordinates of the list of VME locations, and of the fishing activity in the EEZs of the Outermost Regions.

WKOUTVME reviewed results from an ICES metadata call, developed and disseminated questionnaires asking for information on VMEs and deep-sea fishing activities, collated open-source information on VMEs and fisheries, and drew on regional expertise through a hybrid meeting format.

Given the broad geographic scope of the request, covering regions in the southeast North Atlantic, the Caribbean Sea and the Indian Ocean, the lists of deep-sea fish and VME Indicator species listed in Annex I and Annex III, respectively, of the deep-sea access regulation were not applicable. WKOUTVME compiled regionally-apposite lists for each of the Outermost Regions. Two VME habitat types (Annex III), Submarine Caves and Mesophotic Zones were identified, and all new VME Indicator Species were evaluated against the FAO criteria for identifying VMEs. Metadata tables were produced summarizing data identified for each region, recognizing that more information may be available. Summaries of the fishing activities in each region were pro-vided, and indicated low levels of deep-water fishing, that are nevertheless economically and culturally important. In some of the regions, a trawl ban, the most disruptive fishing activity acting on the seafloor, has been in place since 2005.

The extent and quality of data available for the identification and mapping of VMEs in the Outermost Regions of the EU is highly variable between the regions. The Azores and Canary Islands provided valuable examples of well-structured and innovative methodologies and approaches that demonstrated what can be achieved through targeted research efforts. These regions were considered data rich and details of their approaches are provided as a resource for other regions where data was more limited. Knowledge gaps were greatest for Madeira, who were not represented at the meeting.

A four-step data assessment framework was developed which considered data availability, type, resolution, and uncertainty. For each step different sampling and assessment methods can be utilized with increasing spatial resolution and complexity, resulting in increased confidence in identifying and delineating areas of VME. This, combined with a knowledge of where important fishing activities occur, along with gear-specific risk assessments, should enable future options to be considered for potential VME protection measures.

ii Expert group information

Expert group name	Workshop on the Occurrence of VMEs (Vulnerable Marine Ecosystems) and Fishing Activities in EU waters of the Outermost Regions (WKOUTVME)
Expert group cycle	Annual
Year cycle started	2024
Reporting year in cycle	1/1
Chair(s)	Ellen Kenchington, Canada
Meeting venue(s) and dates	15-19 April 2024, Copenhagen, Denmark, 37 Participants

1 Review of the Knowledge base in each region

1.1 Glossary of terms used in this report

Vulnerable Marine Ecosystem (VME): A VME is identified by its characteristics and by its vulnerability under the FAO International Guidelines for the Management of Deep-sea Fisheries in the High Seas (FAO 2009), hereafter referred to as the FAO DSF Guidelines. Vulnerability is dependent upon the nature of the fishery and hence region-dependent.

Paragraph 42 (FAO 2009): "A marine ecosystem should be classified as vulnerable based on the characteristics that it possesses. The following list of characteristics should be used as criteria in the identification of VMEs.

i. Uniqueness or rarity – an area or ecosystem that is unique or that contains rare species whose loss could not be compensated for by similar areas or ecosystems. These include:
   a) habitats that contain endemic species;
   b) habitats of rare, threatened or endangered species that occur only in discrete areas; or
   c) nurseries or discrete feeding, breeding, or spawning areas.
ii. Functional significance of the habitat – discrete areas or habitats that are necessary for the survival, function, spawning/reproduction or recovery of fish stocks, particular life history stages (e.g. nursery grounds or rearing areas), or of rare, threatened or endangered marine species.
iii. Fragility – an ecosystem that is highly susceptible to degradation by anthropogenic activities.
iv. Life-history traits of component species that make recovery difficult – ecosystems that are characterized by populations or assemblages of species with one or more of the following characteristics:
   a) slow growth rates;
   b) late age of maturity;
   c) low or unpredictable recruitment; or
   d) long-lived.
v. Structural complexity – an ecosystem that is characterized by complex physical structures created by significant concentrations of biotic and abiotic features. In these ecosystems, ecological processes are usually highly dependent on these structured systems. Further, such ecosystems often have high diversity, which is dependent on the structuring organisms." (FAO 2009).

Examples of potentially vulnerable species groups, communities and habitats, as well as features that potentially support them are contained in Annex 2 of the FAO DSF Guidelines (FAO 2009).

VME Indicator Species: Species that signal the possible occurrence of a vulnerable marine ecosystem (VME).

When identifying VME Indicator Species, the FAO DSF Guidelines (FAO 2009) indicate that species groups, communities, habitats, and features often display characteristics consistent with possible VMEs, but they clearly state that merely detecting the presence of a VME Indicator Species or habitat feature is itself not sufficient to identify a VME. This has two related and important implications: a) the full spatial distribution of an indicator species which meets the VME criteria does not constitute a VME, and b) actual VMEs must possess a level of organization larger than the scale of a singular/individual presence.

Therefore, VME Indicator Species can be defined as: Species that meet one or more of the FAO (2009) criteria for possible occurrence of VMEs. Their simple presence is not an automatic indication of a VME, but when found in significant aggregations with conspecifics, or other VME Indicator Species, can constitute a VME.

Several of the bottom-fishing Regional Fisheries Management Organizations (RFMOs) have defined lists of VME Indicator Species and associated species biomass/density thresholds denoting the presence of VMEs (e.g. see FAO VME indicators lists[1]). In addition, the EU has established specific conditions for fishing deep-sea stocks in the northeast Atlantic which also protect VMEs (Regulation (EU) 2016/ 2336[2]). This deep-sea access regulation provides a list of representative VME Indicator Species by habitat type (Annex III) for reference when considering potential VME habitat areas.

Many commonly encountered deep-sea VME Indicator Species are associated with different types of sponge and coral habitat, although there are examples of VME Indicator Species belonging to other phyla, such as ascidians, polychaetes, bryozoans and crustaceans to name a few.

VME Elements: Topographical, hydrophysical or geological features which are associated with VME Indicator Species in a global context and have the potential to support VMEs (FAO 2009). Examples of such features are:

i. submerged edges and slopes;
ii. summits and flanks of seamounts, guyots, banks, knolls, and hills;
iii. canyons and trenches;
iv. hydrothermal vents; and
v. cold seeps (FAO 2009).

The Northwest Atlantic Fisheries Organization (NAFO 2015) and the North-East Atlantic Fisheries Commission (NEAFC 2014) define Steep Flanks as those with slopes > 6.4°, and that definition has been used by WKOUTVME.

Submarine Canyons are defined as "steep-walled, sinuous valleys with V-shaped cross sections, axes sloping outwards as continuously as river-cut land canyons and relief comparable to even the largest of land canyons" (Shepard 1963) that extend over a depth range of at least 1000 m and are incised at least 100 m into the slope at some point along their thalweg (Harris & Whiteway 2011) following Harris *et al.* (2014).

WKOUTVME identified Submarine Caves as a VME Element as these features are prevalent in many of the EU Outermost Regions. Submarine caves are known to host VME Indicator Species and are subject to fishing pressures (Pérez *et al.* 2016). They are unique habitats that reach depths of 10s to 100s of meters.

Mesophotic Zones were also identified as VME Elements. The mesophotic zone lies between 30 and 200 m depth. It is a critical transition zone characterized by diminished light irradiance compared to shallower areas. The mesophotic zone harbours a high biodiversity, with species that show adaptations to low light conditions (Loya *et al.* 2019).

[1]Vulnerable Marine Ecosystems. 2024. Food and Agricultural Organization of the United Nations. https://www.fao.org/in-action/vulnerable-marine-ecosystems/vme-indicators/en/

[2] Regulation (EU) 2016/2336 of the European Parliament and of the Council. 2024. Official Journal of the European Union. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32016R2336

Deep-sea Fisheries: Various depth limits have been used to define what constitutes deep-sea fisheries. The FAO DSF Guidelines do not define deep-sea fisheries, but characterize deep-sea fisheries as fisheries in which the total catch includes species that can only sustain low exploitation rates and where the gear is likely to contact the sea floor during the normal course of fishing.

FAO, in a global review of deep-sea fisheries, included those that target demersal and benthic species and are likely to contact the sea floor during the course of the fishing operation. Fishing depth was not considered a major criterion, but the review generally included "fisheries conducted below 200 metres on the continental shelf or isolated typographical features such as seamounts, ridge systems and banks" (Bensch *et al*. 2009).

Deep-sea Fishes: "Many marine living resources exploited by DSFs [deep-sea fisheries] in the high seas have biological characteristics that create specific challenges for their sustainable utilization and exploitation". These include:

i. maturation at relatively old ages;
ii. slow growth;
iii. long life expectancies;
iv. low natural mortality rates;
v. intermittent recruitment of successful year classes; and
vi. spawning that may not occur every year.

As a result, many deep-sea marine living resources have low productivity and are only able to sustain very low exploitation rates. Also, when these resources are depleted, recovery is expected to be long and is not assured. The great depths at which marine living resources are caught by DSFs in the high seas pose additional scientific and technical challenges in providing scientific support for management. Together these factors mean that assessment and management have higher costs and are subject to greater uncertainty." (Paragraph 13; FAO 2009).

1.2 Background

ICES received a special request for Advice on the list of areas where vulnerable marine ecosystems (VMEs) are known to occur, or are likely to occur, and on the existing deep-sea fishing areas in EU waters of the Outermost Regions subject to the deep-sea access regulation (Regulation (EU) 2016/2336). The nine Outermost Regions of the EU (French Guiana, Guadeloupe, Martinique, Mayotte, Réunion Island and Saint-Martin (France), Azores and Madeira (Portugal), and the Canary Islands (Spain)) (Figure 1.1) have not yet been part of ICES deliveries.

ICES has responded to this request by offering step-wise deliverables, with the first phase a scoping technical service (review) in the form of this workshop (Workshop on the Occurrence of VMEs (Vulnerable Marine Ecosystems) and Fishing Activities in EU waters of the Outermost Regions; WKOUTVME). WKOUTVME has laid the foundations for a subsequent workshop which could apply the methodology and deliver the coordinates of the list of VME locations, and of the fishing footprint for static gears, mobile-contacting gears and a combined footprint in the EEZs of the Outermost Regions.

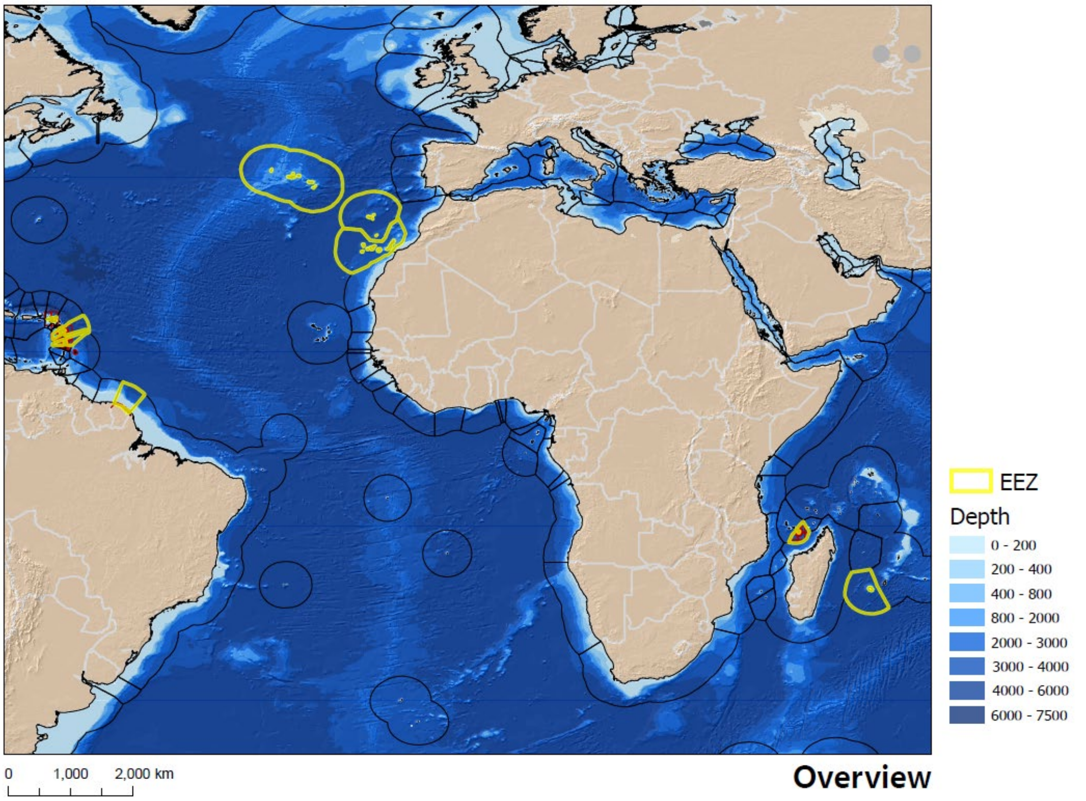

Figure 1.1. Exclusive economic zones (EEZs) of the nine Outermost Regions of the EU (French Guiana, Guadeloupe, Martinique, Mayotte, Réunion Island and Saint-Martin (France), Azores and Madeira (Portugal), and the Canary Islands (Spain).

A Planning Committee (Annex 1) was organized to advance the terms of references for WKOUT-VME (Annex 2) by initiating a metadata call, and developing and disseminating a questionnaire asking for information on deep-sea fishing activities and VMEs from regional experts. They also collated open-source information on VMEs in order to provide a baseline of information for the experts to consider at the workshop. During the workshop, experts reviewed and updated the information provided (ToRa; Section 2) and gave examples of methods used to identify VMEs and fishing footprints (ToRb; Sections 3 and 5). This updated information was used to formulate data and analytical recommendations for a subsequent workshop in ToRc (Sections 4 and 5).

1.3 Review of species included in the response

There was a need to re-focus the scope of the request on deep-sea fish species and VMEs occurring in the Outermost Regions, as many of the deep-sea fish listed in Annex I of the Regulation (Regulation (EU) 2016/ 2336) are not found in the Indian Ocean and Caribbean Sea, while other species do occur and are commercially fished. The list of VME Indicator Species listed in Annex III of the Regulation generally can be applied as they are listed at a higher level of taxonomic resolution (VME habitat type and Family), although new VME Elements have been identified (Submarine Caves and Mesophotic Zones) with associated taxa, and each Outermost Region has different dominant VME Indicator Species.

We note that shallow-water tropical coral reef ecosystems were not considered in Annex III of the Regulation, and are beyond the scope of this request. WKOUTVME created lists of regional species and habitats complementary to Annexes I and III of the Regulation (Regulation (EU)

2016/ 2336) to be used when considering deep-sea VMEs and fisheries in the Outermost Regions. Those are provided in Section 2 for each region.

1.3.1 Deep-sea fish species

The list of deep-sea fish species found in Annex I of the Regulations (Regulation (EU) 2016/ 2336) was reviewed by the Planning Committee, and the distribution of each was examined using FishBase[3], a global information system on fishes. From the list of 49 species listed in Annex I, 15 species are not likely to occur in the nine Outermost Regions (Table 1.1).

Table 1.1. Deep-sea species listed in Annex I of the Deep-Sea Access Regulations (Regulation (EU) 2016/ 2336) that are not likely found in any of the nine Outermost Regions.

Scientific name	Common name
*Etmopterus princeps**	Greater Lanternshark
Galeus murinus	Mouse Catshark
Oxynotus paradoxus	Sailfin Roughshark (Sharpback Shark)
Somniosus microcephalus	Greenland Shark
Alepocephalus Bairdii	Baird's Smoothhead
Argentina silus	Greater Silver Smelt
Coryphaenoides rupestris	Roundnose Grenadier
Macrourus berglax	Roughhead Grenadier (Rough Rattail)
Molva dypterigia	Blue Ling
Reinhardtius hippoglossoides	Greenland Halibut
Raja fyllae	Round Skate
Raja hyperborea	Arctic Skate
Raja nidarosiensus	Norwegian Skate
Lycodes esmarkii	Greater Eelpout
Sebastes viviparus	Small Redfish (Norway Haddock)

*WKOUTVME noted that this species is found in the Azores.

In order to add relevant species to the list, the FAO Fisheries and Resources Monitoring System (FIRMS[4]) "Review of the state of world marine fishery resources 2009" was consulted and four additional taxa were added (Table 1.2). As a next step, FishBase was again consulted using a search by each of the nine countries in the Outermost Regions, filtered by "commercial species" and separately by "deep-water species". Saint Martin did not have any deep-water species listed and some other countries did not have a commercial category.

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[3] FishBase. A Global Information System on Fishes. 2024. https://fishbase.se/home.htm

[4] Fisheries and Resources Monitoring System. 2024. Food and Agricultural Organization of the United Nations. https://firms.fao.org/firms/fishery/755/en

To populate the local lists of deep-sea species, the presence of the species from Annex I of the Regulations (Regulation (EU) 2016/ 2336) and FIRMS, regardless of the location was checked in the national landing databases.

In a second step, the depth range of each remaining species in the landings was checked using Fishbase and, where available, from species identification guides for institutional observers at sea (or at fish markets). Species occurring in water deeper than 300 m and occurring on a regular basis in the landings were selected. The 300-400 m upper depth limit acts a buffer zone for the upper limit of the deep-sea access regulation of 400 m, as those depth ranges might not be accurately known and valid everywhere.

Table 1.2. Deep-sea fish species not listed in Annex I of the Deep-Sea Access Regulations (Regulation (EU) 2016/ 2336) but were reported in the FAO FIRMS database and are found in one or more of the nine Outermost Regions.

Scientific name	Common name
Allocyttus spp. (*Allocyttus guineensis; A. verrucosus*)	Oreos
Neocyttus spp. (*Neocyttus acanthorhynchus; N. helgae*)	Oreos
Brotulidae *(Brotula barbata; B. multibarbata)*	Bearded Brotula; Goatsbeard Brotula
Merlucciidae *(Merluccius albidus; M. polli; M. senegalensis)*	Hakes

These first steps selected deep-sea species that can be found in shallower water and also some species that are not considered as deep-sea ones, but are known to be found deeper than 400 m. Their presence and interest for fishermen may trigger some deep-water fishing effort to catch them, which might in turn bring in the catches' species of interest for this study.

A final step was to consider only species that had local names (rather than a common or commercial name) and/or were the most important in the local catches. The existence of local names was considered to be an indicator that the species is commonly landed and therefore has some importance for the local fisheries.

Consolidated species lists were then produced for the Caribbean Sea (French Guiana, Guadeloupe, Martinique, and Saint-Martin (France); Table 1.3), for the Indian Ocean (Mayotte, Réunion Island (France); Table 1.4), and for the Atlantic (Azores, Madeira (Portugal) and the Canary Islands (Spain); Table 1.5).

For the Atlantic (Azores, Madeira (Portugal) and the Canary Islands (Spain)) the species lists were very long and so the list from the Canary Islands, ordered by landings in kilograms, was used for all three regions. Only landings from 2023 and greater than 124 kg were included to avoid rarities that were likely caught as bycatch (Table 1.5).

The resultant tables were used for the production of the Questionnaires that were sent out, asking for regional metadata from local experts (Section 1.6). During WKOUTVME, participants re-viewed the lists of fish species used in the Questionnaires (Tables 1.3, 1.4, 1.5) to account for missing species, and to remove from the initial lists those that are unlikely to be present in re-gional waters. The final lists of deep-water fish species are provided under the text for each of the Outermost Regions in Section 2.

Table 1.3. List of deep-sea fish species landed in the French Antilles and French Guiana (Caribbean Sea) and used in the Questionnaires (see Section 1.6). Hyperlinks for each fish species direct to Fishbase.

Order	Species	FAO Code	Name in Country	Local Name	Depth (m)
Anguilliformes	*Avocettina infans*	ANV			785 - 4580
Aulopiformes	*Bathypterois dubius*	BDU			750 - 1941
Carangiformes	*Coryphaena hippurus*	DOL	Coryphène commune	Dorad	
Carangiformes	*Makaira nigricans*	BUM	Makaire bleu	Varé, marlin blé	0 - 1000
Carangiformes	*Rachycentron canadum*	CBA	Mafou	Cobia	0 - 1200
Carcharhiniformes	*Galeocerdo cuvier*	TIG	Requin tigre commun	Tig,Tigre	0 - 800
Eupercaria/misc	*Etelis oculatus*	EEO	Vivaneau royal	Granzié, Oil de bœuf	100 - 450
Lupercalia/misc	*Lutjanus synagris*	SNL	Vivaneau gazou	Brakou, Sad bondié minyin, Ssarde bon dieu	10 - 400
Eupercaria/misc	*Dentex* spp.				
Eupercaria/misc	*Pagellus bogaraveo*	SBR	Dorade de fond		150 - 300
Gadiformes	*Coryphaenoides mexicanus*	CPX			110-1600
Gadiformes	*Macrourus berglax*	RHG	Grenadier berglax		100 - 1000
Lamniformes	*Isurus oxyrinchus*	SMA	Taupe bleue	Mako, taupe, Pich ton	0-750
Mugiliformes	*Mugil curema*	MGU	Mulet blanc	Mulet	0 - 300
Perciformes/Scorpaenoidei	*Helicolenus dactylopterus*	BRF	Sébaste chèvre		50 - 1100
Scombriformes	*Thunnus atlanticus*	BLF	Thon à nageoires noires	Ton nwè, Ti ton nwè, Thon noir, Boulé, Tonkay, Lak (< 2kg), Bonite (< 2kg)	50 - …
Scombriformes	*Lepidopus caudatus*	SFS	Sabre argenté		42 - 620
Squaliformes	*Scymnodon ringens*	SYR	Squale-grogneur commun		200 - 1600
Stomiiformes	*Chauliodus sloani*	CDN			200 - 4700
Zeiformes	*Allocyttus verrucosus*	ALL			0 - 1800

Table 1.4. List of deep-sea fish species landed in La Réunion and Mayotte (Indian Ocean) and used in the Questionnaires (see Section 1.6). Hyperlinks for each fish species direct to Fishbase.

Order	Species	FAO Code	Name in Country	Local Name	Depth (m)
Acropomatiformes	*Epigonus telescopus*	EPI	Poisson cardinal		75 - 1305
Acropomatiformes	*Polyprion americanus*	WRF	Cernier commun		40 - 600
Acropomatiformes	*Polyprion oxygeneios*	WHA	Cernier de Nouvelle-Zélande		50 - 854
Alepocephaliformes	*Searsia koefoedi*	PSO			450 - 1500
Argentiniformes	*Argentina* spp.				
Aulopiformes	*Alepisaurus ferox*	ALX	Lancier longnez	Snoek	0 - 1830
Beryciformes	*Beryx decadactylus*	BXD	Béryx commun		110-1300
Beryciformes	*Beryx splendens*	BYS	Béryx long		180-1300
Carangiformes	*Decapterus* spp.	SDX	Comètes	Bancloches	0 - 550
Carangiformes	*Tetrapturus angustirostris*	SSP	Makaire à rostre court	Lancier	0 - 1830
Carangiformes	*Rachycentron canadum*	CBA	Mafou	Cobia	0 - 1200
Carangiformes	*Xiphias gladius*	SWO	Espadon	Lamprèr royal	1 - 800
Carcharhiniformes	*Carcharhinus albimarginatus*	ALS	Requin pointe blanche	Pointe blanche	1 - 800
Carcharhiniformes	*Prionace glauca*	BSH	Requin peau bleue	Peau bleue	0 - 1082
Carcharhiniformes	*Triaenodon obesus*	TRB	Requin corail	Requin corail	0 - 330
Carcharhiniformes	*Galeocerdo cuvier*	TIG	Requin tigre commun	Tigre	0 - 800
Carcharhiniformes	*Galeus melastomus*	SHO	Chien espagnol		55 - 1873
Carcharhiniformes	*Sphyrna lewini*	SPL	Requin-marteau halicorne	Requin marteau	0 - 1043
Carcharhiniformes	*Sphyrna mokarran*	SPK	Grand requin marteau	Requin marteau	0 - 300
Carcharhiniformes	*Centrophorus moluccensis*	DGX	Squale-chagrin cagaou	Requins zépines, aiguillats	125 - 823
Carcharhiniformes	*Squalus megalops*	DOP	Aiguillat nez court	Requins zépines, aiguillats	30 - 750
Carcharhiniformes	Emissoles	TRK			0 - 400

Order	Species	FAO Code	Name in Country	Local Name	Depth (m)
Eupercaria/misc	*Cephalopolis aurentia*	CFZ	Vieille dorée	Rouge bâtard, Ananas bâtard, Rouge peau dure	40 - 300
Eupercaria/misc	*Branchiostegus doliatus*	UGY	Malacanthe à rayures	Jacquot, Sangol, Cabot mauricien	90 - 612
Eupercaria/misc	*Aphareus rutilans*	ARQ	Vivaneau rouillé	Vivaneau lantanier, Lantanier argenté, Largenté	0 - 330
Eupercaria/misc	*Etelis carbunculus*	ETA	Vivaneau rubis	Gros tête, Vivaneau rouge, Vivaneau rubis	90-400
Eupercaria/misc	*Etelis coruscans*	ETC	Vivaneau flamme	La Flamme	45 - 400
Eupercaria/misc	*Etelis radiosus*	EEW	Vivaneau pâle	Ti dents	90-360
Eupercaria/misc	*Pristipomoides argyrogrammicus*	LRY	Colas orné	Cerf volant, Jaune thomas	0 - 350
Eupercaria/misc	*Pristipomoides auricilla*	LWA	Colas drapeau	Vivaneau cendré	90 - 360
Eupercaria/misc	*Pristipomoides filamentosus*	PFM	Colas fil	Vivaneau blanc, Kalbal	40 - 400
Eupercaria/misc	*Pristipomoides multidens*	LRI	Colas à bandes dorées	Gros Zecail	40 - 350
Eupercaria/misc	*Pristipomoides zonatus*	LWZ	Colas bagnard	Jaune thomas, Jaune de creux, Vivanveau rayé	70 - 300
Eupercaria/misc	*Cookeolus japonicus*	CJN	Beauclaire longues ailes	Boclair de creux	0 - 400
Eupercaria/misc	*Heteropriacanthus cruentatus*	HTU	Beauclaire de roche	Boclair la rouille, Boclair du large, Boclair de roche, Laqué noir	0 - 300
Gadiformes	*Macrourus berglax*	RHG	Grenadier berglax		100 - 1000
Holocentriformes	*Ostichthys kaianus*	HWK	Soldat japonais rayé	Cardinal de creux, Cardinal tambour, Tabouret, Brosse	180 - 640
Lamniformes	*Isurus spp.*	MAK	Requins taupes	Mako	0-750
Lampriformes	*Lampris guttatus*	LAG	Opah	Saumon des dieux, Lampris royale	0 - 500
Lampriformes		RRG			0 - 1200
Lophiiformes	*Cryptopsaras couesii*	CTQ			500 - 1250
Mulliformes	*Parupeneus heptacanthus*	RQF	Capucin à tache rouge	Capucin	0 - 350
Myliobatiformes	*Pteroplatytrygon violacea*	PLS	raie		1 - 381
Myliobatiformes	*Taeniura meyeni*	RTE	Pastenague éventail		1 - 500

Order	Species	FAO Code	Name in Country	Local Name	Depth (m)
Ophidiiformes	*Brotula multibarbata*	WBM	Mostelle tropicale	Anguille Morel	0 - 650
Ophidiiformes	*Spectrunculus grandis*	OSG	Abadèche boulotte		800 - 4300
Perciformes/Scorpaenoidei	*Neoscorpaena nielseni*	QRF		Grondin, Rascasse de creux	40 - 507
Perciformes/Scorpaenoidei	*Setarches guentheri*	SVG	Rascasse serran	Grondin, Rascasse de creux	150 - 850
Perciformes/Scorpaenoidei	*Helicolenus dactylopterus*	BRF	Sébaste chèvre		50 - 1100
Perciformes/Serranoidei	*Epinephelus chlorostigma*	EFH	Mérou pintade	Grifin, Pintard	4 - 300
Perciformes/Serranoidei	*Epinephelus magniscuttis*	EEJ	Mérou grandes écailles	Cabot gros zécail, Cabot de fond	0 - 300
Perciformes/Serranoidei	*Epinephelus morrhua*	EEP	Mérou comète	Cabot de fond	80 - 370
Perciformes/Serranoidei	*Epinephelus radiatus*	EZR	Mérou zébré	Cabot rayé, Cabot de fond	18 - 383
Perciformes/Serranoidei	*Epinephelus tauvina*	EPT	Mérou loutre	Grand gueule	0 - 300
Perciformes/Serranoidei	*Hyporthodus octofasciatus*	EWO	Mérou huit raies	Plate de creux, Cabot sale	150 - 300
Perciformes/Serranoidei	*Variola louti*	VRL	Croissant queue jaune	Rouge grand queue, Grand queue	3 - 300
Perciformes/Serranoides	*Aulacocephalus temminckii*	UFT	Poisson savon	Savonette	20 - 350
Perciformes/Serranoides	*Liopropoma lunulatum*		Serran jaune	Sucre d'orge, Sangol	0 - 300
Polymixiiformes	*Polymixia berndti*	QIJ	Barbe	Barbu de creux	0 - 640
Polymixiiformes	*Polymixia japonica*	PXJ	Barbe		160 - 628
Scombriformes	*Ariomma* spp.	DRK	Ariommes	Libine	0 - 350
Scombriformes	*Eumegistus illustris*	EBS	Brème noire	Zombas, Machong, Castagnole, Bigue noire	1 - 620
Scombriformes	*Taractichthys steindachneri*	TST	Brème à longues nageoires	Zombas, Machong, Zirondelle	0 - 700
Scombriformes	*Lepidocybium flavobrunneum*	LEC	Escolier noir	Escolier	200 - 1100
Scombriformes	*Promethichthys prometheus*	PRP	Escolier clair	Snoek	80 - 800
Scombriformes	*Rexea prometheoides*	RXP	Escolier royal	Snoek	100 - 975
Scombriformes	*Ruvettus pretiosus*	OIL	Rouvet	Thon l'huile, Thon la chiasse, Sap-tille, Fuka, La misik	100 - 975
Scombriformes	*Thyrsitoides marleyi*	THM	Escolier gracile	Barracuda de creux, Snoek	0 - 400
Scombriformes	*Gymnosarda unicolor*	DOT	Thon dents de chien	Thon noir, Bonite à gros yeux	0 - 300

Order	Species	FAO Code	Name in Country	Local Name	Depth (m)
Scombriformes	*Thunnus alalunga*	ALB	Thon germon	Thon blanc, Thon batard	0 - 600
Scombriformes	*Thunnus obesus*	BET	Thon obèse	Patudo, Thon rouge, Big eye, Thon gros yeux, Zobok (petit)	0 - 600
Scombriformes	*Aphanopus carbo*	BSF	Sabre noir		200 - 2300
Squaliformes	*Alopias pelagicus*	PTH	Renard pélagique	Loup de mer	0 - 300
Squaliformes	*Alopias superciliosus*	BTH	Renard à gros yeux	Loup de mer	0 - 800
Squaliformes	*Alopias vulpinus*	ALV	Renard		0 - 800
Squaliformes	*Isistius brasiliensis*	ISB	Squalelet féroce		0 - 3700
Squaliformes	*Etmopterus princeps*	ETR	Sagre rude		300-2213
Squaliformes	*Etmopterus spinax*	ETX	Sagre commun		70 - 2490
Stomiiformes	*Diplophos taenia*	DPT			15 - 650
Tetraodontiformes	*Masturus lanceolatus*	MRW	Poisson-lune lancéolé		0 - 670
Tetraodontiformes	*Mola mola*	MOX	Poisson lune		0 - 1515
Torpenidiformes		TOD	Torpille	Trembleur	1 - 439

Table 1.5. List of deep-sea fish species landed in the Azores, Madeira and Canary Islands (Atlantic Ocean) in 2023 as determined from landing data from the Canary Islands, and used in the Questionnaires (see Section 1.6). Hyperlinks for each fish species direct to Fishbase and those for shrimp direct to SeaLifeBase[5]. Species are sorted by landings (large to small).

Order	Species	FAO Code	Name in Country	Landings (kg)	Depth (m)
Eupercaria	*Sparisoma cretense*	PRR	Vieja	285,594	20 - 50
Eupercaria	*Dentex gibbosus*	DEP	Pargo macho	160,978	20 - 220
Eupercaria	*Pagrus pagrus*	RPG	Bocinegro	142,212	0 - 250
Beryciformes	*Beryx splendens*	BYS	Fula colorada	132,370	25 - 1300
Carangiformes	*Pseudocaranx dentex*	TRZ	Jurel	96,913	10 - 238
Scombriformes	*Acanthocybium solandri*	WAH	Peto	81,115	0 - 20
Carangiformes	*Seriola dumerili*	AMB	Medregal	78,704	1 - 385
Clupeiformes	*Engraulis encrasicolus*	ANE	Longoron, Anchoa	70,035	
Decapoda	*Plesionika narval*	PVJ	Camarón narval	54,850	10 - 910
Anguilliformes	*Conger conger*	COE	Congrio	53,980	0 - 1171
Perciformes	*Epinephelus marginatus*	GPD	Mero	37,453	8 - 300
Anguilliformes	*Muraena helena*	MMH	Morena	30,399	1 - 801
Eupercaria	*Spondyliosoma cantharus*	BRB	Chopa, Negrón	27,979	5 - 300
Perciformes	*Serranus cabrilla*	CBR	Cabrilla reina, Cabrilla	27,659	5 - 500
Anguilliformes	*Muraena augusti*	MWK	Morena negra	24,613	0 - 250
Tetraodontiformes	*Balistes capriscus*	TRG	Gallo cochino	24,488	0 - 100
Eupercaria	*Pagrus auriga*	REA	Sama roquera	23,615	- 170
Perciformes	*Serranus atricauda*	WSA	Cabarilla Negra or Cabrilla ruana	22,999	3 - 150
Gadiformes	*Merluccius merluccius*	HKE	Pescadilla, Merluza	22,942	18 - 1075
Perciformes	*Mycteroperca fusca*	MKF	Abade or abae	21,011	1 - 200
Eupercaria	*Plectorhinchus mediterraneus*	GBR	Burro de ley, Burro de la costa	20,913	10 - 180
Eupercaria	*Parapristipoma octolineatum*	GRA	Boca de oro, Burro listado	20,603	1 - 60
Eupercaria	*Dentex canariensis*	DEN	Chacarona	19,918	- 450
Eupercaria	*Dentex macrophthalmus*	DEL	Anto ñito, Dientón	18,688	30 - 500

[5] SeaLifeBase ver.3. 2024. https://www.sealifebase.ca/

Order	Species	FAO Code	Name in Country	Landings (kg)	Depth (m)
Decapoda	*Plesionika edwardsii*	LKW	Camarón soldado rayado	16,082	50 - 850
Gadiformes	*Mora moro*	RIB	Merluza del país	11,642	50 - 2500
Anguilliformes	*Gymnothorax polygonius*	AGI	Papada, Morena papada	11,436	10 - 256
Perciformes	*Helicolenus dactylopterus*	BRF	Gallineta, Boca negra	11,390	50 - 1100
Eupercaria	*Lithognathus mormyrus*	SSB	Herrera	11,349	0 - 150
Eupercaria	*Pagellus bellottii*	PAR	Breca colorada, Breca garapello	10,500	100 - 250
Eupercaria	*Pagellus erythrinus*	PAC	Bica, Breca	10,378	- 300
Gadiformes	*Phycis phycis*	FOR	Brota, Agriote	9,562	13 - 614
Carangiformes	*Seriola rivoliana*	YTL	Medregal	9,262	5 - 245
Anguilliformes	*Gymnothorax unicolor*	AGK	Macho de morena	9,203	0 - 20
Gadiformes	*Merluccius senegalensis*	HKM	Merluza Negra, or Merluza del Senegal	8,671	15 - 1248
Eupercaria	*Bodianus scrofa*	IVD	Pejeperro	8, 653	20 - 200
Beryciformes	*Beryx decadactylus*	BXD	Colorado anchete	8,328	110 - 1300
Tetraodontiformes	*Stephanolepis hispidus*	FIK	Gallito, Gallo verde	6,546	0 - 293
Anguilliformes	*Gymnothorax maderensis*	AGD	Morena verde	6,437	85 - 200
Decapoda	*Aristaeopsis edwardsiana*	SSH	Gamba carabinero, Carabinero	6,409	274 - 1850
Scombriformes	*Pomatomus saltatrix*	BLU	Anjova	5,886	0 - 200
Eupercaria	*Heteropriacanthus cruentatus*	HTU	Catalufa or Alfonsiño	5,735	3 - 300
Scombriformes	*Lepidopus caudatus*	SFS	Pejesable	4,606	42 - 620
Eupercaria	*Pagellus acarne*	SBA	Besuguito, Aligote	4,573	- 500
Eupercaria	*Dentex dentex*	DEC	Sama de ley	4,114	0 - 200
Scombriformes	*Auxis rochei*	BLT	Melva	3,997	
Carangiformes	*Seriola fasciata*	RLF	Loquillo, Blanquilla	3,704	55 - 348
Eupercaria	*Boops boops*	BOG	Boga	3,566	0 - 350
Perciformes	*Scorpaena scrofa*	RSE	Cantarero	3,464	20 - 500
Eupercaria	*Umbrina canariensis*	UCA	Verrugato, María Francisca	3,323	150 - 200
Polymixiiformes	*Polymixia nobilis*	PXV	Barbudo or Salmón de lo alto	3,079	360 - 540
Scombriformes	*Auxis thazard*	FRI	Melva	3,060	50 -

Order	Species	FAO Code	Name in Country	Landings (kg)	Depth (m)
Scombriformes	*Ruvettus pretiosus*	OIL	Escolar, Escolar rasposo	2,987	100 - 975
Carangiformes	*Makaira nigricans*	BUM	Aguja azul	2,756	0 - 1000
Eupercaria	*Oblada melanura*	SBS	Galana, Galán	2,755	- 30
Acropomatiformes	*Polyprion americanus*	WRF	Cherna, Cherne, Romerete	2,575	40 - 600
Scombriformes	*Lepidocybium flavobrunneum*	LEC	Escolar negro, Escolar chino	2,436	200 - 1100
Carcharhiniformes	*Mustelus mustelus*	SMD	Tollo	2,346	5 - 50
Acropomatiformes	*Epigonus telescopus*	EPI	Candil, Pez diablo	2,313	75 - 1305
Anguilliformes	*Enchelycore anatina*	AWM	Morena isleña	2,145	3 - 60
Perciformes	*Pontinus kuhlii*	POI	Obispo or Volón	1,938	100 - 460
Eupercaria	*Pagellus bogaraveo*	SBR	Voraz, Goraz	1,867	150 - 300
Perciformes	*Serranus scriba*	SRK	Cabrilla pintada, Vaquita	1,815	- 30
Carangiformes	*Coryphaena hippurus*	DOL	Dorado	1,499	0 - 85
Carcharhiniformes	*Galeorhinus galeus*	GAG	Cazón de altura, Cazón dientuso	1,388	0 - 1100
Decapoda	*Aristaeomorpha foliacea*	ARS	Gamba roja	1,305	250 - 750
Tetraodontiformes	*Canthidermis sufflamen*	CZT	Gallo	1,195	5 - 60
Eupercaria	*Pomadasys incisus*	BGR	Roncador, Tronelero	1,059	10 - 100
Scombriformes	*Aphanopus carbo*	BSF	Conejo diablo	1,052	200 - 2300
Centrarchiformes	*Kyphosus sectatrix*	KYS	Chopón or Chopa perezosa	1,043	1 - 10
Ovalentaria	*Chromis limbata*	HZL	Fula	882	5 - 45
Pleuronectiformes	*Lepidorhombus boscii*	LDB	Gallo	814	7 - 800
Mugiliformes	*Chelon labrosus*	MLR	Lisa	725	2 - 15
Scombriformes	*Promethichthys prometheus*	PRP	Conejo	719	80 - 800
Eupercaria	*Dentex maroccanus*	DEM	Calé, Sama ma, Marroquí	699	20 - 500
Eupercaria	*Umbrina ronchus*	UMO	Verrugato, Burrogato	639	20 - 200
Mugiliformes	*Mugil cephalus*	MUF	Cabesote, Lebrancho	635	0 - 120
Eupercaria	*Argyrosomus regius*	MGR	Corvina	586	15 - 300
Carangiformes	*Seriola carpenteri*	RLR	Medregal rosa, Medregal, Pedregal	561	0 - 200
Perciformes	*Epinephelus caninus*	EFJ	Cherne	501	30 - 400

Order	Species	FAO Code	Name in Country	Landings (kg)	Depth (m)
Scombriformes	*Stromateus fiatola*	BLB	Pampano	467	10 - 70
Perciformes	*Scorpaena porcus*	BBS	Rascacio, Rascacio negro	464	- 800
Gadiformes	*Phycis blennoides*	GFB	Brotola de fango	385	10 - 1351
Zeiformes	*Zenopsis conchifer*	JOS	Gallo plateado	383	50 - 600
Lophiiformes	*Lophius piscatorius*	MON	Rape blanco	368	20 - 1000
Perciformes	*Epinephelus aeneus*	GPW	Cherne blanco	366	20 - 200
Pleuronectiformes	*Solea solea*	SOL	Lenguado	359	0 - 150
Squaliformes	*Deania profundorum*	SDU	Picopato or Tollo flecha	323	717-1785
Decapoda	*Chaceon affinis*	KEF	Cangrejo rey	321	200 - 2000
Tetraodontiformes	*Aluterus scriptus*	ALN	Gallo azul	313	3 - 120
Squaliformes	*Centroscyllium* spp.	YCX	Tollos, Mielgas, or Cazones	301	269 - 1170
Scombriformes	*Schedophilus ovalis*	HDV	Rufo imperial	258	70 - 700
Rajiformes	*Raja clavata*	RJC	Raya de clavos	226	5 - 1020
Zeiformes	*Zeus faber*	JOD	Gallo San Pedro, Gallo Barbero	184	5 - 400
Carangiformes	*Lichia amia*	LEE	Palometon	166	0 - 50
Decapoda	*Plesionika* spp.	XKX	Camarones	163	
Oegopsida	*Sthenoteuthis pteropus*	OFE	Pota de luz	156	0 - 1500
Oegopsida	*Ommastrephes bartramii*	OFJ	Pota saltadora	152	0 - 2200
Trochida	*Phorcus atratus*	OAW	Burgado hembra	124	

1.3.2 VME Indicator Species and VME Elements

The deep-sea access regulations (Regulation (EU) 2016/ 2336) provide a list of representative VME Indicator Species by habitat type (Annex III) for reference when considering potential VME habitat areas. Those were mostly identified to the Family level which allows for transfer to the three different oceanic regions of the Outermost Regions. Specific examples are provided in Table 1.6 from the Canary Islands as extracted from the response from Spain to the ICES data call (Sec-tion 1.5). Table 1.6 was used in the Questionnaires for all regions to seek information on VMEs and VME Indicators from regional experts. WKOUTVME compiled a list of regionally-appropri-ate VME indicators using the FAO (2009) criteria to identify taxa (Section 2).

WKOUTVME further considered the VME Elements present in the regions. An additional VME Element, 'Submarine Caves' was accepted as such geomorphological features contain species meeting one or more of the FAO criteria for VME indicators (FAO 2009). Underwater marine caves are reservoirs of undescribed biodiversity. They are also habitats that concentrate particular targets of small-scale fisheries, mainly large crustaceans (lobsters). They are dark habitat units isolated in the littoral zone (Navarro-Barranco *et al*. 2023) and cave systems can reach depths of 100s of meters. Therefore, the environmental gradients prevailing in caves are very sharp: light (therefore primary production) and water circulation (therefore allochthonous food input and propagule pressure) drastically decrease. These gradients define various levels of "confinement" for cave communities (Harmelin *et al*. 1985). At the cave entrance in shallow waters, macrophytes are gradually replaced by a rich community of erect sessile invertebrates, mostly sponges, bryozoans and octocorals that have been characterized in the Mediterranean as the "Semi-Dark Cave community". This community also exists outside the Mediterranean, with slightly different combinations of taxa (see for example Pérez *et al.* 2016). Deeper within caves, where confinement is maximal, the Mediterranean researchers defined the "Totally Dark Cave community". There, biomass and species diversity are low, but the dominant group is always Porifera, often represented by small encrusting forms, but also sometimes by massive and long-lived hypercalcified or hypersilicified species such as the so-called "sclerosponges" or "lithistids". The cave mobile fauna is mainly represented by crustaceans, teleost fish and molluscs. Finally, cave bottoms are often made of a very fine, silty sediment harbouring a yet largely unknown infauna. Their meiobenthic component has been shown to have close ties to abyssal species (Janssen *et al.* 2013).

Cave communities are thus often considered poorly resilient, similarly to deep-sea communities, and their inhabitants are often highly specialized, being sometimes shared with the deep sea; caves are therefore considered as "natural mesocosms" of the bathyal or abyssal zone. These are among the main reasons for their ecological interest and the need for better conservation strategies. Most of them being of volcanic origin, the islands of the European Outer-Most regions concentrate a great number of submarine caves of various configurations. However, most caves of these regions were only poorly studied, except for marine caves of the French Lesser Antilles that have recently received a dedicated effort (Pérez 2015). As in the French Antilles, such systematic monitoring in the volcanic islands known for their numerous caves (Canaries, Azores, Madeira, Réunion and Mayotte) should bring to light many vulnerable species (sponges and anthozoans). Underwater caves are remarkable habitats listed by the EU Habitats Directive 92/43/EEC, Habitat type 8330).

Table 1.6. VME Indicator Species listed in Annex III of the Deep-Sea Access Regulations (Regulation (EU) 2016/2336) (black) augmented by species provided by Spain in the Data Call for the Canary Islands (red). This Table was used for the Questionnaires (see Section 1.6) and regionally-appropriate lists are provided in Section 2.

VME Habitat type	Representative Taxa
1. Cold-water coral reef	*Lophelia pertusa* [sic. *Desmophyllum pertusum*] reef
(a) *Lophelia pertusa* [sic. *Desmophyllum pertusum*] reef	
(b) *Solenosmilia variabilis* reef	*Solenosmilia variabilis*
	Dendrophyllia cornigera, Flabellum (Flabellum) chunii, Madrepora oculata
2. Coral garden	
(a) Hard bottom garden	
(i) Hard bottom gorgonian and black coral gardens	Anthothelidae, Chrysogorgiidae, Isididae, Keratoisididae, Plexauridae [sic. Paramuriceidae], Acanthogorgiidae, Coralliidae, Paragorgiidae, Primnoidae, Schizopathidae
	Acanella arbuscula, Antipathes furcata, Bathypathes patula, Bebryce mollis, Callogorgia verticillata, Candidella imbricata, Eunicella verrucosa, Hemicorallium niobe, Hemicorallium tricolor, Keratoisis grayi, Metallogorgia melanotrichos, Narella bellissima, Paramuricea biscaya, Parantipathes hirondelle, Placogorgia coronata, Stichopathes gracilis, Stichopathes graviera, Swiftia dubia, Villogorgia bebrycoides, Viminella flagellum
(ii) Colonial scleractinians on rocky outcrops	*Lophelia pertusa* [sic. *Desmophyllum pertusum*], *Solenosmilia variabilis*
(iii) Non-reefal scleractinian aggregations	*Enallopsammia rostrata, Madrepora oculata*
(iv) Soft corals	*Alcyonium glomeratum, Anthomastus grandiflorus*
(b) Soft-bottom coral gardens	
(i) Soft-bottom gorgonian and black coral gardens	Chrysogorgiidae
(ii) Cup-coral fields	Caryophylliidae
(iii) Cauliflower coral fields	Flabellidae, Nephtheidae
3. Deep-sea sponge aggregations	
(a) Other sponge aggregations	Geodiidae, Ancorinidae, Pachastrellidae
	Characella tripodaria, Pachastrella monilifera, Penares helleri, Thenea muricata
(b) Hard-bottom sponge gardens	Axinellidae, Mycalidae, Polymastiidae, Tetillidae
	Aphrocallistes beatrix, Chondrocladia (Chondrocladia) grandis, Chondrosia reniformis, Ircinia dendroides, Leiodermatium lynceus, Neophrissospongia nolitangere, Petrosia (Petrosia) ficiformis, Phakellia robusta, Phakellia ventilabrum, Regadrella phoenix, Spongia virgultosa, Spongosorites topsenti
(c) Glass sponge communities	Rossellidae, Pheronematidae
	Asconema setubalense, Pheronema carpenteri
4. Sea pen fields	Anthoptilidae, Pennatulidae, Funiculinidae, Halipteridae [Balticinidae], Kophobelemnidae, Protoptilidae, Umbellulidae, Vigulariidae
5. Tube-dwelling anemone patches	Cerianthidae
6. Mud- and sand-emergent fauna	Bourgetcrinidae, Antedontidae, Hyocrinidae, Xenophyophora, Syringamminidaem *Endoxocrinus wyvillemthomsoni*
7. Bryozoan patches	

‘Mesophotic Zones’ were also identified as VME Elements present in the Outermost Regions. This physical zone contains species meeting one or more of the FAO criteria for VME indicators (FAO 2009). The mesophotic zone occurs between 30 and 200 m depth depending upon the clarity of the water affecting light quality and quantity. It is a critical transition zone characterized by diminished light irradiance compared to shallow areas. Due to limited light penetration, the mesophotic zone is also known as the "twilight zone".

The mesophotic zone remained unexplored for a long time, because it wasn't deep enough to justify sending out manned submarines or ROVs, and was too deep for scuba diving (Pyle & Copus 2019). Over the past 10 years, however, exploration has accelerated considerably with the democratization of trimix diving with rebreathers. In addition, the discovery of coral reefs, long considered as “marginal reefs”, such as those off the Amazon (Moura *et al.* 2016), has particularly stimulated scientific research at these depths.

Despite the limited light irradiance, the mesophotic zone harbours a high biodiversity, with species that show adaptations to low light conditions. They are characterized by the presence of light-dependent corals and algae that are often very different from the species found on more superficial reefs. In such conditions, sponges are usually also very abundant and diverse. VME Indicator Species typically found in the 400-800 depth zone are also found in the mesophotic zone.

As the mesophotic zone represents a transition zone between shallow (< 30 m depth) and deep waters (> 200 m depth), it serves as a transitional habitat for species migrating between shallow and deep waters, contributing to connectivity across marine ecosystems. Lastly, the mesophotic zone can function as a refuge for shallow-water species affected by climate change disturbances, mainly by increases in seawater temperature.

1.4 Depth range considered in the response

The depth of the fisheries varies greatly among the Outermost Regions due to their different topographies and markets. For some a maximum is 2000 m, while for others a maximum is 400 m or less. Hence, the mainland Europe 400-800 m depth range specified in the Deep-Sea Access Regulations (Regulation (EU) 2016/2336) will not work to identify VMEs that may be subject to significant adverse impacts from fishing. WKOUTVME collected information on where the VMEs are known or likely to occur and on fisheries targeting deep-sea species (see Section 2). Further the steep slopes found in many of the Outermost Regions would make this zone very narrow in many instances, creating issues for enforcement.

1.5 ICES data call

The Advisory Department of ICES activated a data call on 4 December 2023 with a closing data of 12 January 2024 (ICES 2023). The Data Call applied to all of the Outermost Regions and requested metadata that could aid in mapping the location of sensitive habitats, i.e., Vulnerable Marine Ecosystems (VMEs), including important ecosystem features, communities of hydrothermal vents/fields, cold water coral reefs and deep-sea sponge aggregations, as well as nursery areas, fishing practices, fishing grounds (ICES 2023). For EU Member States, this data call is under Council Regulation (EU) No 1380/2013 on the Common Fisheries Policy and regulation (EU) 2017/1004 of the European Parliament and the Council of 17 May 2017 and Commission Delegated Decision (EU) 2021/1167 of 27 April 2021.

Only Spain and France responded to the call. Spain provided detailed data of VMEs from four research surveys led by Dr. Pablo Martín-Sosa of CSIC-IEO in the Canary Islands between 2010 and 2012. Beam trawls, rock dredges and underwater images were used to collect data. There were 45 species of corals and sponges identified (see Figure 2.15). France also responded to the request and provided metadata for each aspect of the call. No onboard observer programme is implemented by IFREMER in the Outermost Regions and so no fisheries-dependent data were available. No response was received from Portugal.

1.6 Questionnaire sampling and design

Firstly, specific goals for the Questionnaire responses were defined, based on the overall request work, that is, to collect personal knowledge of the location of 1) VMEs, 2) deep-sea fisheries, 3) deep-sea fish nursery areas and 4) where deep-sea fish aggregate, and to collect metadata for data holdings pertaining to those same subjects from research studies, deep-sea surveys, fishing activity data, etc. The intention was to treat the former as geo-referenced data, to be evaluated and collated during the workshop. Metadata collected from the survey would also be reviewed along with similar data provided from the data call, and used in the workshop to inform the discussion of potential analytical approaches (Sections 4 and 5). Data holdings that appeared useful for addressing the EU request could then be secured prior to a subsequent workshop which, if approved, would apply the methodology and deliver the coordinates of the list of VME locations, and of the fishing footprint for static gears, mobile-contacting gears and a combined footprint in the EEZs of the Outermost Regions.

A funnel approach was used, starting with broad and general questions at the beginning of the questionnaire followed by more specific questions. For each of the goals, to the degree possible, close-ended questions were elaborated. These were accompanied by a brief explanatory sentence and instructions, for example:

In this section, we would like you to tell us about your experience fishing.

1. What type of fishing activities do you generally participate in? Check all that apply.
   - ☐ Full-time Commercial fishing
   - ☐ Part-time Commercial fishing
   - ☐ Recreational fishing
   - ☐ I go fishing to supply food for my family

For each question, we articulated why we were asking the question. This helped to reduce the number of questions to only those that were directly relevant to the stated goals. For example, in the example above, responses to this question help us to understand the level and nature of experience behind the responses and to identify gaps in expertise inputting to the workshop and data. It was also noted that how a question is asked directly impacts the insights that are received. For that reason, all questions were revised in terms of minimizing bias. Copies of the full Questionnaires are available from ICES upon request.

1.6.1 Data processing and analysis

Questions were also considered in terms of their potential for data analyses to produce averages, compare groups, and compute percentages, should sufficient responses be generated. Close-ended questions allow for data summaries to be extracted and analysed.

To identify locations, maps were provided with 5 km x 5 km grid overlays for the area of each country’s exclusive economic zone (EEZ) to 2000 m (the Area of Interest). Each cell of the grid was given a unique identifier code and respondents were asked to use those codes to indicate where data were collected or where they had personal knowledge of species and/or fishing activities. Grid size was discussed with the ICES Data Centre and was seen as adequate for maintaining the anonymity of respondents. ICES uses a grid size of 0.05 x 0.05 degrees (approximately

3 km x 5 km) to collect spatial data on fisheries. As this grid size varies among regions, a square grid was used to make the grid cell areas equal in all regions.

1.6.2 Pilot testing

Several steps were taken to increase response rate and eliminate potential sources of difficulty for respondents. This included; 1) screening and revision of poorly worded questions, 2) ensuring the survey as a whole was kept as short and simple as possible, 3) avoiding the use of scientific and other jargon, 4) perform an internal peer pilot test to collate input on whether the survey could easily be followed, 5) provide an introduction that describes the rationale, aims and expectation of respondents, and defines any terms used, 6) provide the respondents a realistic time estimate and remind them their opinions are anonymous and secure, 7) provide respondents with a final thought (in the format of an open-ended question) in the survey asking for any additional ideas, and 8) avoid questions placed out of order or out of context.

Once the survey questions were in place the following steps were agreed:

1. Pilot test

Purpose: To revise the survey to help improve the survey as a whole, and maximize response rates. The surveys were reviewed by Dr. Nathalie Steins (ICES SCICOM-ACOM, Human Dimension Steering Group. Leading social sciences and humanities related expert groups at ICES), Dr. Mark Tasker (Former Vice Chair, Advisory Committee), and Neil Holdsworth (Head of the ICES Data Centre), and adjusted accordingly. The revised surveys were then translated into the three languages by ICES staff.

2. Prepare a contact list

A contact list was prepared by the WKOUTVME Planning Committee drawing on the published literature and personal networks. Le Conseil Consultatif pour les Régions Ultrapériphériques (CC RUP) was asked to provide support in reaching fishers and other knowledgeable experts in each of the Outermost Regions.

1.6.3 Response rate

Questionnaires were posted on the WKOUTVME page on the ICES website and a contact list of 22 regional experts were emailed directly and invited to participate. They in turn were invited to circulate the survey links amongst colleagues. In addition, the surveys were presented to the CCRUP meeting in Paris prior to the workshop to encourage participation from fishers. The response to the surveys was disappointing in that none of the respondents were fishers. Fifteen questionnaires were returned as of the time of the workshop, 11 with information on the French Outermost Regions, three with information on the Canary Islands, and one with information from Azores. This suggests that there was a reasonable response from the primary contacts but as the surveys are anonymous it is unknown what the actual response rate was given that the number of non-respondents is unknown.

Several local scientists present at the workshop pointed out that they had not directly received the questionnaires or had never heard that the local fishers got a copy. Some participants noted that the grids on the map were too numerous for fishermen to take the time to point out fishing areas. Confidentiality of fishing spots can also be a reason for the lack of information from fishers. In many areas, the lack of a local workforce prevented undertaking *in situ* interviews with fishers and in some remote areas, dialects may be prevalent over the official language creating difficulties in interpreting the questionnaires. Responses to the Questionnaires for the location of VMEs are reported in Section 4 (Figure 4.1).

1.7 Other sources of information on VMEs

The readily available open access sources of information and data accessed and prepared by the Planning Committee for WKOUTVME are summarized in Table 1.7. This table was prepared so that experts attending WKOUTVME could focus on identifying data to augment the preliminary and non-exhaustive list using their specialized knowledge.

Prior to the workshop the CBD Ecologically or Biologically Significant Areas (EBSA) documents were reviewed from the clearing house of the Convention on Biological Diversity[6]. The World Database on Protected Areas[7] was similarly consulted and all documentation downloaded and put on the WKOUTVME SharePoint. EBSAs and MPAs overlying the areas of interest (AOIs) were mapped for each Outermost Region. No Other Effective Conservation Measures (OECMs) were reported for the AOIs. Both EBSA and MPA documentation provided details of use for this report, including descriptions and citations supporting the presence of VMEs, VME Indicators, VME Elements and in some cases of fishing activities.

The Tropical Deep Sea Benthos[8] (TDSB), led by the French National Natural History Museum (Muséum national d'Histoire naturelle; MNHN) and the French National Re-search Institute for Sustainable Development (Institut de Recherche pour le Dévelopement; IRD) – MNHN database BasExp - Référentiel Campagnes were consulted as advised from the Data Call (Section 1.5). Census of Marine Life projects with relevant information were identified from A Decade of Discovery[9] and ChEssBase[10].

The published literature was also reviewed, noting that relevant citations within the primary literature were also consulted but not included as a primary source. Links to relevant EU R&D projects funded through the Horizon programme were noted and data published in PANGAEA[11] reviewed. Where the above sources noted Species Distribution Models (SDMs) for VME Indicator taxa, those were also listed as areas where VMEs are likely to occur.

WKOUTVME notes that the ICES Vulnerable Marine Ecosystems Database[12] also holds records of VME habitats and VME Indicator Species for the ICES/NAFO areas which includes the Azores. As those records have been reported under their separate project affiliations in Section 2.1, with more updated information provided, they are not separately considered in this report. Further, ICES has published an Ecosystem Overview for the Azores which gives an overview of fishing activities there (ICES 2022a).

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[6] Ecologically or Biologically Significant Marine Areas. 2024. The Clearing-House Mechanism of the Convention on Biological Diversity (CHM). https://www.cbd.int/ebsa/

[7] UNEP-WCMC and IUCN (2024), Protected Planet: [The World Database on Protected Areas (WDPA)/The World Database on Other Effective Area-based Conservation Measures (WD-OECM)], Cambridge, UK: UNEP-WCMC and IUCN. https://www.protectedplanet.net/en/thematic-areas/wdpa?tab=WDPA

[8] Tropical Deep Sea Benthos (TDSB). 2024. French National Natural History Museum (Muséum national d'Histoire naturelle; MNHN) and the French National Research Institute for Sustainable Development (Institut de Recherche pour le Dévelopement; IRD) – MNHN database BasExp - https://expeditions.mnhn.fr/program/tropicaldeep-sea-benthos;jsessionid=7FFBCB18C62233299201E651E5EC2739

[9] A Decade of Discovery. 2024. Census of Marine Life. http://www.coml.org/

[10] Biogeography of Deep-Water Chemosynthetic Ecosystems. 2024. Census of Marine Life. https://metadatacatalogue.lifewatch.eu/srv/api/records/oai:marineinfo.org:id:dataset:212

[11] PANGAEA Data Publisher. 2024. Data Publisher for Earth & Environmental Science. https://www.pangaea.de/

[12] ICES Vulnerable Marine Ecosystems Database. 2024. ICES. https://www.ices.dk/data/data-portals/Pages/vulnerable-marine-ecosystems.aspx

Table 1.7. Summary of open-source deep-sea biodiversity data and information accessed for each of the Outermost Regions prior to WKOUTVME. See text for details of the data sources. SDM=Species Distribution Model. Hyperlinks to EBSA descriptions, TDSB data and EU Horizon Projects are provided. Presence/Absence of VME Elements are summarized in Table 1.8.

Region	EBSAs	MPAs (WDPA)	Primary Literature	EU Horizon Projects	PANGAEA	SDMs	TDSB (MNHN)
Azores	North Azores Plateau Atlantis-Meteor Seamount Complex Ridge South of the Azores	Luso fisheries closure Arquipélago Submarino do Meteo Campos Hidrotermais a Sudoeste dos Açores Banco Princes Alice Banco D. João de Castro Ilhéus das Formigas e Recife Dollabarat Banco Condor Canal Faial-Pico/Sector Faial Costa do Corvo Monte Submarino Sedlo Oceânica do Corvo Oceânica do Faial	Morato *et al*. 2020 Sampaio *et al*. 2012 Taranto *et al*. 2023a Taranto *et al*. 2023b	ATLAS iAtlantic EurofleetsPlus [Not reviewed: OASIS, HERMIONE, CoralFISH, MERCES, SponGES, MarinePlan]	Taranto *et al*. 2023a	14 Cold-water coral (VME) SDMs	
Madeira	Desertas Madeira - Tore	Cetáceos da Madeira Ilhas Desertas	Geldmacher *et al*. 2006 Braga-Henriques *et al*. 2022 Christiansen *et al*. 2009 Xavier & van Soest 2007				
Canary Islands	Oceanic Islands and	Espacio marino del oriente y sur de Lanzarote-Fuerteventura	Valdés & Déniz - González 2015				

Region	EBSAs	MPAs (WDPA)	Primary Literature	EU Horizon Projects	PANGAEA	SDMs	TDSB (MNHN)
	Seamounts of the Canary Islands Tropic Seamount	Banco de la Concepción Espacio marino de La Gomera-Teno Franja marina Teno-Rasca Franja marina de Mogán Sebadales de Güigüí Monumento Natural do edifício vulcânico das Ilhas Selvagens Área marina de La Isleta Espacio marino de la zona occidental de El Hierro Espacio marino del norte de La Palma					
Mayotte	Northern Mozambique Channel	Mayotte	Hanafi-Portier 2021 Obura 2012 Thomassin 1977 Corbari *et al.* 2017				BENTHEDI BIOMAGLO
Réunion			Oehler *et al.* 2008 Duncan 1990 Marsac *et al*. 2020 Durville *et al*. 2009				
Martinique	Eastern Caribbean	Martinique	Davies & Guinotte 2011 Legrand *et al*. 2012				
Guadeloupe	Eastern Caribbean	Guadeloupe (Aire D'Adhésion) Agoa	Davies & Guinotte 2011				KARUBENTHOS

Region	EBSAs	MPAs (WDPA)	Primary Literature	EU Horizon Projects	PANGAEA	SDMs	TDSB (MNHN)
Saint Martin	Eastern Caribbean	Saint-Martin Agoa	Davies & Guinotte 2011				
French Guiana	Amazonian-Orinoco Influence Zone		Artigas *et al*. 2003	GUYANA 2014			

1.7.1 Location of VME Elements

Seamounts, hydrothermal vents and shelf-indenting and blind canyons locations were readily obtained from open access sources. Open access bathymetric data enabled the mapping of steep slopes greater than 6.4°. These VME Elements were mapped prior to the WKOUTVME and the presence/absence of all VME Elements identified in each of the Outermost Regions is summarized in Table 1.8.

Global databases for seamounts[13] (Yesson *et al*. 2020) were consulted to identify VME Elements (Table 1.8). The data was composed of two shapefiles:

- YessonEtAl2019-Seamounts-V2.shp - a point shapefile providing locations of the seamounts.
- YessonEtAl2019-SeamountBases-V2.shp – a polygon shapefile providing an area (polygon) at the base of each polygon (Yesson *et al.* 2020).

All seamounts (point locations) inside the Outermost Region study areas (delimited to 2000 m and the EEZ) were selected and a shapefile of these seamounts for each area was created. For Martinique and Saint Martin the seamount peak did not fall inside the study area but part of the base area did, and those partial base areas were retained. Where base polygons overlapped (they often did), they were dissolved to create a continuous polygon (e.g. in the Azores).

For hydrothermal vents, the InterRidge Global Database of Active Submarine Hydrothermal Vent Fields[14] Version 3.4, with bathymetry from NOAA ETOPO1 was consulted. A shapefile containing the global distribution of hydrothermal vent fields in a WGS84 coordinate system was downloaded from the Pacific Data Hub[15]. This shapefile provides metadata and global locations (points) for active hydrothermal vents. Locations were selected that fell in each Outermost Region study area and shapefiles were produced.

Shelf-indenting and blind canyons were obtained from a digital seafloor geomorphic features map (GSFM) of the global ocean (Harris *et al*. 2014)[16].

Slopes greater than 6.4° meet the definition of a steep flank VME Element (Section 1.1). Steep flanks were identified from GEBCO 2023[17] bathymetry in ArcGIS Pro 2.9.8. Downloaded GEBCO bathymetry was converted to a WGS84 UTM projection (cell size 15 arc seconds or 463 m at the equator, increasing with latitude):

French Antilles - 458.1m (~16.50 N latitude) [Projection: WGS UTM 20N];
French Guiana - 462.4m (~60 N latitude) [Projection: WGS UTM 22N];
Azores WGS UTM 25N - 420.4m (~390 N latitude) [Projection: WGS UTM 25N];
Azores WGS UTM 26N - 424.7m (~370 N latitude) [Projection: WGS UTM 26N];
Canary / Maderia - 446.0m (~300 N latitude) [Projection: WGS UTM 28N];
Mayotte - 487.6m (~130 S latitude) [Projection: WGS UTM 38S];
Réunion Island - 454.6m (~210 S latitude) [Projection: WGS UTM 40S].

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[13] List of seamounts in the world oceans - An update. 2024. Yesson *et al*. (2020). https://doi.org/10.1594/PANGAEA.921688

[14] InterRidge Global Database of Active Submarine Hydrothermal Vent Fields. 2024. https://vents-data.interridge.org/

[15] Pacific Data Hub. 2024. Pacific Community (SPC), New Zealand Ministry of Foreign Affairs and Trade. https://pacific-data.sprep.org/system/files/Global_2020_HydrothermalVents_InterRidgeVentsDatabasev3.4.zip

[16] Seafloor Geomorphic Features Map. 2024. Blue Habitats. Harris *et al*. (2014). https://bluehabitats.org/

[17] Grided Bathymetry Data. 2024. The GEBCO_2023 Grid. https://www.gebco.net/data_and_products/gridded_bathymetry_data/gebco_2023/

A slope surface was produced for each region using the Spatial Analyst Slope Tool. The Slope Tool calculates the maximum rate of change between each cell and its neighbours, for example, the steepest downhill descent for the cell (the maximum change in elevation over the distance between the cell and its eight neighbours). To isolate the Steep Flank VME Element in each region, the slope surface was classified to distinguish slope areas above and below 6.4° using the Spatial Analyst Reclassify Tool. This surface was converted to a polygon (Raster to Polygon Tool) and areas with slopes above 6.4° were isolated, representing steep flank VME Elements in the EU Outermost Regions.

Table 1.8. Presence (Y) and Absence (N) of VME Elements in each of the nine Outermost Regions as identified from global open-source databases for seamounts and hydrothermal vents and as determined from bathymetry. For Submarine Caves and Mesophotic Zones only regions where information is used in this report are indicated. Empty cells indicate that no information was found to support the presence or absence of the element.

Outermost Region	Seamounts	Steep Flanks	Canyons	Hydrothermal Vents	Submarine Caves	Mesophotic Zones
Azores	Y	Y	Y	Y		
Madeira	Y	Y	N	N		
Canary Islands	Y	Y	Y	Y		Y
Mayotte	Y	Y	Y	N	Y	Y
Réunion Island	Y	Y	N	N	Y	
Martinique	Y	Y	Y	N	Y	Y
Guadeloupe	Y	Y	Y	Y	Y	
Saint-Martin	Y	Y	Y	N	Y	
French Guiana	N	Y	Y	N	N	Y

2 Summary of knowledge for each of the Outermost Regions

For each of the Outermost Regions WKOUTVME summarized the available information on VMEs, deep-sea fish species and on the local fisheries. At the end of each section tables of the "List of deep-sea fish species", "Lists of VME Indicator Species" and "Metadata of relevant data sources" are provided. For the lists of species, these are meant to replace the list of deep-water fish species presented in Annex I of the deep-sea access regulation with regionally relevant taxa. In the case of the Lists of VME Indicator Species, the lists are meant to augment the list found in Annex III of the regulation, providing regionally-relevant examples where known. The list of VME Indicator Species in particular is non-exhaustive, and with more exploration additional species may be documented in future. These lists should be updated periodically as new information becomes available. Datasets selected from these lists to be used in a subsequent workshop for analyses for advice purposes would need to be received by ICES, quality control checked and signed off for use in the advice process. Workflows have been established to achieve this (e.g. for VMES, see ICES 2024; for fisheries data, see ICES 2021).

2.1 Azores

Lying between continental Europe and North America, the Azores is the most isolated archipelago in the North Atlantic Ocean (Figure 2.1). It has a one million km^2 Exclusive Economic Zone (EEZ) which comprises mostly deep seafloor interspersed with shallower areas associated with the Mid-Atlantic Ridge, over 100 seamounts, and the slopes of nine islands (Morato *et al*. 2020). The Azores EEZ intersects three EBSAs, namely; (i) Ridge South of the Azores (CBD 2023c), (ii) North Azores Plateau (CBD 2023d), and (iii) Atlantis-Meteor Seamount Complex (CBD 2023e).

Originally adopted in 2011 and revised in 2016, the Azores government adopted the revised version of the network of protected areas, named the Azores Marine Park. The network of MPAs encompassed several VMEs including all known hydrothermal vents and several seamounts that include or likely include VMEs and Essential Fish habitats. Eleven MPAs were included in the Azores Marine Park in 2011 (DLR n.º 28/2011/A), while the MPA of the Meteor Submarine Archipelago (PM12), seamounts Condor and Princesa Alice (PM14 and PM15, respectively) and a large area in the Mid Atlantic Ridge southwest of Flores were included in 2016 (DLR n.º 13/2016/A). With the 2016 update defined in the regulatory decree-law, and the 2019 addition of the Luso hydrothermal vent field defined in the Portaria nº 68/2019, the Azores Marine Park is now composed of 16 Marine Protected Areas, covering an area of 135,507 km^2 both within and partially beyond the Portuguese EEZ.

In 2019, the Azores government adopted the Blue Azores Program aiming at revising and expanding the existing network of MPAs to achieve well-defined management and conservation goals, and achieve the Convention on Biological Diversity Kunming-Montreal Global Biodiversity Framework 30/30 targets. This process benefited from cost-effective deep-sea biodiversity assessments and a systematic conservation planning approach using a Marxan type of analysis, aiming to inform the design of the network of MPAs. This approach considered all known VMEs (hydrothermal vents and benthic habitats), essential fish habitats, and other important or vulnerable features. A network of MPAs aimed at the conservation and sustainable management of deep-sea ecosystems was agreed with the main stakeholders, and is now undergoing a public consultancy process.

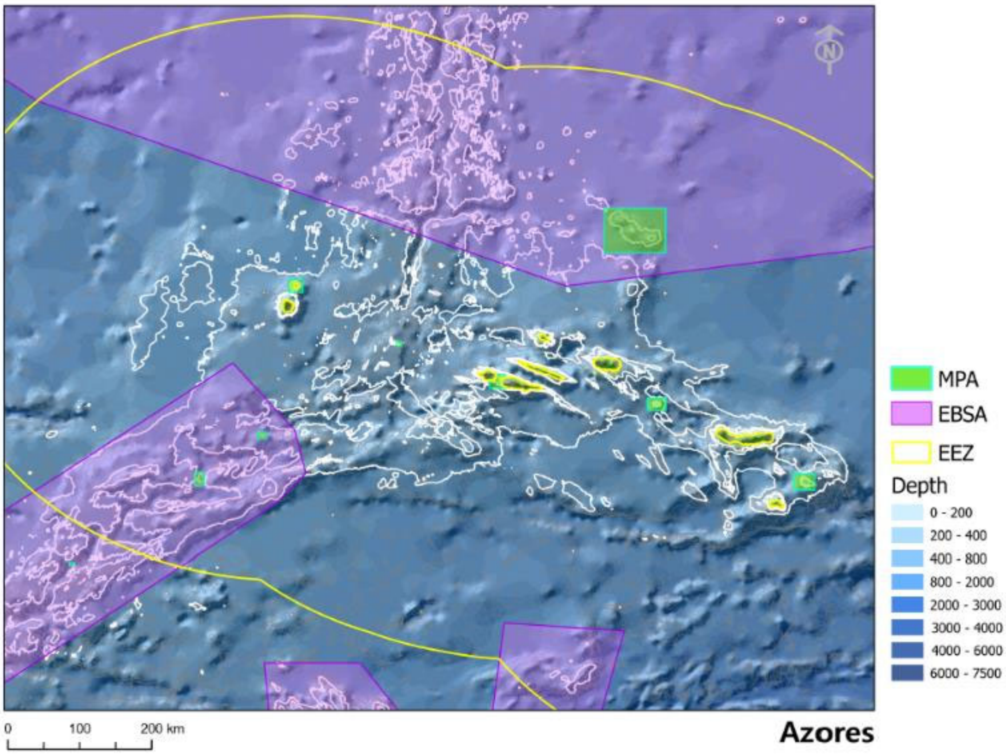

Figure 2.1. Map of the Azores showing the 200 m, 400 m and 2000 m depth contour (white) and the location of the EBSAs and MPAs within the Portuguese Exclusive Economic Zone (EEZ).

2.1.1 VMEs known to occur

The Azores have a long history of deep-sea research supported by various regional (e.g., 2020, MapGES, DeepWalls, FunAzores, Deep-sea habitat mapping), national (e.g., DeepData), and European funded research projects and international collaborations (e.g,, OASIS, HERMIONE, CoralFISH, ATLAS, MERCES, SponGES, iAtlantic, MarinePlan). This research, carried out with IMAR and Okeanos of the University of the Azores, consolidated the knowledge about VMEs on seamounts, ridges and hydrothermal vent ecosystems. The Azores region was found to harbour particularly diverse coral gardens, forming at least seven distinct coral garden communities dominated by different species of octocorals (Braga-Henriques *et al*. 2013) discovered through multiple cruises (e.g., Tempera *et al*. 2011, Carreiro-Silva *et al*. 2018, Carreiro-Silva *et al*. 2019, Dominguez-Carrió *et al*. 2019a, b, Morato & Taranto 2019, Morato *et al*. 2019a, b, Morato *et al*. 2020a, b, Carreiro-Silva *et al*. 2021, Dominguez-Carrió *et al*. 2021a, Morato *et al*. 2021; Ramos *et al*. 2021, Morato *et al*. 2022a, b, Puerta *et al*. 2022, Morato *et al*. 2023a, b, c). Both historical and new knowledge generated from these projects have demonstrated that the Azores is a hotspot of cold-water coral diversity, representing the highest species richness known of Octocorallia in Europe and in any of the North Atlantic archipelagos (Sampaio *et al*. 2019).

A new hydrothermal vent field (the Luso) was discovered on the slopes of Gigante, a seamount on the Mid-Atlantic Ridge in the seas of the Azores. This system differs considerably from other known hydrothermal fields along the MAR in terms of fluid chemistry with dominance of hydrogen and iron, and a relatively low temperature environment. Accordingly, in September 2019, the Regional Government of the Azores declared the Luso hydrothermal vent field a Marine Protected Area (Portaria no. 68/2019). The vent field was discovered during the Blue Azores Expedition in 2018, which used Remotely Operated Vehicle (ROV) operations as part of the ATLAS project.

Within the ATLAS project[18], several areas were identified and preliminarily assessed as potential Vulnerable Marine Ecosystems (VMEs). These areas require further evaluation using the VME data identification and multi-criteria assessment framework proposed by this workshop to be fully recognized as VMEs. The preliminary VMEs are situated within Cavalo Seamount, a ridge on the Mid-Atlantic Ridge, Gigante Seamount, Condor Seamount, Dom João de Castro Seamount, and Mar de Prata Seamount, all initially noted for their diverse coral gardens. Additionally, the area south of Pico Island has been highlighted for its deep-sea sponge aggregation of *Pheronema carpenteri*, and the newly discovered hydrothermal vent Luso.

The mesophotic zone on the island slopes of the Azores hosts dense populations of black corals that may fit the criteria of VME habitats. The black coral *Antipathella wollastoni* is mostly found associated with vertical walls between 20 and 50 m depth (Tempera *et al*. 2013), while *Antipathes furcata* and *Antipathella subpinnata* have been found to form monspecific coral gardens at depths of 109 and 186 m and 150 and 196 m, respectively (de Matos *et al*. 2014, Mano 2019). The whip-like octocoral *Viminella flagellum* and the soft corals *Alcyonium* spp. have also been recorded between 120 – 170 m (de Matos *et al*. 2014, Tempera *et al*. 2013). Further studies are needed to determine their functional significance, such as provision of shelter, food and nursery areas for associated species, as well as nutrient regeneration, and carbon remineralization and sequestration.

2.1.2 VMEs likely to occur

Habitat suitability models have been developed for 14 vulnerable and foundation cold-water coral (CWC) taxa of the Azores (NE Atlantic) using GAM and MAXENT (Taranto *et al*. 2023a, b). The modelled taxa are: *Acanthogorgia* spp., *Callogorgia verticillata*, Coralliidae spp., *Dentomuricea* aff. *meteor*, *Desmophyllum pertusum*, *Errina dabneyi*, *Leiopathes* cf. *expansa*, *Madrepora* oculata, *Narella bellissima*, *Narella versluysi*, *Paracalyptrophora josephinae*, *Paragorgia johnsoni*, *Solenosmilia variabilis* and *Viminella flagellum*. Models were built using a model grid having a cell size of a 1.13 x 1.11 km (i.e., about 0.01° in the UTM zone 26N projection). The combined habitat of all modelled species covered 11% of the study area (Figure 2.2). These models are being updated based on the large-scale data collection described above.

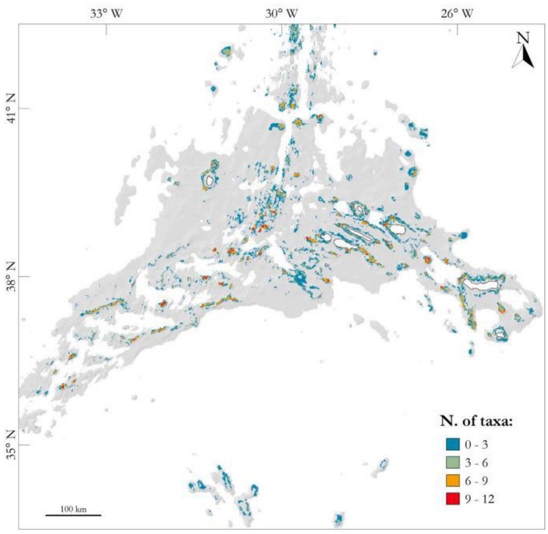

Figure 2.2. Map showing the overlap of modelled species distributions of 11 cold water coral VME Indicator taxa (Taranto *et al*. 2023a,b).

[18] ATLAS - a transatlantic assessment and deep-water ecosystem-based spatial management plan for Europe. 2024. https://www.eu-atlas.org/

In 2012, Sampaio *et al*. (2012) identified the principal CWC species landed by bottom longlining in Faial (Azores) from 150 to 600 m depth. Corals were relatively common by-catch in bottom longline fisheries around the Azores.

The work by Puerta *et al*. (2022) provided a local to large-scale comprehensive description of deep-sea megabenthic assemblages along the western branch of the Mediterranean Outflow Water (MOW), from its origin in the western Mediterranean Sea to the Central North Atlantic including the Formigas Seamount (SE Azores archipelago). This work characterized and quantified these assemblages (which included several VMEs as well as VME Indicator taxa).

2.1.3 VME elements

Steep flanks with slopes > 6.4° are prevalent in the Azores (Figure 2.3) while shelf-indenting and blind canyons were identified (Figure 2.4). Seamounts and their bases to 2000 m as well as known hydrothermal vents were mapped (Figure 2.5). It should be highlighted that the Azores scientific community has partnered with the Government of the Azores, the Portuguese Hydrographic Institute and with other international organizations (e.g., NIOZ, IFREMER) to collect detailed multibeam data for most of the deep seabed within the Azores sub-area of the Portuguese EEZ down to 1500 m. This new information is being analyzed and will improve the assessment of the spatial distribution of biodiversity in the deep sea and will help to inform areas where VME elements and VMEs are known or likely to occur.

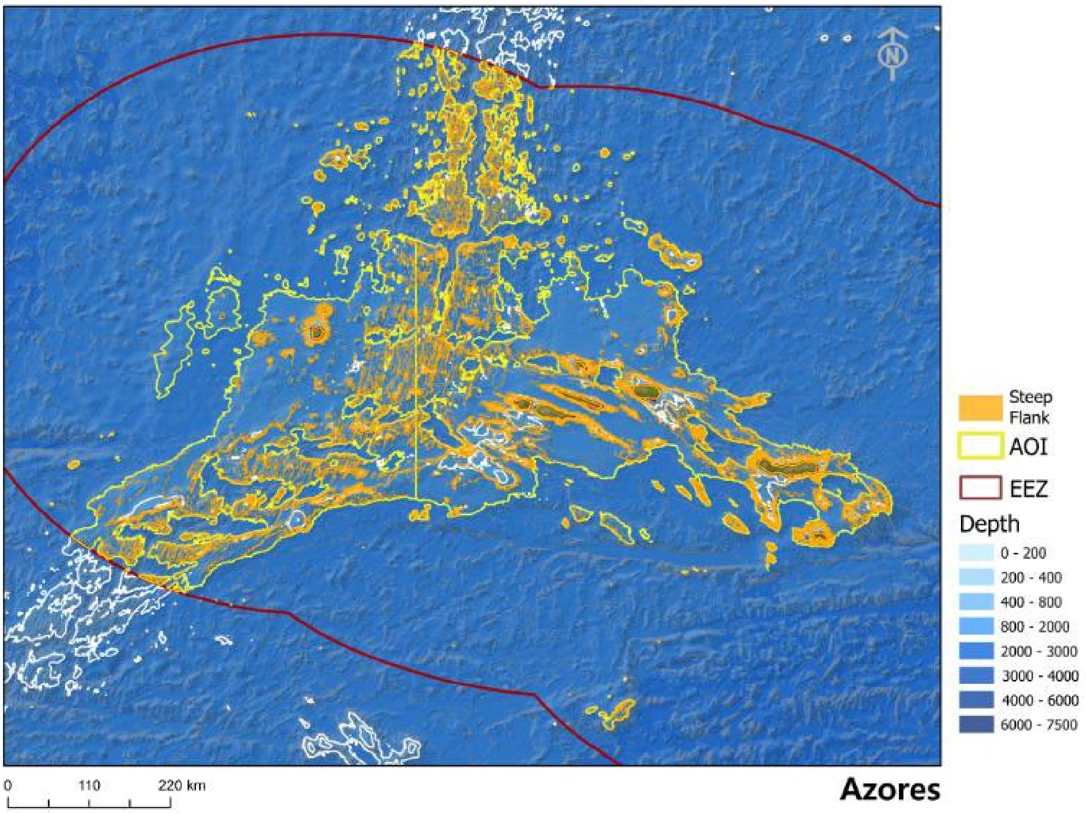

Figure 2.3. Map of the Azores showing the location of steep flanks with slopes > 6.4° within the area of interest (AOI) of waters < 2000 m depth within the Portuguese Exclusive Economic Zone (EEZ).

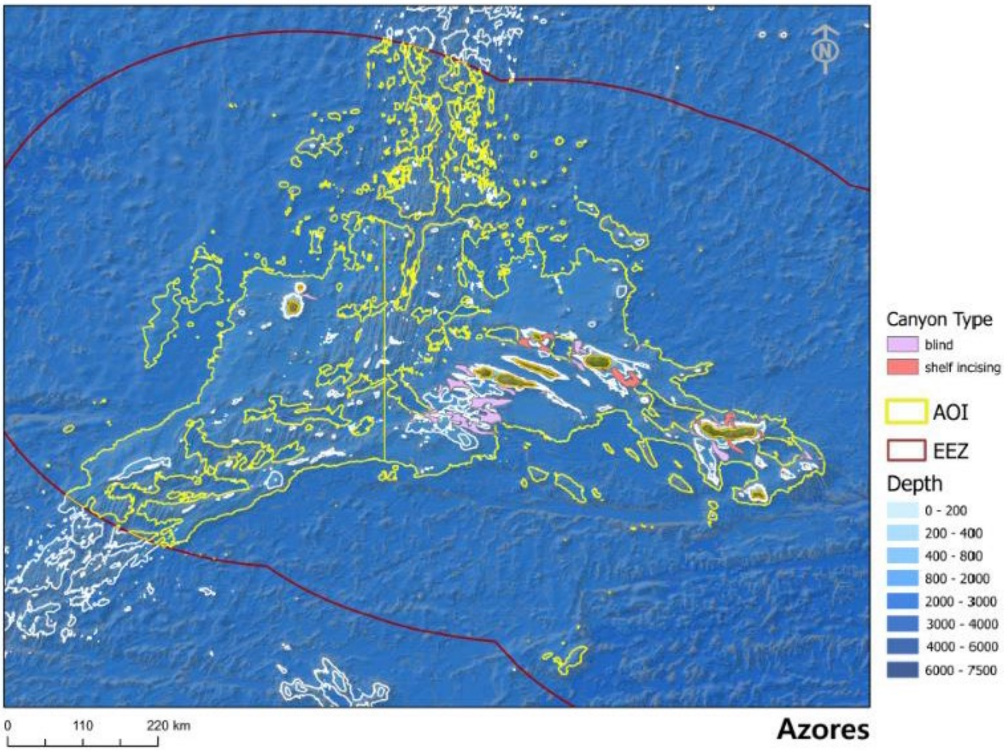

Figure 2.4. Map of the Azores showing the location of shelf-indenting and blind canyons within the area of interest (AOI) of waters < 2000 m depth within the Portuguese Exclusive Economic Zone (EEZ).

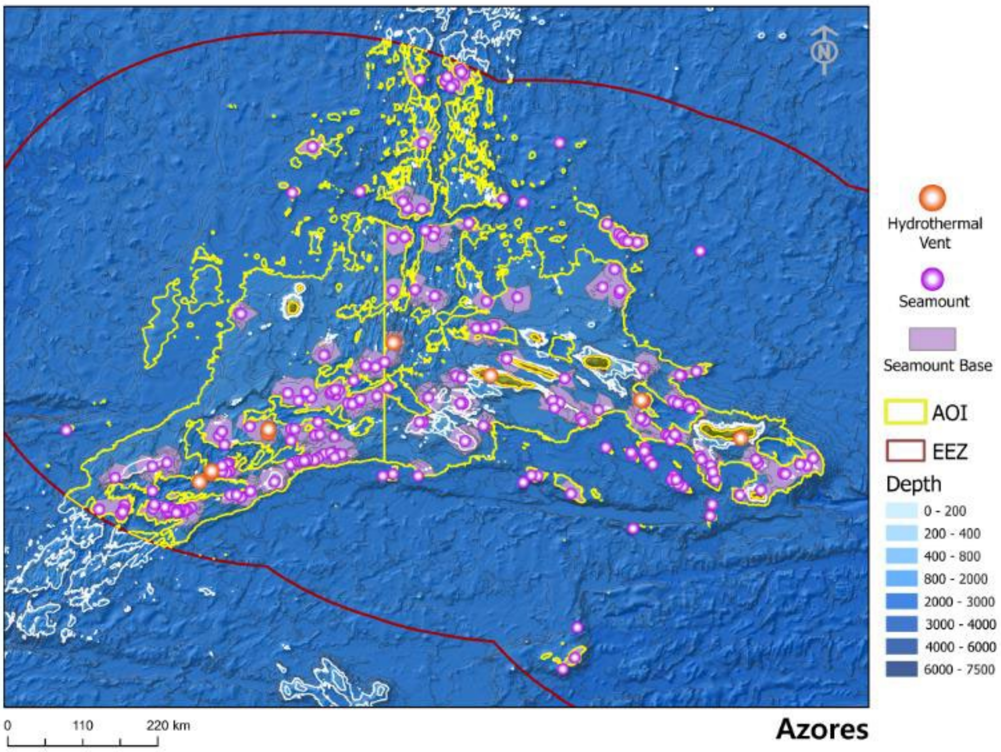

Figure 2.5. Map of the Azores showing the location of seamounts, seamount bases and known hydrothermal vents within the area of interest (AOI) of waters < 2000 m depth within the Portuguese Exclusive Economic Zone (EEZ).

2.1.4 Overview of the local fisheries

As in most oceanic islands, fishing has always been a key driver of the subsistence and economy of the Azores (Carvalho 2010). The Azores fisheries are typically characterized as being artisanal and small-scale in nature, with a multi-segmented fleet, targeting multiple species with a wide range of fishing gears and methods (Carvalho 2010). With the absence of a continental shelf and surrounding great depths, modern fishing occurs around the island slopes and the many seamounts present in its vast exclusive economic zone of 1 million km² (Menezes 1996, Silva & Pinho 2007, Morato *et al*. 2008, Morato *et al*. 2013, Diogo *et al*. 2015). Dominated by hooks-and-lines, fisheries in the Azores can be categorized as pelagic and deep-sea fishing (Table 2.1). The pelagic fishing industry is currently composed of: i) a pole-and-line Tuna fishery, with an average total catch of about 5,900 t·year-1 and its associated live bait fishery with an estimated catch of about 270 t·year-1, ii) a pelagic longline fishery targeting Swordfish (*Xiphias gladius*), Blue Shark (*Prionace glauca*), and other pelagic sharks (2,500 t·year-1) operated by Azores, mainland Portugal and foreign fleets; and iii) a small purse-seine fishery for small pelagic species targeting mostly Blue Jack Mackerel (*Trachurus picturatus*), and Chub Mackerel (*Scomber colias*), with an average total catch of 2,100 t·year^{-1} (Table 2.1; Fauconnet *et al*. 2019a; Pham *et al*. 2013).

2.1.5 Deep-sea fishing activity in the Azores

Deep-sea fisheries are currently composed of a bottom longline and handline fisheries targeting deep-sea demersal fishes such as Blackspot Seabream (*Pagellus bogaraveo*), Wreckfish (*Polyprion americanus*), Alfonsinos (*Beryx* spp.) or Blackbelly Rosefish (*Helicolenus dactylopterus*) with an average total catch of 4,300 t·year^{-1}. A drifting deep-water longline fishery for Black Scabbardfish (*Aphanopus carbo*) has been in an experimental phase since 1998 (Machete *et al*. 2011) with an average catch of about 125 t·year^{-1}, but never developed (Fauconnet *et al*. 2019a).

Table 2.1. Average annual catch and discards, with 95% confidence interval (CI), and weighted annual discarded fraction (%) by fishery over the 2000–2014 period (Fauconnet *et al*. 2019a).

Fishery	Main target	Average Catch (t)	CI	Average Discard (t)	CI	Discards (%)
Pole-and-line	Tunas	5902	[4014.8 - 7789.9]	2	[1.3 - 2.6]	0.03
Tuna live bait fishery	Small pelagics	272	[223.6 - 320.8]	30.5	[24.2 - 36.7]	11.19
Bottom longline and handline	Deep-sea demersal fishes	4336	[4043.7 - 4629.2]	447.3	[354.7 - 539.9]	10.32
Purse-seine	Small pelagics	2087	[1827.2 - 2347.6]	270.5	[220.4 - 320.5]	12.96
Pelagic longline – foreign fleet	Swordfish and pelagic sharks	1156	[1015.4 - 1297.5]	25	[23.4 - 26.5]	2.16
Pelagic longline – mainland fleet	Swordfish and pelagic sharks	816	[564.1 - 1068.8]	20.6	[14.2 - 27]	2.52
Pelagic longline – regional fleet	Swordfish and pelagic sharks	565	[415.7 - 715.3]	246.3	[183.6 - 309]	43.55
Recreational fishing	Diverse species	540	[471.2 - 609.9]	24.6	[20.8 - 28.4]	4.56
Handline jig	Squids (*Loligo forbesii*)	404	[300.1 - 509.2]	0		0
Collection of invertebrates	Coastal invertebrates	236	[211 - 261.1]	0		0
Drifting deep-water longline	Black Scabbardfish	125	[40.4 - 210.7]	2.5	[0.8 - 4.2]	2.01

Other fishing activities in the Azores include recreational fishing, seasonal squid fisheries targeting Veined Squid (*Loligo forbesi*), and collection of coastal marine invertebrates such as octopus (*Octopus vulgaris*), limpets or Slipper Lobster (*Scyllarides latus*) (Morato 2012, Pham *et al*. 2013). In recent years there has been an increasing interest in harvesting algae.

2.1.6 The deep-sea bottom longline and handline fishery

Gear type and maximum operating depth of the fishery

Many different types of longlines and handlines are used in the Azores (Figure 2.6). The bottom longline and handline fisheries include a broad range of fishing techniques from horizontal bottom longline rock/buoy technique with thousands of hooks, to vertical longlines (*gorazeira*), to handlines with only hundreds of hooks. One of the most common longline gears used in the commercial demersal fishery in the Azores has a stone/buoy configuration (Menezes 2003, Menezes *et al*. 2006, Menezes & Sigler 2016). The longlines are usually set from four-sided skates, with about 30, size no. 8, hooks (i.e., the legal size corresponding to 14 mm gape width) by quarter-skate side, of approximately 36.5 m long. On average, a 12 skates gear length covers approximately one nautical mile (Menezes 2003). The bait used is mostly chopped, salted sardine or mackerel (Morato 2012). The fishing gears are deployed at depths up to 800-1200 m, with a mode between 200–600 m where the most important commercial species occur (Menezes 1996).

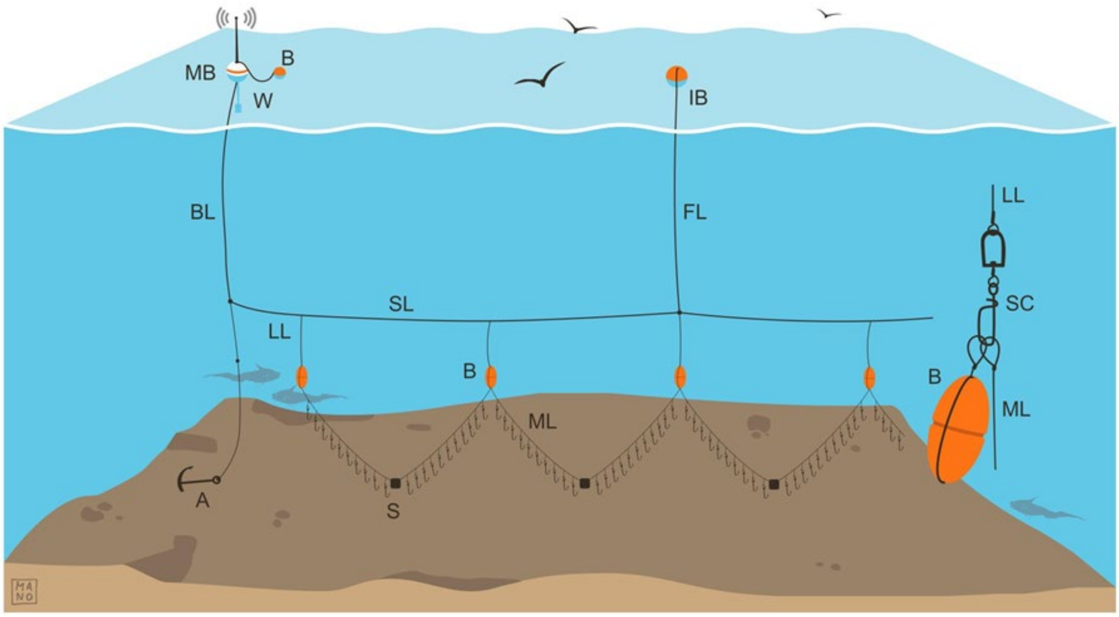

Figure 2.6. Drawing exemplifying the bottom longline fishing techniques for demersal species in the Azores. Source: Menezes & Sigler 2016.

Fishing Fleet

Over the period 2010-2018, an average of 370 vessels were registered in the bottom longline and handline fisheries, representing 47% of the total number of fishing vessels registered in the Azores over this period (https://srea.azores.gov.pt/). Out of those 370 vessels, 84% (310 vessels) declared their catch originated from handlining, while 16% (61 vessels) declared their catch originated from bottom longlines. The bottom longline and handline fisheries are predominantly small-scale with > 89% of fishing vessels smaller than 12m length, most of which being open-deck wooden boats. The proportion of small boats is higher for vessels deploying handlines (with

> 94% of fishing vessels < 12m length) when compared to longliners. In recent years, the number of bottom longliners has decreased while the handliners remained approximately constant. The incentive to this conversion may lie in need to reduce cost but also in differences in fishing rights between both gears in the coastal areas. Bottom longliners are currently forbidden to fish in coastal areas and island slopes, in most areas up to 6 nm from shore, while this limitation is only set to 1 nm from the coast for most handliners. Due to those limitations and the absence of continental shelf, the bottom longline fishery is at present mostly an offshore seamount fishery (Morato 2012, Diogo *et al*. 2015).

Deep-sea fish species and yields

The total catch (including landings, unreported catch and discards) of the bottom longline and handline fishery was estimated to average 4,500 t·year^{-1} over the period 2008-2017, of which discards were estimated to represent 11%, i.e. 510 t·year^{-1} (Figure 2.7) (Fauconnet *et al*. 2019a, Savina-Rolland *et al*. 2019). Landings from bottom longlines represented 68% of the total landed volume for this fishery, i.e., 2,100 t·year^{-1}, over the period 2010-2018, while landings from handlines averaged 960 t·year^{-1} (Figure 2.7). Discarded fractions are usually higher for bottom longlines than for handlines representing, respectively, 20.03% and 12.65% of the total catch measured in number of individuals (Figure 2.7). Information on the reasons for discarding revealed that "undersize" was the main reason for discards with both gears. Existing regulations were identified as the predominant reason for discarding in this fishery, with the increase in discarding coinciding with the implementation of the Total Allowable Catch (TAC) system (Pham *et al*. 2013, Fauconnet *et al*. 2019a) and increased Minimum Landing Size (MLS).

The main target species of the bottom longline and handline fishery, and top species in landed value in the Azores, is the Blackspot Seabream *Pagellus bogaraveo,* with 540 t·year^{-1} landed (average 2013-2023). Yet, the total catch of this fishery includes more than 20 species of commercial importance in the Azores, including: European Conger (*Conger conger*; 133 t·year^{-1}), Wreckfish (*Polyprion americanus;* 180 t·year^{-1}), Blackbelly Rosefish (*Helicolenus dactylopterus*; 212 t·year^{-1}), Forkbeard (*Phycis phycis;* 180 t·year^{-1}), alfonsinos (*Beryx splendens*; 94 t·year^{-1}, and *B. decadactylus;* 45 t·year^{-1}), Red Porgy (*Pagrus pagrus;* 85 t·year^{-1}), and offshore rockfish (*Pontinus kuhlii;* 51 t·year^{-1}). Species with high discard amounts included the Silver Scabbardfish (*Lepidopus caudatus*), European Conger and Blackbelly Rosefish due to MLS and the low economic value of small individuals, and alfonsinos, especially in years when the TAC was exceeded. Many of these species have had Regional TACs since 2020 (Portaria n.º 92/2019 de 30 de dezembro de 2019).

Marked differences in catch compositions exist between handliners and longliners. Catch diversity is higher with bottom longlines (> 100 species) than with handlines (around 40 species). With handlines, the catch is largely dominated by Blackspot Seabream (42.2%), while with bottom longlines, Blackspot Seabream is also among the species caught in largest proportions (25.7%) but the catch is more widely distributed among species. Catch weights of handliners are lower than those of longliners.

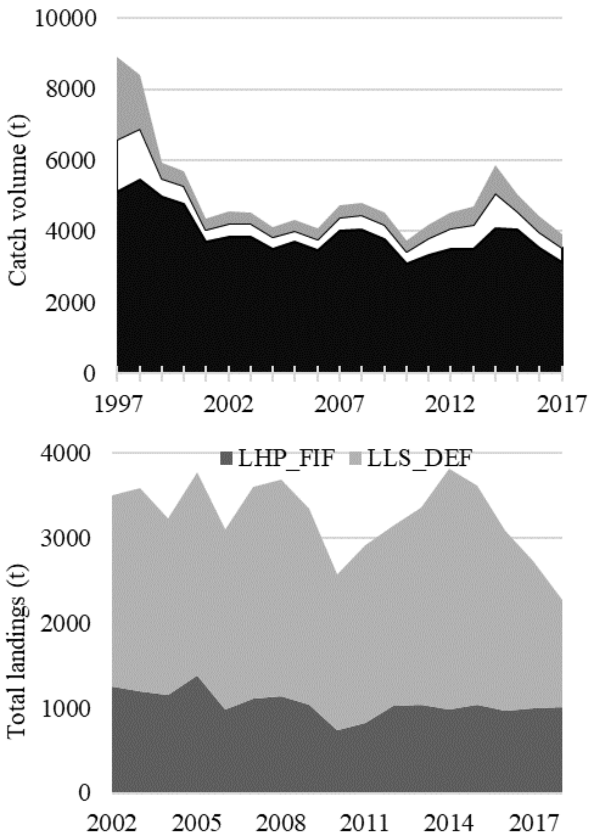

Figure 2.7. Left; Time series of catch volume of the bottom longline and handline fishery, segregated between reported catch (i.e. official landings; in black), unreported discards (white) and unreported catch for other uses (including bait; in grey) (Fauconnet *et al*. 2019a, Savina-Rolland *et al*. 2019). Right; landed volumes segregated between handlines (LHP_FIF) and bottom longlines (LLS_DEF) based on official landings statistics.

Economic and social performances

The bottom longline and handline fishery is the most important fishery in terms of landed value, with an average value of 18.3 M€ per year over the period 2010-2018, representing 57% of the total landed value in the Azores. While in terms of landed volume, it only accounts for 37% of the total landed volume in the Azores, with an average of 3670 t per year (SREA, http://estatistica.azores.gov.pt, 2019). The last assessment of the number of fishers employed in this fishery was undertaken in 2005, and estimated that the bottom longline fisheries directly employed in 2005 about 350 crew members while the handline fishing employed about 930 fishers, representing about 60% of all professional fishers in the Azores (Carvalho *et al*. 2011). Since 2005, the total number of fishers (i.e. all fisheries confounded) increased until 2017 but sharply decreased in 2018 (SREA, http://estatistica.azores.gov.pt, 2019).

Interviews with bottom longline and handline fishers suggested that the recent trend of gear conversion from bottom longlines to handlines is expected to have some socio-economic consequences (Fauconnet *et al*. 2019b). Handlining was perceived as more cost-effective, with higher selling prices due to better fish condition and larger individuals, reduced expenses (in employment/crew, bait, number of hooks, fuel) and increased flexibility in fishing tactics and techniques, largely compensating lower catches (Fauconnet *et al*. 2019b). From a social perspective though, this conversion likely has detrimental effects on employment as the number of crew members needed by handliners is much lower than by longliners, including crew members on board, but also inland crew (including many women) that are hired by longliners to prepare/bait the gear (Fauconnet *et al*. 2019b).

Effect of fisheries on natural habitats

Pham *et al*. (2014) found that deep-sea bottom longline fishing has reduced impact on vulnerable marine ecosystems when compared to bottom trawling. They found reduced bycatch of cold-water corals and limited additional damage to benthic communities. Bycatch of cold-water corals was registered in 44.7% of the longline sets, but with a very small average number of organisms (Pham *et al*. 2014). Longlines were found to mostly impact large organisms with a complex morphology. The most common species composing the primary, albeit small, bycatch were the antipatharian, *Leiopathes* spp., the stylasterid, *Errina dabneyi* and the gorgonians, *Callogorgia verticillata*, *Acanthogorgia armata*, *Paracalyptrophora josephinae* and *Viminella flagellum* (Sampaio *et al*. 2012). To provide insights on the level of longline damage not accounted for as bycatch, the physical conditions of benthic communities on a fishing ground were also assessed by Pham *et al*. (2014). From the colonies observed close to lost fishing lines, 63% were found intact, 15% with minor damage, 20% with major structural damage but with potential for survival, and only 3% of the cold-water corals were found in a critical status with no survival potential. The probability of contact of the gear had not been scientifically estimated but is perceived to be extremely reduced for handlines, very reduced for rock-buoy longline and reduced for buoy-buoy longline. When compared to bottom trawl the contact of longlines with the seafloor is minimal.

Deep-water bottom fishing effort data

The bottom-fishing effort layer was computed from an analysis of the Vessel Monitoring System (VMS) for vessels licensed for bottom longline or handline fishing gears. The fishing licences granted to each vessel per year were used to allocate a gear type to all VMS pings. Not all boats operating in the spatial planning area (beyond 6 nm from island shores) have VMS systems installed. However, a comparison of the VMS outputs with the fishing effort maps obtained from fishers' inquiries (Diogo *et al*. 2015) revealed similar spatial patterns, but much more spatial detail when using the VMS data. In total, VMS data was obtained from 74 anonymous vessels over the period 2002-2018 with an average of 12 vessels per year. This number represents about 25% of the bottom longline fleet if considering an average of 52 vessels per year that declared landings using bottom longline.

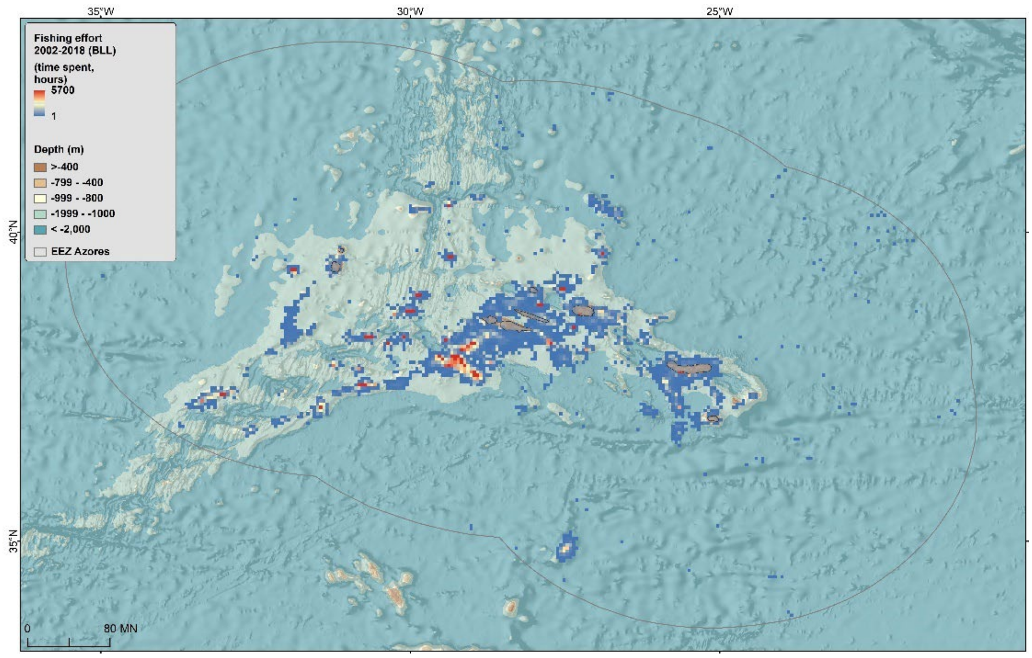

Figure 2.8. Bottom longline fishing in the EEZ of the Azores expressed as a logarithmic index of effort within the fishing footprint at 5 km resolution, based on the analyses of VMS data.

After cleaning the VMS database, the derived speed, heading and change in angle were calculated based on the geographic positions of consecutive pings and used for subsequent analysis. The calculated variables better represent the behaviour of fishing vessels over the time between pings than the instantaneous values provided in the original VMS data. From the VMS pings, a new trip was identified if: i) the vessel was in the harbour (i.e., within a distance inferior or equal to 1.5 nm from a harbour), and at a calculated speed less than or equal to harbour speed (set to 0.5 knots), but the speed of the next ping was greater than the harbour speed, or if ii) the time difference between two consecutive pings was greater than 90 hours, and the next ping was out-side of a harbour (i.e. further than 1.5 nm). A new leg was considered when the angle change between two consecutive calculated headings was superior to 50°, and the vessel was outside the harbour (distance > 1.5 nm from any harbour). Heuristic methods to define the fishing vessels state at any given time using specific rules for speed, course, leg, angle, and distance to harbour were used. The preliminary results have been validated with a quasi-Bayesian approach. Fishing effort was estimated as the sum of the time difference between pings associated with the fishing state (Figure 2.8).

2.1.7 Existing Regulations

Fisheries regulations

As with all EU Member States, the Azores Autonomous Region of Portugal is subject to a broad suite of international and national policies, laws and agreements controlling many sectors such as fisheries, energy and conservation. Consequently, there are many organizations and administrative bodies responsible for managing marine affairs. The current fishery resource manage-ment strategy of the Azores is based on the EU Common Fishery Policy, implemented primarily through TACs for various species including Blackspot Seabream, alfonsinos, and deep-water sharks (EC Reg. 2340/2002; EC Reg. 2270/2004). For deep-water sharks, a zero TAC has been im-plemented since 2010 for 13 taxa (EC Reg. 1359/2008), and since 2018 it was turned into a fishing prohibition (EC Reg 2018/2025). A zero TAC has also been implemented for Orange Roughy (*Hoplostethus atlanticus*), and since 2017 the species has also been declared “prohibited species”. Fishing prohibition implies that under the European Landing Obligation (LO), all catch must be discarded (EC Reg 1380/2013).

Apart from fish quotas, the regional government of the Azores has implemented technical measures over the years, such as minimum landing sizes or weights, minimum hook and mesh sizes, limitation of licences for some specific gears (e.g., trammel nets), area temporal or perma-nent closures, and bans on the use of specific gear. The impact of fishing activities on benthic ecosystems has been a particular concern in the Azores, and bottom trawling and deep-sea net-ting are forbidden around the Azores since 2005 (European Council Regulation [EC] No. 1568/2005 of 20 September 2005; Santos *et al*. 2009). Further protection of the deep sea throughout the Azores region was added in 2014 by the creation of an extensive fishery management area that encompasses most of the Portuguese extended continental shelf where bottom-trawling is banned, and by setting move-on rules for the incidental capture (bycatch) of corals and sponges (Portaria 114/2014). Also, a 100-mile distant polygon around the islands limiting the fishing to vessels registered in the Azores was created in 2003 (EC Reg. 1954/2003) and revised in 2013 (EC 1380/2013) and in place until December 2022. Figure 2.9 shows the areas subject to the bottom fishing regulations.

Other spatio-temporal limitations applying to the bottom longline and handline fishery include a seasonal fishing closure for Blackspot Seabream. This closure has been implemented in one to two winter months in January and/or February from 2015 to 2017 (Portaria 74/2015, Portaria 88/2016, Portaria 13/2017) and was amended in 2017. Spatial fishing restrictions relative to gear type have also been implemented for bottom longliners and handliners: i) longliners are not allowed to fish within 3 nm from shore, ii) longliners may only fish from 3 to 6 nm from shore in São Miguel and Terceira but only for the vessels registered in those islands or having them as home ports, while in the other islands such allowance was only given in some period, and iii) for handliners, vessels ≤ 14 m are not allowed within 1 nm from the coast, this limit is set to 3 nm for the vessels > 14 m, and 30 nm for vessels > 24 m (Reg Portaria 50/2012).

Since 2020, several regional TACs where implemented by the Regional Government for several species, including deep-sea species such as *Phycis phycis*, *Helicolenus dactylopterus*, *Pontinus kuhlii*, *Chaceon affinis*, *Conger conger*, *Mora moro*, and *Raja clavata* (Portaria n.º 92/2019 de 30 de dezembro de 2019).

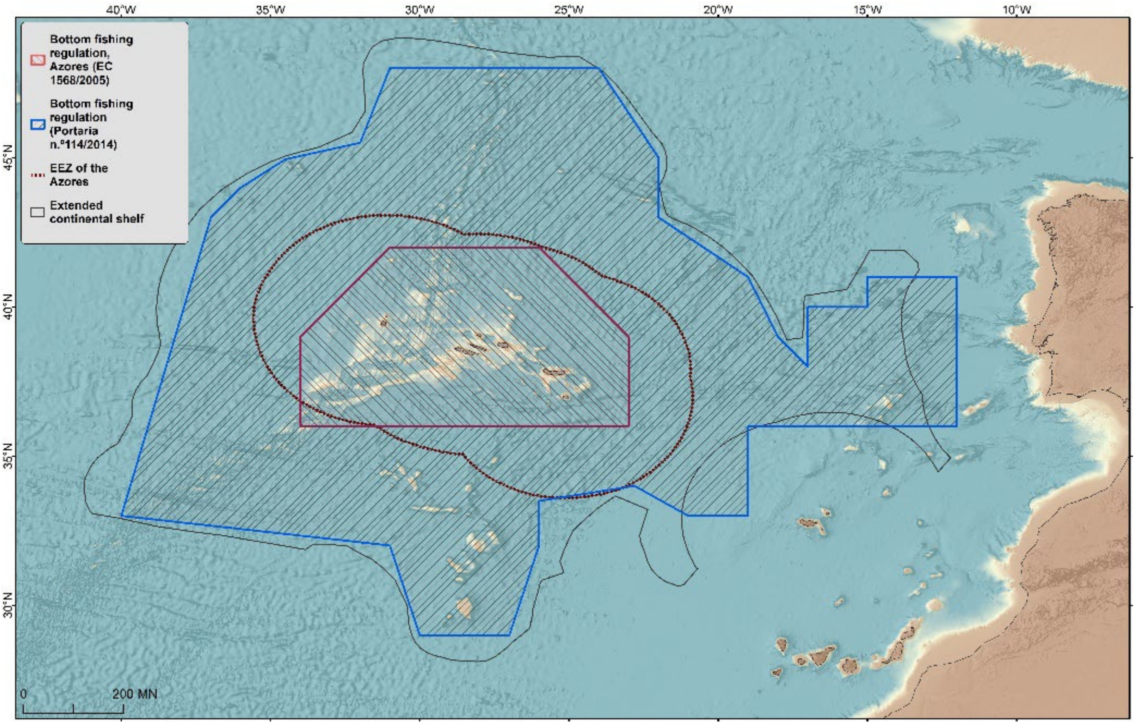

Figure 2.9. Bottom trawling and deep-sea netting are forbidden around the Azores since 2005 (European Council Regulation [EC] No. 1568/2005 of 20 September 2005 and Portaria 114/2014).

Existing conservation regulations

There has been a long history of marine conservation in the Azores (see Abecassis *et al*. 2015) that started back in the 1980s with the establishment of six coastal MPAs and one offshore marine reserve encompassing the Formigas islets and Dollabarat reef, that imposed fishing limitations to promote the sustainable use of marine resources (Martins & Santos 1988, Santos *et al*. 1995). In the 1990s, the Azores was highly involved in the implementation of many EU-driven initiatives, namely the EU Habitats and Birds Directives that supported the creation of the Natura 2000 network of MPAs. During this period several research projects, led by the University of the Azores and in close collaboration with the Regional Government, helped to gather baseline information for the establishment MPAs in the Azores (Abecassis *et al*. 2015) and the identification of many sites of community importance (SCIs), and special areas of conservations (SACs). During the 2000’s a joint effort between the Regional Government of the Azores and the University of the Azores resulted in eleven applications of sites to be included in the OSPAR network of MPAs: seven within national waters and four outside national jurisdiction but within the limits of the areas proposed for legal continental shelf extension that Portugal submitted to the United Nations Commission on the Limits of the Continental Shelf. This made Portugal, and particularly the Azores, a pioneer in the protection of marine biodiversity at an international level (Ribeiro 2010) and a progressive player that helped to progress the ground-breaking OSPAR high seas

MPAs process (Abecassis *et al*. 2015). Many of these MPAs applications were supported by the presence of priority habitats (cold-water gardens and reefs, sponge aggregations, hydrothermal vent fields), and species (Orange Roughy). In the late 2000s, the UNESCO approved the applications submitted to the Man and Biosphere Program, recognizing the islands of Corvo, Flores and Graciosa and their surrounding marine environment as Biosphere Reserves.

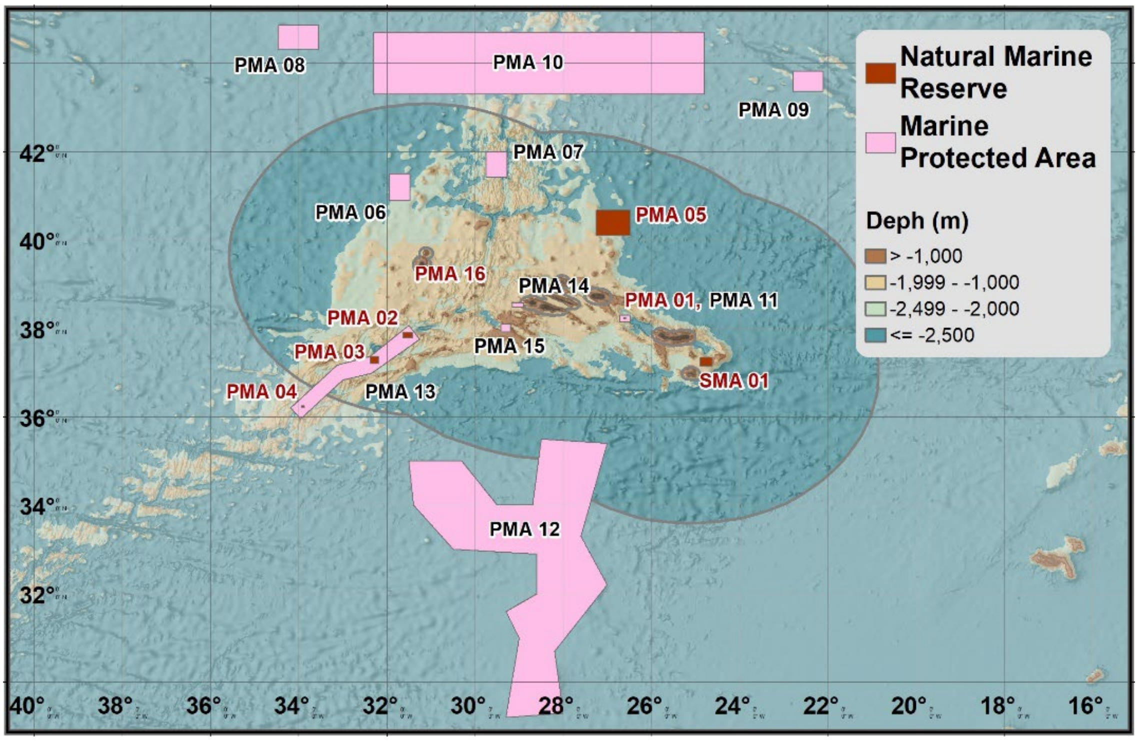

Figure 2.10. The existing network of the marine protected areas relevant for biodiversity management and conservation in the deep-sea of the Azores. Five hydrothermal vent sites, Banco Dom João de Castro (PMA01), Menez Gwen (PMA02), Lucky Strike (PMA03), Rainbow (PMA04), and Luso hydrothermal (PMA16); six seamounts, Sedlo (PMA05), Altair (PMA08), Antialtair (PMA09), Banco Dom João de Castro (PMA11), Condor (PMA14) and Princesa Alice (PMA15); two offshore areas, the Corvo Oceanic MPA (PMA06) and the Faial Oceanic MPA (PMA07); three extensive areas in the Mid-Atlantic Ridge South (PMA13) and north (PMA10) of the Azores (MARNA), and the Meteor Submarine Archipelago (PMA12); and the Formigas islet (SMA01).

More recently, the Azores Network of Marine Protected Areas was set up by the regulation "Decreto Legislativo Regional nº 15/2007/A" with the overall objective to protect and restore biodiversity and habitats, particularly in the deep sea, that have been negatively affected by human activities, or might be negatively affected in the future. The Azores Network of Marine Protected Areas includes the Island Natural Park within the territorial waters (12 nm) and the Azores Marine Park beyond territorial waters. The network of protected areas declared in the Azores Marine Park is the main instrument for marine biodiversity conservation in the deep-sea beyond territorial waters (12 nm). It is coordinated by the Regional Directorate for Maritime Affairs (DRAM) together with an advisory council. Eleven MPAs were included in the Azores Marine Park in 2011 (DLR n.º 28/2011/A), while the MPA of the Meteor Submarine Archipelago (PM12), seamounts Condor and Princesa Alice (PM14 and PM15, respectively) and a large area in the Mid Atlantic Ridge southwest of Flores were included in 2016 (DLR n.º 13/2016/A). With the 2016 update defined in the regulatory decree-law nº 13/2016/A and 2019 addition of the Luso hydrothermal vent field defined in the Portaria nº 68/2019, the Azores Marine Park is now composed of 16 Marine Protected Areas, covering an area of 135,507 km² both within and partially beyond the Portuguese EEZ (Figure 2.10):

- Five hydrothermal vent sites: Banco Dom João de Castro, Menez Gwen Hydrothermal Field, Lucky Strike Hydrothermal Field, Rainbow Hydrothermal Field, and Luso hydrothermal vent field;
- Six seamounts; Sedlo, Altair, Antialtair, Banco Dom João de Castro, Condor and Princesa Alice;
- Two offshore areas of importance for seabirds; the Corvo Oceanic MPA and the Faial Oceanic MPA;
- Three extensive areas in the Mid-Atlantic Ridge South and the Mid-Atlantic Ridge north of the Azores (MARNA), and the Meteor Submarine Archipelago, South of the Azores.

In addition to these areas, the Marine Reserve of the Formigas islets regulated under the Santa Maria Island Natural Park (Decreto Legislativo Regional n.º 39/2012/A), is also a relevant MPA for marine biodiversity conservation in the deep sea.

The seamounts and hydrothermal vents mentioned above are also listed under the OSPAR network of MPAs (OSPAR 2017), aimed at protecting the biodiversity of the waters superjacent to the seabed. More recently, the axial valley and ridge crests of the Mid-Atlantic Ridge, from the Menez Gwen hydrothermal vent field area to the Haynes fracture zone, was described as an area meeting the criteria for Ecologically or Biologically Significant marine Areas (CBD 2022, COP 15/25). This area, named as Ridge South of the Azores, overlaps with the PMA13 and includes all known active hydrothermal vents in the southern part of the MAR in the Azores EEZ. The Meteor submarine Archipelago has also been accepted as an EBSA (CBD 2022, COP 15/25).

2.1.8 List of deep-sea fish species for the Azores

Species	FAO Code	Name in Country / Local Name	Depth (m)	Average Catch (10y) (t)	% Total Demersal Catch	IUCN Status
Pagellus bogaraveo	SBR	Goraz	30 - 763 m	462.21	18.0	Near Threatened
Lepidopus caudatus	SFS	Peixe-espada-branco	100 - 620 m; 41 - 731 m (Menezes 2003)	423.10	16.4	Data Deficient
Conger conger	COE	Congro	0 - 1171 m; 30 - 837 m (Menezes 2003)	379.78	14.8	Least Concern
Helicolenus dactylopterus		Boca-negra	50 - 1100 m; 98 - 1085 m (Menezes 2003)	226.13	8.8	
Phycis phycis	FOR	Abrótea	13 - 614 m; 25 - 573 m (Menezes 2003)	191.57	7.4	Least Concern
Beryx splendens	BYS	Alfonsim	25 - 1300 m; 140 - 786 m (Menezes 2003)	137.89	5.4	Least Concern
Polyprion americanus	WRF	Cherne	40 - 600 m; 162 - 679 m (Menezes 2003)	115.91	4.5	Data Deficient
Raja (Raja) clavata		Raia	20 - 210 AZ (577 m); 25 - 563 m (Menezes 2003)	101.02	3.9	
Mora moro	RIB	Melga	450 - 2500 m; 423 - 1275 m (Menezes 2003)	71.05	2.8	Least Concern
Dalatias licha	SCK	Gata-lixa	37 - 1800 m; 178 - 805 m (Menezes 2003)	70.68	2.7	Vulnerable
Centrophorus squamosus	GUQ	Xara-branca	145 - 2400 m; 652 - 1164 m (Menezes 2003)	57.65	2.2	Endangered
Centrophorus granulosus	GUP	Barroso	100 - 1200 m; 598 - 1047 m (Menezes 2003)	50.29	2.0	Endangered
Galeorhinus galeus	GAG	Cação	0 - 1100 m; 25 - 574 m (Menezes 2003)	49.02	1.9	Critically Endangered
Pontinus kuhlii	POI	Bagre	100 - 600 m; 74 - 626 m (Menezes 2003)	42.90	1.7	Data Deficient
Aphanopus carbo	BSF	Peixe-espada-preto	200 - 1700 m; 652 - 1176 m (Menezes 2003)	31.32	1.2	Least Concern
Beryx decadactylus	BXD	Imperador	180 - 800 m; 224 - 852 m (Menezes 2003)	28.51	1.1	Least Concern
Deania calcea		Sapata Branca	60 - 1490 m; 423 - 1275 m (Menezes 2003)	18.01	0.7	Near Threatened
Etmopterus spinax	ETX	Lixinha-da-fundura	2490 m; 251 - 1185 m (Menezes 2003)	17.33	0.7	Vulnerable
Dipturus batis	RJB	Raia-manteiga	201 - 717 m (Menezes 2003)	15.76	0.6	Critically Endangered
Deania profundorum	SDU	Sapata-áspera	205 - 1800 m; 411 - 1135 m (Menezes 2003)	14.01	0.5	Near Threatened
Molva macrophthalma	SLI	Pescada-dos-Açores	30 - 754 m; 324 - 780 m (Menezes 2003)	13.02	0.5	Least Concern
Hexanchus griseus	SBL	Albafar	0 - 2307 m	12.19	0.5	Near Threatened
Phycis blennoides	GFB	Juliana	10 - 1047 m; 123 - 952 m (Menezes 2003)	7.88	0.3	

Species	FAO Code	Name in Country / Local Name	Depth (m)	Average Catch (10y) (t)	% Total Demersal Catch	IUCN Status
Raja (Raja) brachyura		Raia-pontuada	10 - 380 m	6.00	0.2	
Nezumia aequalis	NZA	Rato-redondo	200 - 2320 m; 227 - 629 m (Menezes 2003)	5.47	0.2	Least Concern
Epigonus telescopus	EPI	Escamuda	75 - 1200 m; 417 - 1014 m (Menezes 2003)	4.62	0.2	Least Concern
Lophius piscatorius	MON	Tamboril	20 - 1000 m; 80 - 619 m (Menezes 2003)	3.26	0.1	Least Concern
Schedophilus ovalis	HDV	Choupa	70 - 700 m; 149 - 446 m (Menezes 2003)	2.91	0.1	
Etmopterus pusillus	ETP	Lixinha-da-fundura	0 - 1070 m; 206 - 1164 m (Menezes 2003)	2.18	0.1	Least Concern
Ruvettus pretiosus	OIL	Escolar	100 - 800 m; 326 - 423 m (Menezes 2003)	1.70	0.1	Least Concern
Magnisudis atlantica	MNL	Rato-bicudo	0 - 2166 m	1.38	0.1	Least Concern
Leucoraja fullonica	RJF	Raia-pregada	30 - 550 m; 255 - 555 m (Menezes 2003)	1.33	0.1	Vulnerable
Coelorinchus caelorhincus	CQL	Rato-bicudo	200-500 m	1.25	0.0	Least Concern
Dipturus oxyrinchus	RJO		715 (Menezes 2003)	0.56	0.0	Near Threatened
Brama brama	POA	Xaputas	0 - 1000 m	0.56	0.0	Least Concern
Lepidocybium flavobrunneum	LEC	Peixe-chocolate	200 - 885 m	0.54	0.0	Least Concern
Lepidorhombus whiffiagonis	MEG	Areeiro	100 - 700 m; 414 - 582 m (Menezes 2003)	0.48	0.0	Least Concern
Aulopus filamentosus	ULF	Lagarto-do-mar	50 - 1000 m; 172 - 262 m (Menezes 2003)	0.45	0.0	Least Concern
Centracanthus cirrus	EHI	Boqueirão	464 m	0.44	0.0	Least Concern
Acantholabrus palloni	AKL	Bodião-do-alto	180; 116 - 173 m (Menezes 2003)	0.23	0.0	Least Concern
Lepidion eques	LPS		127 - 1850 m; 928 - 955 m (Menezes 2003)	0.22	0.0	Data Deficient
Polymixia nobilis	PXV	Salmonete-do-alto	100 - 770 m	0.15	0.0	Least Concern
Heptranchias perlo	HXT	Bico-doce	0 - 1000 m; 175 - 428 m (Menezes 2003)	0.12	0.0	Near Threatened
Alepocephalus rostratus	PHO	Celindra	300 - 2250 m; 731 - 1170 m (Menezes 2003)	0.12	0.0	Least Concern
Synaphobranchus kaupii	SSK	Congrinho	120 - 4800 m; 423 - 1275 m (Menezes 2003)	0.11	0.0	Least Concern
Promethichthys prometheus	PRP	Peixe-coelho	80 - 800 m	0.10	0.0	Least Concern
Setarches guentheri	SVG		150 - 732 m	0.07	0.0	Least Concern
Hoplostethus atlanticus	ORY	Peixe-relógio	180 - 1809 m	0.06	0.0	
Lepidion guentheri	LPH	Periquito	910 - 1166 m (Menezes 2003)	0.03	0.0	Least Concern

Species	FAO Code	Name in Country / Local Name	Depth (m)	Average Catch (10y) (t)	% Total Demersal Catch	IUCN Status
Centroscymnus crepidater		Sapata-preta	230 - 1500 m; 918 - 1182 m (Menezes 2003)	0.01	0.0	
Coryphaenoides rupestris	RNG	Peixe-rato	180 - 2200 m	0.00	0.0	Critically Endangered
Gephyroberyx darwinii	GXW	Peixe-vidro	300 - 1210 m	0.00	0.0	Least Concern

2.1.9 List of VME Indicator Species for the Azores

Assessment of representative taxa against the criteria for defining what constitutes a Vulnerable Marine Ecosystem (FAO 2009) in the Azores. 'X' means direct evidence fitting to the criteria, '(X)' is inferred from the literature on other species; '?' means no information available; and blank cells for species/genera means that the criterion was not met. Several species were assessed by the WGDEC in 2020 (Table 7.3 of ICES 2020). New representative species proposed by the Azores Deep Sea Research Group based on information collected during recent field campaigns are marked in red and were approved by WKOUTVME. § Presence only confirmed in the Great Meteor complex and in the Azores (Grasshoff 1977, Braga-Henriques *et al*. 2013) but suspected in the Canary Islands.

VME Habitat Sub-type	VME Representative Taxa	Uniqueness	Functional Significance	Fragility	Life History	Structural Complexity
Cold-water coral reef	*Lophelia pertusa* [*Desmophyllum pertusum*]		X	X	X	X
	Madrepora oculata		X	X	X	X
Hard bottom coral garden: Colonial scleractinians on rocky outcrops	*Solenosmilia variabilis*		X	X	X	X
Hard bottom coral garden: Hard bottom gorgonian and black coral gardens	PARAMURICEIDAE					
	Acanthogorgia armata		(X)	X	?	X
	Acanthogorgia hirsuta		(X)	X	?	X
	Dentomuricea	X§	X	X	X	X
	Paramuricea spp.		(X)	X	(X)	X
	Placogorgia spp.*		(X)	X	(X)	X

VME Habitat Sub-type	VME Representative Taxa	Uniqueness	Functional Significance	Fragility	Life History	Structural Complexity
	CORALLIIDAE					
	Paragorgia johnsoni		(X)	X	(X)	X
	Hemicorallium niobe		(X)	X	(X)	X
	Hemicorallium tricolor					
	Pleurocorallium johnsoni		(X)	X	(X)	X
	ELLISELLIDAE					
	Viminella flagellum		X	X	X	X
	PRIMNOIDAE					
	Paracalyptrophora josephinae		X	X	(X)	X
	Narella bellissima		(X)	X	?	X
	Narella versluyzi		(X)	X	?	X
	Eunicella modesta		(X)	X	(X)	X
	Candidella imbricata		(X)	X	(X)	X
	CHRYSOGORGIIDAE					
	Chrysogorgia spp.		X	(X)	X	X
	Iridogorgia spp.		X	(X)	(X)	X
	Metallogorgia spp.		X	(X)	(X)	X
	KERATOISIDIDAE					

VME Habitat Sub-type	VME Representative Taxa	Uniqueness	Functional Significance	Fragility	Life History	Structural Complexity
	Acanella arbuscula		X	(X)	X	X
	Keratoisididae clades *J1, D2*		X	(X)	X	X
Black corals	ANTIPATHARIA					
	*Antipathella wollastoni**	X	X	X	X	X
	*Antipathella subpinnata**	X	X	X	X	X
	Bathypathes spp.	X	X	X	X	X
	Dendrobatypathes sp.*	X	X	X	X	X
	*Elatopathes abietina**	X	X	X	X	X
	Leiopathes spp.	X	X	X	X	X
	Phanopathes erinaceus *	X	X	X	X	X
	Parantipathes hirondellae	X	X	X	X	X
	*Stauropathes punctata**	X	X	X	X	X
	Stychopathes gravieri	X	X	X	X	X
	*Tanacetipathes squamosa**	X	X	X	X	X
	Tylopathes sp.*	X	X	X	X	X
	DENDROPHYLLIIDAE					
	Dendrophyllia cornigera		X	X	?	X
	Dendrophyllia ramea		X	X	X	X

VME Habitat Sub-type	VME Representative Taxa	Uniqueness	Functional Significance	Fragility	Life History	Structural Complexity
	*Dendrophyllia alternata**		X	X	?	X
	Enallopsammia rostrata		X	X	?	X
Soft bottom coral garden: Non-reefal scleractinian aggregations	DENDROPHYLLIIDAE					
	Eguchipsammia sp.		(X)	X	?	X
Hard bottom coral garden: Stylasterid corals on hard substrata	STYLASTERIDAE					
	Errina dabneyi	X	(X)	X	X	X
	*Errina atlantica**		(X)	X	X	X
Sponge grounds						
DEMOSPONGIAE						
GEODIIDAE	*Geodia phlegraei*		X	(X)	C	X
	Geodia hentscheli		X	X	(X)	X
	Geodia parva		X	X	(X)	X
	*Geodia megastrella**		X	(X)	X	X
PACHASTRELLIDAE	*Characella* spp.*		X	(X)	X	X
	Pachastrella spp.*		X	(X)	X	X
AZORICIDAE	*Leiodermatium spp.*		X	X		X
CORALLISTIDAE	*Neophrissospongia nolitangere*		X	X	(X)	X
	Neoschrammeniella spp.		X	X	(X)	X

VME Habitat Sub-type	VME Representative Taxa	Uniqueness	Functional Significance	Fragility	Life History	Structural Complexity
MACANDREWIIDAE	*Macandrewia* spp.			X	(X)	X
TETILLIDAE	*Tetilla longipilis*			X		X
BUBARIDAE	*Phakellia* spp.		X	X		X
PETROSIIDAE	*Petrosia* spp.		X	X		X
CHALINIDAE	*Haliclona* spp.*	X	X	X	(X)	X
HEXACTINELLIDA	*Hyalonema* spp.	X		X	(X)	X
HYALONEMATIDAE		(X)	X	X	X	X
EUPLECTELLIDAE	*Regadrella* spp.*	X	X	X	X	X
EURETIDAE	*Chonelasma* spp.*	X		X	(X)	X
ROSSELLIDAE	*Asconema setubalense*	X		X	(X)	X
	Asconema foliatum		X	X	(X)	X
	*Asconema fristedti**	X	X	X	(X)	X
PHERONEMATIDAE	*Pheronema carpenteri*					
Xenophyophore aggregations						
SYRINGAMMINIDAE	*Syringammina fragilissima*		X	X	?	X
Hydrothermal vents/fields	KADOSACTINIDAE					
	Maractis rimicarivora	X	X	X	(X)	X
	MYTILIDAE					

VME Habitat Sub-type	VME Representative Taxa	Uniqueness	Functional Significance	Fragility	Life History	Structural Complexity
	Bathymodiolus sp.	X	X	X	(X)	X
	Bathymodiolus azoricus	X	X	X	(X)	X
	ALVINOCARIDAE					
	Rimicaris exoculata	X	X	X	(X)	X
	Chorocaris chacei	X	X	X	(X)	X
	Mirocaris fortunata	X	X	X	(X)	X
	BYTHOGRAEIDAE					
	Segonzacia mesatlantica	X	X	X	(X)	
	BYTHITIDAE					
	Cataetyx laticeps		X	X	(X)	
	ZOARCIDAE					
	Pachycara sp.	X	X	X	(X)	

2.1.10 Metadata of relevant data sources available for the Azores

Type	Data Source	Data Description	Data Format	Native Resolution	Collection Date(s)	Data Publicly Available?	Contact for Data if not Public
Geomorphology	Geomorphologic units in the Azores	Identification of the main management units of the Azores, including individual peaks, seamounts, ridges or slopes	.shp	na	2015-2024	2025	Telmo Morato
Geomorphology	Habitat classification of the Azores deep-sea	Habitat classification of the Azores deep-sea using a new r-script developed by Gerald Taranto (submitted) and a new DTM	.shp file, .tiff file, UTM 26 N	100m	2015-2024	2025	Gerald Taranto
Geomorphology	Substrate annotation	The type of substrate was visually evaluated along the whole length of the video transect, annotating the sections where each substrate is dominant: Mud, Sand, Gravels, Cobbles and pebbles, Boulders, Flat rock, Outcropping rock, Vertical walls, Coral rubble, Coral framework, Lava flows, and Mineral deposits	.csv	na	2018-2023	2025	Gerald Taranto
VME Elements	Seamounts 2008	This geographic information related to the abundance and distribution of seamounts of the Azores. A total of 63 large and 398 small seamount-like features are mapped and described in the Azorean EEZ. The distribution of seamount extracted from this source published in 2008 predicts that about 57% of the potential Azores seamounts lie in the zone protected from deep-water trawling by European	.csv		2008	Morato *et al*. 2008.	

Type	Data Source	Data Description	Data Format	Native Resolution	Collection Date(s)	Data Publicly Available?	Contact for Data if not Public
		Commission Council Regulation No. 1568/2005					
VME Elements	Seamounts 2013	This work aims at characterising the seamount physiography and biology in the OSPAR Convention limits (north-east Atlantic Ocean) and Mediterranean Sea.	.csv		2013	Morato *et al*. 2013.	
VME Elements	Geomorphology of the Oceans	Submarine Canyons	Vector (Shapefile, Polygon)	derived from 30 arc second resolution (~1km at equator)	2020	https://bluehabitats.org/ https://doi.org/10.1016/j.margeo.2014.01.011	
VME Elements	Canyons	The canyon geomorphic feature layer represents the spatial extent of the submarine canyons of the Azores region, based on interpretation of the SRTM30 plus v7 global bathymetry model.	.shp		2014	Harris *et al*. 2014	
VME Elements	GEBCO	Steep Flanks	Vector (Shapefile, Polygon)	15 arc second (~500m at equator)	2023	https://www.gebco.net/data_and_products/gridded_bathymetry_data/gebco_2023/	
VME Elements	InterRidge Global Database of Active Submarine Hydrothermal Vent Fields 3.4	Hydrothermal Vents	Vector (Shapefile, Polygon)	1 arc minute (~2km at equator)	2020	https://doi.pangaea.de/10.1594/PANGAEA.917894	
Habitat	EUNIS-classified habitat maps	Improve the EUNIS-classified habitat map for the deep-sea (below 200 m) of the Exclusive Economic Zone (EEZ) of the	.shp	na	2015-2023	2024	Luís Rodrigues

Type	Data Source	Data Description	Data Format	Native Resolution	Collection Date(s)	Data Publicly Available?	Contact for Data if not Public
		Azores using the best available bathymetry, as of February 2023.					
Science	Imagery surveys	Database of imagery surveys conducted in the Azores EEZ	.csv	na	2000-2023	2024	Telmo Morato
VME Indicators Biodiversity /models	CWC richness HSM	Cold water coral richness based on habitat suitability predictions. The .tiff file shows the number of taxa predicted as suitable for each raster cell. Note that only high confidence suitable cells of combined habitat suitability maps are considered.	.tiff	0.01°		https://doi.org/10.1594/PANGAEA.955223 ; https://doi.org/10.1016/j.dsr.2023.104028	Telmo Morato
VME Indicators Biodiversity /models	Individual CWC species HSM (13 spp.)	Combined habitat suitability maps. Suitable raster cells of combined habitat suitability maps were classified as follows: (i) high confidence suitable cell (3 in raster layers), raster cell predicted as suitable with high-confidence by both GAM and Maxent models; (ii) medium confidence suitable cell (2 in raster layers), raster cell predicted as suitable with medium or high confidence by GAM, Maxent or both and with a local fuzzy similarity greater than 0.5; (iii) low confidence suitable cell (1 in raster layers), any other cell predicted as suitable by GAM and/or Maxent.	.tiff	0.01°		https://doi.org/10.1594/PANGAEA.955223 ; https://doi.org/10.1016/j.dsr.2023.104028	Telmo Morato
Deep-Sea Fish Biodiversity /models	Deep-sea fish species richness	Generalized additive models (GAMs) were used to relate presence–absence data of eight	.tiff	0.0027°	1996-2011	https://doi.org/10.1016/j.dsr2.2016.01.004	Telmo Morato

Type	Data Source	Data Description	Data Format	Native Resolution	Collection Date(s)	Data Publicly Available?	Contact for Data if not Public
		economically-important fish species to environmental variables (depth, slope, aspect, substrate type, bottom temperature, salinity and oxygen saturation). We combined 13 years of catch data collected from systematic longline surveys performed across the region. Species richness is the number of species predict to occur in each grid cell.					
Deep-Sea Fish Biodiversity /models	Individual fish species occurrence HSM (8 spp)	GAMs were used to relate presence–absence data of eight economically-important fish species to environmental variables (depth, slope, aspect, substrate type, bottom temperature, salinity and oxygen saturation). We combined 13 years of catch data collected from systematic longline surveys performed across the region: *Phycis phycis / Abrotea, Beryx splendens / Alfonsim, Pontinus kuhlii / Bagre, Helicolenus dactylopterus / Boca negra, Pagellus bogaraveo / Goraz, Beryx decadactylus / Imperador, Pagrus pagrus / Pargo, Polyprion americanus / Cherne.*	.tiff	0.0027°	1996-2011	https://doi.org/10.1016/j.dsr2.2016.01.004	Telmo Morato
Deep-Sea Fish Biodiversity /models	Individual fish species abundance SDM (6 spp)	GAMS were used to model the abundance of six economically-important fish species to environmental variables (depth, slope, aspect, substrate type, bottom temperature, salinity and oxygen saturation). We	.tiff	0.0027°	1996-2011	https://doi.org/10.1016/j.dsr2.2016.01.004	Telmo Morato

Type	Data Source	Data Description	Data Format	Native Resolution	Collection Date(s)	Data Publicly Available?	Contact for Data if not Public
		combined 13 years of catch data collected from systematic longline surveys performed across the region: *Phycis phycis / Abrotea, Beryx splendens / Alfonsim, Pontinus kuhlii / Bagre, Helicolenus dactylopterus / Boca negra, Pagellus bogaraveo / Goraz, Beryx decadactylus / Imperador.*					
Deep-Sea Fish Biodiversity /models	Deep-sea sharks species richness	Species richness: This dataset contains the number pf species predicted to occur in each grid cell from binary maps of the predicted probability of presence (Pp) of 15 deep-water shark and rays species in a 1000-hook bottom longline fishing set (type LLA) in the Azores, using GAMs. *Raja clavata; Galeorhinus galeus; Dipturus batis; Leucoraja fullonica; Dalatias licha; Etmopterus spinax; Squaliolus laticaudus; Etmopterus pusillus; Deania profundorum; Deania calcea; Centrophorus squamosus; Centroscymnus owstonii; Centroscymnus crepidater; Centroscymnus coelolepis; Etmopterus princess*.	.tiff	0.012°	1996-2017	https://doi.org/10.1594/PANGAEA.940808 https://doi.org/10.1016/j.dsr.2022.103707	Telmo Morato
Deep-Sea Fish Biodiversity /models	Individual Deep-sea sharks species HSM (15 spp)	BinPresence_MSS: This dataset contains the binary maps of the predicted probability of presence (Pp) of 15 deep-water shark and rays species in a 1000-hook bottom longline fishing set (type	.tiff	0.012°	1996-2017	https://doi.org/10.1594/PANGAEA.940808 https://doi.org/10.1016/j.dsr.2022.103707	Telmo Morato

Type	Data Source	Data Description	Data Format	Native Resolution	Collection Date(s)	Data Publicly Available?	Contact for Data if not Public
		LLA) in the Azores, using GAMs. *Raja clavata; Galeorhinus galeus; Dipturus batis; Leucoraja fullonica; Dalatias licha; Etmopterus spinax; Squaliolus laticaudus; Etmopterus pusillus; Deania profundorum; Deania calcea; Centrophorus squamosus; Centroscymnus owstonii; Centroscymnus crepidater; Centroscymnus coelolepis; Etmopterus princess*.					
Biodiversity /observations	Operational Taxonomic deep-sea Units	Non-spatial database of the Operational Taxonomic Units known megafauna occurring in the Azores deep-sea	.csv	na		2025	Telmo Morato
Biodiversity /observations	Communities list	Non-spatial database of the visually classified benthic communities occurring in the Azores deep-sea	.csv	na		2025	Telmo Morato
Biodiversity /observations	Marine Biological Reference Collection (COLETA)	Database of deep-sea marine invertebrate fauna accidentally captured during fishing activities	.csv	na	1980-2023	not public (ongoing until 2025)	Marina Carreiro-Silva
VME Indicators Biodiversity /observations	Benthic megafauna L1 database	The database of the occurrence of benthic species observed in videos collected up to 1,000 m depth a spatial scale of approximately 1,000 m (videoAnnotationDB_L1)	.csv	na	2018-2023	not public (ongoing until 2025)	Telmo Morato
VME Indicators Biodiversity /observations	Benthic megafauna L2 database	The database of the occurrence of benthic species observed in videos collected up to 1,000 m depth (videoAnnotationDB_L2),	.csv	na	2018-2023	not public (ongoing until 2025)	Telmo Morato

Type	Data Source	Data Description	Data Format	Native Resolution	Collection Date(s)	Data Publicly Available?	Contact for Data if not Public
		assigning a SACFOR scale value to each OTU observed in the 100 m long segments					
VME Indicators Biodiversity /observations	Benthic megafauna L3 database	The database of the occurrence and abundance of benthic species observed in videos collected up to 1,000 m depth (videoAnnotationDB_L3)	.csv	na	2018-2023	not public (ongoing until 2025)	Telmo Morato
Biodiversity /observations	Benthic communities database	A structured and organized database (communitiesDB) with the occurrence of biological communities in the deep sea of the Azores	.csv	na	2018-2023	not public (ongoing until 2025)	Telmo Morato
Biodiversity /observations	Benthic communities	Operational Taxonomic Units identified in Formigas Seamount	Table	na	2017	Puerta *et al*. 2022	Covadonga Orejas
Fishing	Bottom longline and handline fishing effort from VMS	The bottom-fishing (longline plus handline) effort layer was computed from an analysis of the Vessel Monitoring System (VMS) for vessels licensed for bottom longline or handline fishing gears. The fishing licences granted to each vessel per year were used to allocate a gear type to all VMS pings. We acknowledge that not all boats operating in the spatial planning area (beyond 6 nm from island shores) have VMS systems installed. However, a quick comparison of the VMS outputs with the fishing effort maps obtained from fishers' inquiries (Diogo *et al*. 2015) revealed similar spatial patterns, but much more spatial	.tiff	5km	2002-2018	not public	Telmo Morato

Type	Data Source	Data Description	Data Format	Native Resolution	Collection Date(s)	Data Publicly Available?	Contact for Data if not Public
		detail when using the VMS data. In total, VMS data was obtained from 74 anonymous vessels over the period 2002-2018 with an average of 12 vessels per year. This number represents about 25% of the bottom longline fleet if considering an average of 52 vessels per year that declared landings using bottom longline.					
Fishing	Bottom longline and handline fishing effort from fishers inquiries	Fishing effort data were collected during the period of 1998–2012 as part of the mandate of the Data Collection Framework (DCF). Sampling was designed to cover the main ports of the archipelago and was performed by clerks who carried out standardized interviews (n=6253) with the captains of the bottom longline vessels on a daily basis during the landing period. The interviews provided information on fishing effort and fishing operation	na	10x10nm	1998–2012	Diogo *et al*. 2015	Hugo Diogo
Management	VME indicator assessment	Database containing the assessment of the OTUs against the 2009 FAO VME criteria	.csv	na	na	2025	Telmo Morato
Management	VMC assessment	Database containing the assessment of the deep-sea benthic communities against the 2009 FAO VME criteria	.csv	na	na	2025	Telmo Morato
Management	VME assessment L3	Database containing the assessment of the geomorphological	.shp	na	2018-2023	2025	Telmo Morato

Type	Data Source	Data Description	Data Format	Native Resolution	Collection Date(s)	Data Publicly Available?	Contact for Data if not Public
		units against the 2009 FAO VME criteria					
Management	VME assessment	Database containing the assessment of the OTUs against the 2009 FAO VME criteria	.csv	na	2017		Covadonga Orejas
Legal	Special requirements of bottom fishing activity in the Azores	This layer represents geographic information related to the geographic limits for the new requirements of the bottom fishing activity in the Azores.					
Legal	Fishing limits 100 nm	100 nautical miles polygon around the islands limiting the fishing to vessels registered in the Azores was created in 2003 (EC Reg. 1954/2003) and revised in 2013 (EC 1380/2013)					
Legal	Bottom trawl ban	Bottom trawling and deep-sea netting are forbidden around the Azores since 2005 (European Council Regulation [EC] No. 1568/2005 of 20 September 2005					
Legal	Marine Protected Areas	The existing network of the marine protected areas relevant for biodiversity management and conservation in the deep-sea of the Azores					

2.2 Madeira

Madeira is located ~700 km off the NW African coast; it forms a prominent NE trending submarine seamount complex in the central east Atlantic and is bounded by abyssal plains to the west and south, and by a number of large, isolated seamounts on its eastern side and the Madeira Islands to the southeast (Figure 2.11). Seamounts rise from ~5000 m water depth to as shallow as 25 m below sea level and represent prominent geomorphological features affecting the entire water column (Geldmacher *et al*. 2006). The area is covered by the Madeira–Tore EBSA (CBD 2023b) which covers pelagic waters through to lower bathyal depths and the Desertas EBSA (CBD 2023g) primarily designated for the protection of seabirds. The area includes a total of 17 seamounts (Ampere, Ashton, northern part of Coral Patch, Dragon, Erik, Gago Coutinho, Godzilla, Gorringe Bank - Ormond and Gettysburg seamounts, Hirondelle II, Josephine, Lion, Pico Pia, Tore, Seine, Sponge Bob and Unicorn).

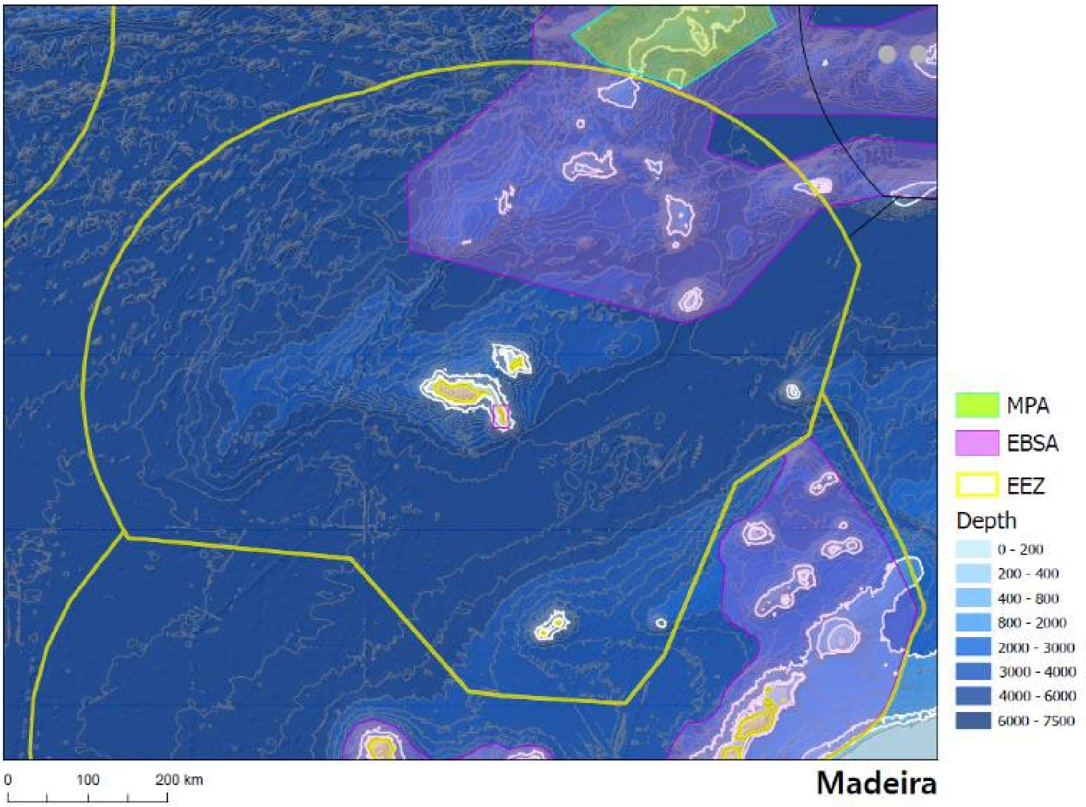

Figure 2.11. Map of Madeira showing the 400 m, 800 m and 2000 m depth contour (white) and the location of EBSAs within Portuguese Exclusive Economic Zone (EEZ).

2.2.1 VMEs likely to occur

In a recent study using underwater cameras in the Madeira archipelago at the Madeira-Desertas Ridge, Braga-Henriques *et al*. (2022) observed deep sea coral gardens and sponge grounds at depths ranging from ~175 m to ~375 m. The study noted that between 252 m and 366 m a mixed *Viminella flagellum* and *Pachastrella monilifera* sponge garden assemblage was characteristic of exposed rock slope covered by a layer of sediment. Such a habitat may represent important feeding and sheltering grounds for seamount fishes, potential shark nurseries, and thickets of habitat-forming scleractinian *Lophelia pertusa* [sic. *Desmophyllum pertusum*] (Etnoyer & Warrenchuk 2007). In addition, at depths of between 173 m – 252 m, occurring in areas dominated by exposed and sediment covered bedrock, the most characteristic and dominant species observed was the temperate alcyonacean gorgonian *Eunicella verrucosa* (Gorgoniidae) occurring with up to 12 colonies per 100 m^2.

Overall, the chain of 17 seamounts support a unique faunistic complex, including fauna of hard substrata inhabited sessile suspension feeders such as corals (e.g., *Antipathella wollastoni*, *A. sibpinnata*, *Antipathes furcata, Stichopathes gracilis*, *Leiopathes* spp.), sponges and associated fauna (Christiansen *et al*. 2009) with some taxa showing a high level of endemism. For example, 28 per cent of Demospongia reported from the Gorringe Bank are endemic to this feature or have a restricted geographical distribution (Xavier & van Soest 2007). Madeira-Tore includes various species of scleractinian and gorgonian corals (CBD 2023b). Dense gorgonian coral habitat-forming aggregations of *Callogorgia verticillata* and *Viminella flagellum*, have been reported may be important feeding and sheltering grounds for seamount fishes and also potential shark nurseries as observed elsewhere (CBD 2023b).

2.2.2 VME Elements

Steep flanks with slopes > 6.4° are prevalent in around Madeira (Figure 2.12). Seamounts and their bases are shown in Figure 2.13.

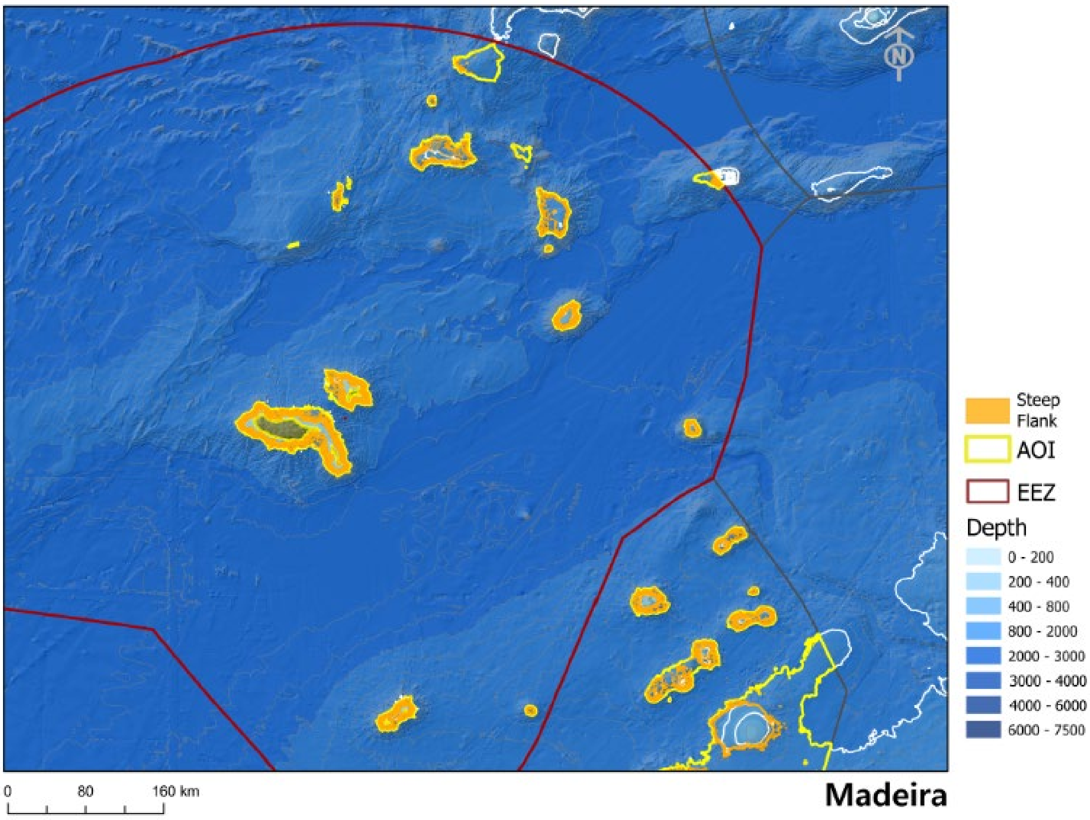

Figure 2.12. Map of Madeira showing the location of steep flanks with slopes > 6.4° within the area of interest (AIO) of waters < 2000 m depth within the Portuguese Exclusive Economic Zone (EEZ).

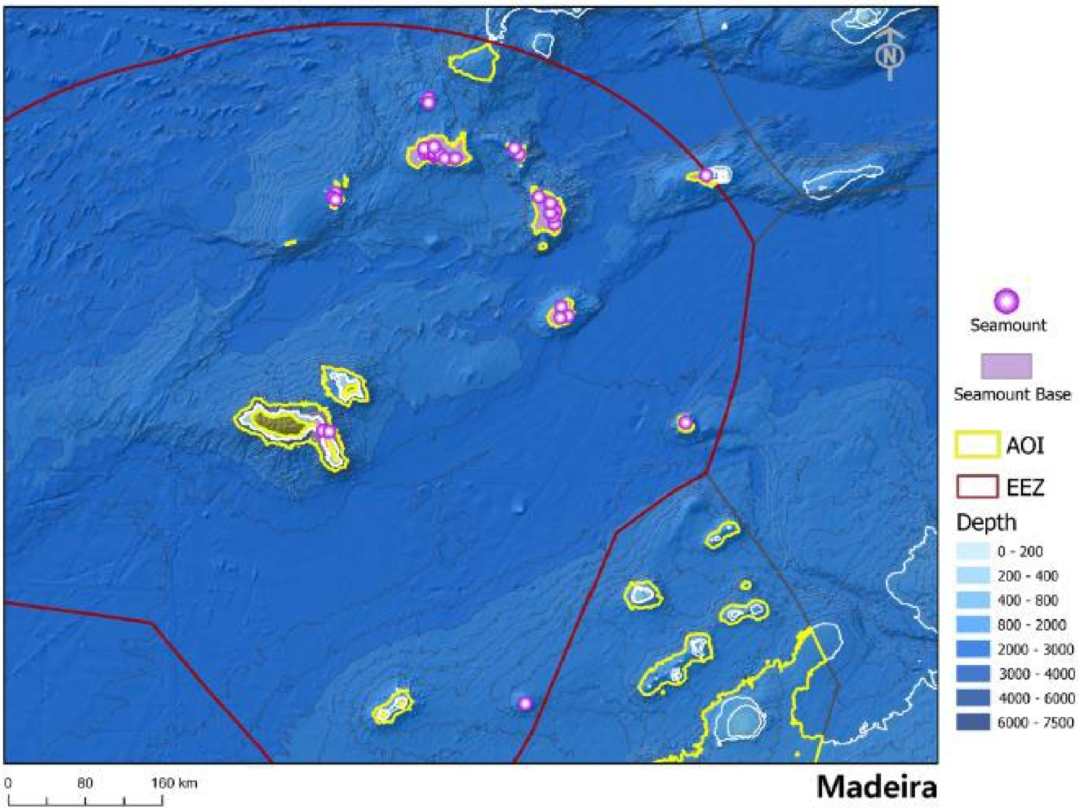

Figure 2.13. Map of Madeira showing the location of the seamounts and their bases within the area of interest (AIO) of waters < 2000 m depth within the Portuguese Exclusive Economic Zone (EEZ).

2.2.3 Overview of the local fisheries

In 2015, the Madeiran fishing fleet consisted of 434 vessels with 54% of those unpowered and 89% < 12 m LOA (Vallerani *et al*. 2017). Only 12 vessels were between 24 and 40 m long. The polyvalent small-scale segment of the fleet use passive gears to catch different species, while the larger vessels greater than 12 m mostly target deep-sea species using handlines. Black Scabbardfish (*Aphanopus carbo*) fishing is particularly important, as it represents around one third of the catches and almost half of the landed value. A large proportion of the catches are made with drifting longlines, at depths of between 800 and 1300 m.

Vallerani *et al*. (2017) report tunas (*Thunnus obesus*, *T. alalunga*, *Katsuwonus pelamis*), mackeral (*Scomber collas*, *Trachurus picturatus*), and limpets (*Patella aspera* and *P. candei*) as the main species caught in 2015, in addition to Black Scabbardfish. Experts from Madeira were not present at the meeting and so WKOUTVME was not able to assemble current information on the fish and fisheries of this region.

2.2.4 Deep-sea fishing activity in Madeira

The long-standing deep-sea fishery targets the sympatric Black and Intermediate Scabbardfish (*Aphanopus carbo* and *A. intermedius*) off the Madeira archipelago, with about 80% of the catch being Black Scabbardfish although this varies across fishing grounds (Delgado *et al*. 2018). Deep-water sharks are taken as bycatch. The fishery was traditionally concentrated mostly off the islands of Madeira and Porto Santo, but with the decline of catches, from 2005 the fleet expanded in the search for new fishing grounds both within the Madeira EEZ and in international waters (Delgado *et al*. 2018).

The fishing gear used by the Madeira deep-sea fleet is a drifting longline which is usually above the bottom, at depths between 800 and 1300 m (Morales-Nin & Sena-Carvalho 1996). The fishing gear used in this way does not contact the seafloor.

Data on fishing set positions as well as yields and fishing effort were collected from paper (2005–2012) and electronic logbooks (2013–2015), and sales notes from the Data Collection Framework database of the Regional Directorate of Fisheries of Madeira, and analyzed by Delgado *et al*. (2018). The authors have produced density plots illustrating the geographical distribution of the fishing sets in 2005, 2010 and 2015.

<u>Recommendation</u>: In the absence of more recent information, the lists of deep-sea fish species from the Azores and the Canary Islands could be used for Madeira.

2.2.5 List of VME Indicator Species for Madeira

Assessment of representative taxa against the criteria for defining what constitutes a Vulnerable Marine Ecosystem (FAO 2009) in Madeira. 'X' means direct evidence fitting to the criteria, '(X)' is inferred from the literature on other species; '?' means no information available. Several species were assessed by the WGDEC in 2020 (Table 7.3 of ICES 2020). Taxa were additional drawn from the publications cited in the text of Section 2.2. This list is incomplete due to lack of local knowledge at WKOUTVME.

	VME Representative Taxa	Functional Significance	Fragility	Life History	Structural Complexity
Cold-water coral reef	*Lophelia pertusa* [*Desmophyllum pertusum*]	X	X	X	X
Hard bottom coral garden: Hard bottom gorgonian and black coral gardens	ELLISELLIDAE				
	Viminella flagellum	X	X	X	X
	EUNICELLIDAE				
	Eunicella verrucosa	X	X	X	X
	PRIMNOIDAE				
	Callogorgia verticillata				
Black Corals	ANTIPATHARIA				
	Antipathella wollastoni	X	X	X	X
	Antipathella subpinnata	X	X	X	X
	Antipathes furcata	X	X	X	X
	Leiopathes spp.	X	X	X	X
	Stichopathes gracilis	X	X	X	X

	VME Representative Taxa	Functional Significance	Fragility	Life History	Structural Complexity
Hard bottom coral garden: Non-reefal scleractinian aggregations	*Dendrophyllia ramea*	X	X	?	X
Sponge grounds					
DEMOSPONGIAE					
ANCORINIDAE	*Ancorina* sp.	X	X	(X)	X
	Stryphnus mucronatus	X	X	(X)	X
GEODIIDAE	*Geodia geodina*	X	X	(X)	X
	Erylus euastrum	X	X	X	X
PACHASTRELLIDAE	*Pachastrella monilifera*	X	(X)	X	X
SUBERITIDAE	*Aaptos aaptos*	X	X	(X)	X
TETHYIDAE	*Tethya aurantium*	X	X	(X)	X

2.2.1 Metadata of relevant data sources available for Madeira

Type	Data Source	Data Description	Data Format	Native Resolution	Collection Date(s)	Data Publicly Available?
VME Indicators	Carvalho *et al*. 2014	Lithistid sponges	excel file			
VME Indicators	Braga Henriques *et al*. 2022	Madeira-Desertas Ridge benthic communities	point			
VME Elements	GEBCO	GEBCO grided bathymetric data	Raster (Geotiff)	15 arc second (~500m at equator)	2023	https://www.gebco.net/data_and_products/gridded_bathymetry_data/gebco_2023/
VME Elements	World Seamount Database	Seamounts	Vector (Shapefile, Point = Peak, Polygon = Base)	derived from 30 arc second resolution (~1km at equator)	2021	https://doi.pangaea.de/10.1594/PANGAEA.921688
VME Elements	GEBCO	Steep Flanks	Vector (Shapefile, Polygon)	15 arc second (~500m at equator)	2023	https://www.gebco.net/data_and_products/gridded_bathymetry_data/gebco_2023/
Fisheries	Delgado *et al*. 2018	Density plots of the deep sea fishing sets for scabbardfish from logbooks and sales data			2005, 2010 and 2015	https://doi.org/10.1016/j.rsma.2018.05.001

2.3 Canary Islands

The Canary Islands consist of volcanic islands and seamounts forming an island archipelago approximately 100 km west of the coast of Morocco, North Africa (Figure 2.14). They were created by magma-driven processes over tens of millions of years of continuous volcanism. The islands and seamounts appear with complex or simple morphologies, dome-shaped to irregular reliefs, and total heights ranging 4000-8000 m from the bottom to the highest island peak (Teide-Pico Viejo, Tenerife Island), but less than 3500 m (below sea-level) on seamounts.

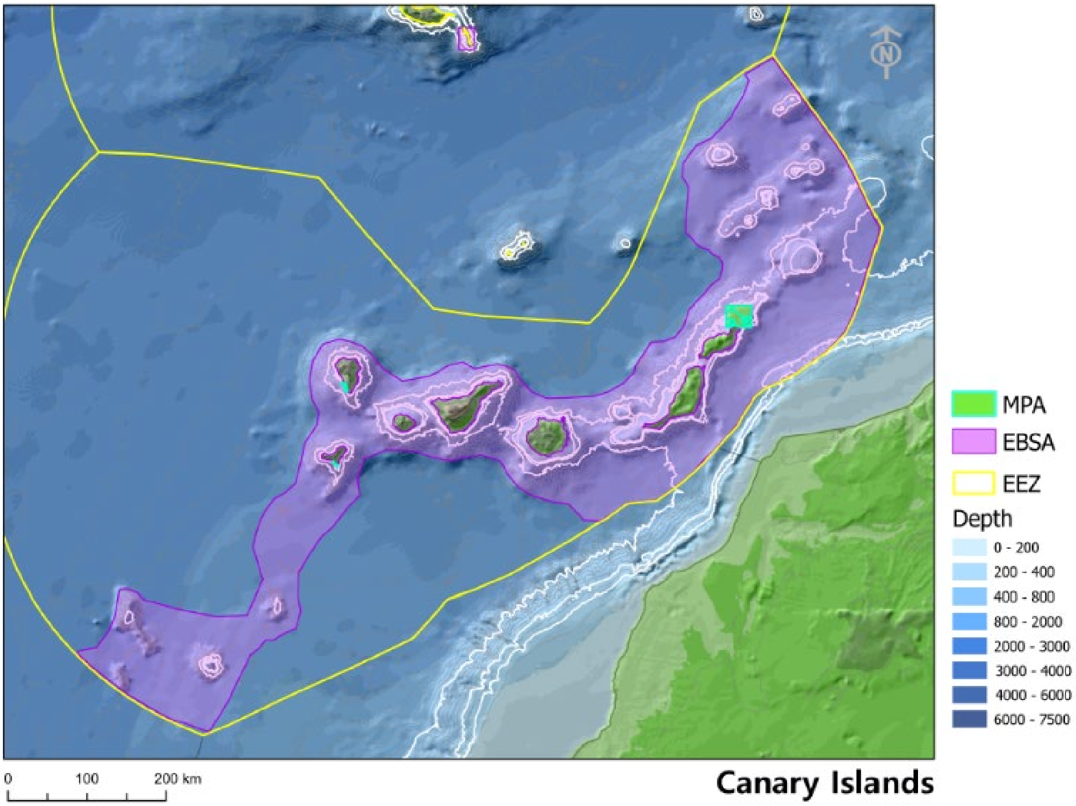

Figure 2.14. Map of the Canary Islands showing the 400 m, 800 m and 2000 m depth contour (white) and the location of the EBSAs within the Spanish Exclusive Economic Zone (EEZ).

2.3.1 VMEs known to occur

The mesophotic zone around the Canary Islands hosts dense populations of black corals which form true forests. These black coral forests (BCFs) have been recognized as VME habitats. BCFs around the island of Lanzarote are particularly large and dense, with a bathymetric range spanning between 50 and more than 100 m depth. In particular, the BCF situated near Puerto del Carmen is composed of three distinct species, with a well-defined vertical distribution: *Antipathella wollastoni* is the most abundant species between 50 and 70 m depth, while between 60 and 80 m depth, there is a high abundance of *Antipathes furcata* mixed with isolated whip coral (*Stichopathes gracilis*) colonies (Czechowska *et al*. 2020, Feldens *et al*. 2023). Then the *S. gracilis* extends from 80 to more than 100 m depth dominating marine animal forests mixed with sponges (*Axinella* spp.). In particular, this BCF deserves particular attention because it has been recently declared as BCF “Km 0” by the International Committee of the Global Biological Corridor.

However, due to logistic and technical limitations, scientific studies have focused only on the 50-70 m depth zone. BCF are unique and vulnerable habitats, which also promote a high level of associated biodiversity (i.e. biodiversity hosted in the BCF) (Bosch *et al*. 2023, Navarro-Mayoral *et al*. 2024). However, due to the depth at which black corals live, data are still missing on the spatial distribution, the ecological functioning (e.g. biodiversity richness, provision of food and shelter, nutrient recycling, etc.) and services (e.g. life cycle maintenance, regulatory or recreational activities) of these habitats in the Canary Islands.

2.3.2 VMEs likely to occur

In the bathyal zone, corals (Antipatharia) and large hexactinellid sponges (*Asconema* sp.) are frequently observed on different substrates (rocky, soft and mixed sediments). Other important habitats and communities present are gorgonian forests comprising *Callogorgia verticillata* and *Narella bellissima* species and accompanied by high densities of *Bebryce mollis* and *Eunicella verrucosa*, as well as *Pheronema carpenteri* and *Paramuricea biscaya* on rocky bottoms between 500 and 1500 m. At the same depth range, siliceous sponges occur on rocky substrates covered by sediments along with the anthozoan *Viminella flagellum*. *Corallium niobe* and *Corallium tricolor* are found on rocky substrate between 500 and 1600 m depth. Cold-water corals (Scleractinia), such as *Dendrophyllia cornigera* and *Phakellia ventilabrum*, can be found in the rocky reefs of the lower part of the continental shelf and upper area of the slope. At depths between 1300 and 1700 m coral reefs of *Lophelia pertusa* [*Desmophyllum pertusum*], *Madrepora oculata* and *Solenosmilia variabilis* can be found (CBD 2023a).

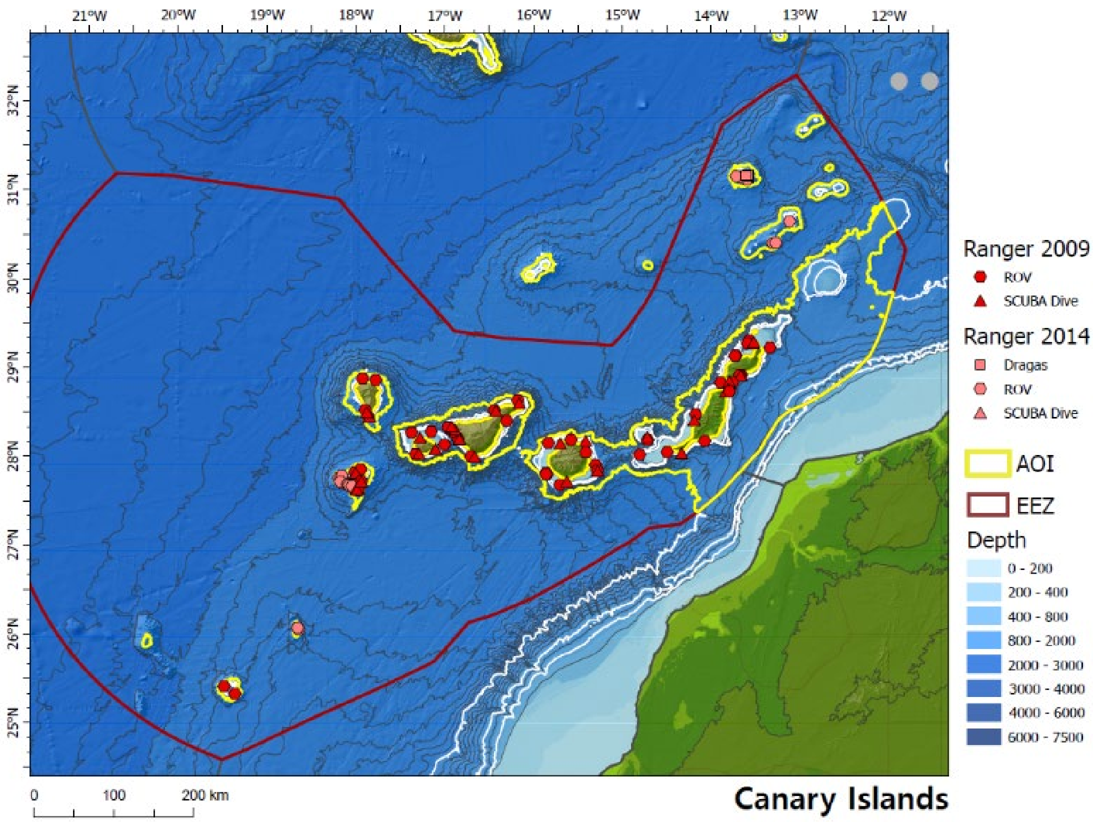

Figure 2.15. Map of the Canary Islands showing the location of VME Indicators observed with remotely operated vehicles (ROV), drags and by SCUBA, in 2009 and 2014, collected by Oceana (R. Aguilar). The 400 m, 800 m and 2000 m depth contours within the French Exclusive Economic Zone (EEZ) (the Areas of Interest-AOI) are indicated.

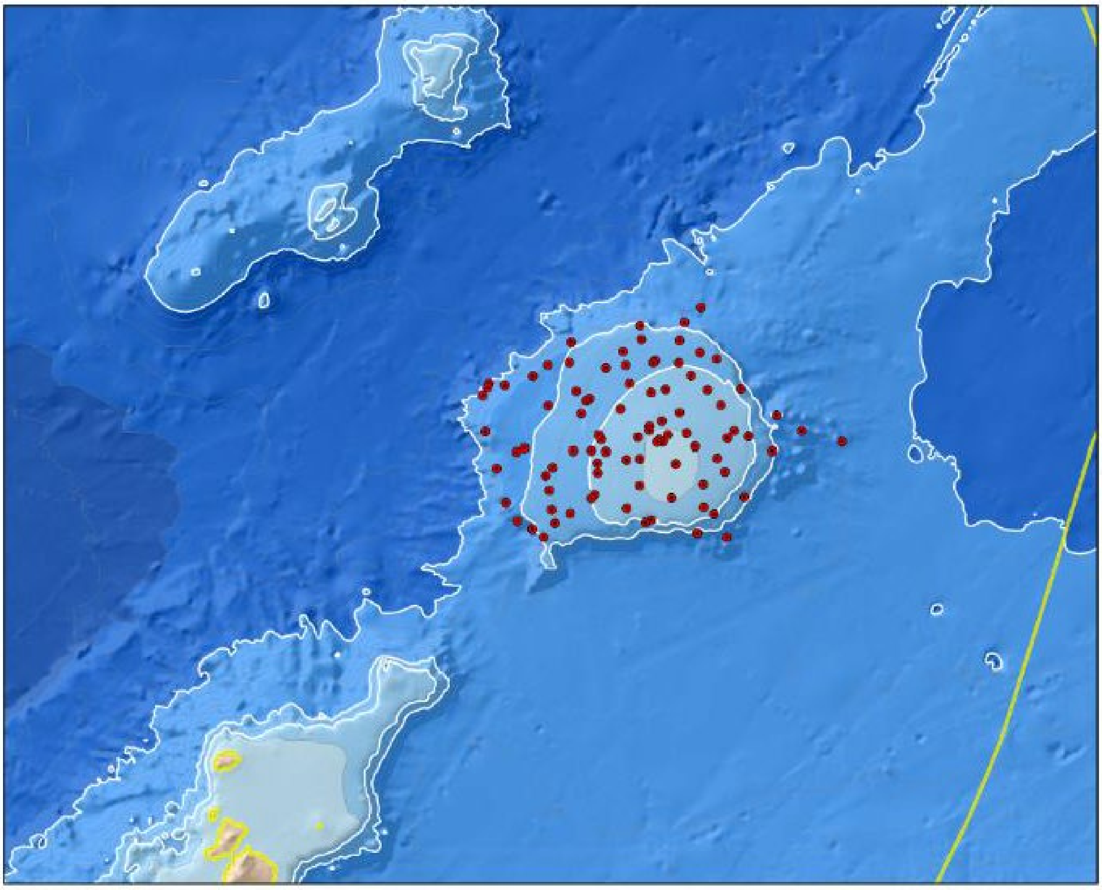

Figure 2.16. Map of the Canary Islands showing the location of VME Indicators provided by Spain through the ICES Data Call. The 400 m, 800 m and 2000 m depth contours within the French Exclusive Economic Zone (EEZ) are indicated.

Oceana (R. Aguilar) has conducted two surveys using various sampling gears throughout the region, the first in 2009 and the second in 2014. VME taxa were recorded at all of these locations (Figure 2.15). Spain also provided data on VMEs through the Data Call (Figure 2.16) which complement the data provided by Oceana.

Under The Pole[18] is an underwater exploration programme which combines innovative expeditions around the world, support for scientific research, and awareness-raising, to promote better knowledge and conservation of the Ocean. Armed with its experience in deep scientific diving and ambitions for improving the scientific knowledge base for more effective conservation, Under The Pole has initiated a research programme DEEPLIFE 2021-2030, under the UN Decade of Ocean Science for Sustainable Development. The project is dedicated to the study of marine animal forests down to 200 m, and was designed by French National Centre for Scientific Research (CNRS) researchers. It is implemented as part of a collaboration between Under The Pole and a scientific consortium of international researchers. Marine Animal Forests formed by sponges, corals, bryozoans and other VME Indicator Species, have been recently recognized as Vulnerable Marine Habitats by the International Union for Conservation of Nature (IUCN) requiring urgent management, conservation and restoration actions. The Mesophotic Zone, a VME Element supported by WKOUTVME, offers optimal conditions for Marine Animal Forest development, but specific diving techniques are needed to work at these depths. The objective of DEEPLIFE is to study the ecological function of Marine Animal Forests through identification of the key engineer species composing the animal forests, a study of the microclimate generated by the forest

[18] Under The Pole IV Deeplife 2021-2030. 2024. https://underthepole.org/utp4/?lang=en

canopies, and a description and quantification of the associated biodiversity (Annex 3). Data for the Canary Islands were collected between 13 October and 14 December 2022, and metadata provided.

2.3.3 VME Elements

The seamounts in the region are biodiversity hotspots, where slopes modify the circulation regime of both deep and shallow currents, changing the biogeochemical constituents of seawater (Valdés & Déniz-González 2015). Some of these seamounts (Concepción Bank, El Banquete and Amanay), as well as coastal areas of the Canary region, have been intensively studied. Thirty-nine marine Special Areas of Conservation and two Sites of Community Importance (both under the Natura 2000 network), as well as three marine reserves are located in the area. The entire area is covered by two EBSAs which were designated in 2023, namely: (i) Tropic Seamount (CBD 2023f) and, (ii) Oceanic Islands and Seamounts of the Canary Region (CBD 2023a).

Steep flanks with slopes > 6.4° are prevalent in around the Canary Islands (Figure 2.17). Shelf-indenting and blind canyons were also identified (Figure 2.18), as were seamounts and hydrothermal vents (Figure 2.19).

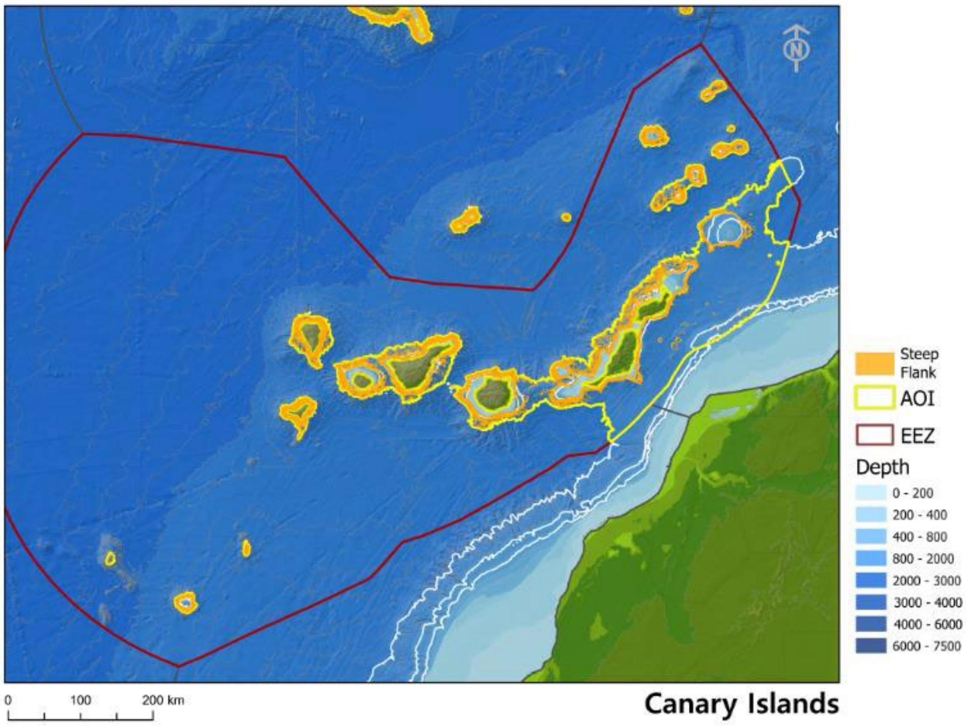

Figure 2.17. Map of the Canary Islands showing the location of steep flanks with slopes > 6.4° within the area of interest (AO!) of waters < 2000 m depth within the Spanish Exclusive Economic Zone (EEZ).

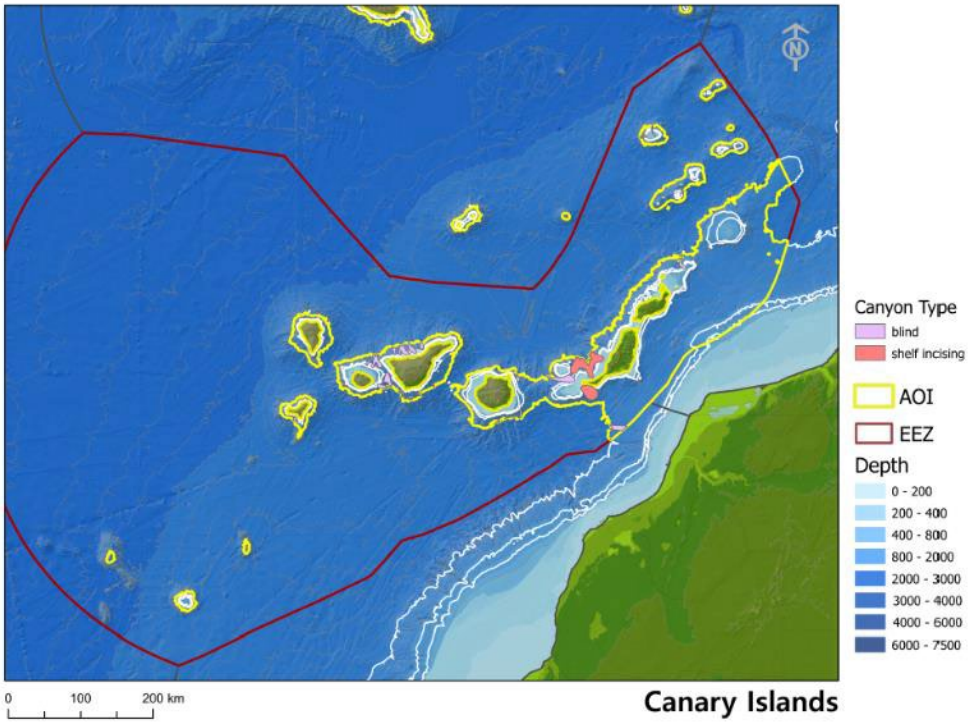

Figure 2.18. Map of the Canary Islands showing the location of shelf-indenting and blind canyons within the area of interest (AOI) of waters < 2000 m depth within the Spanish Exclusive Economic Zone (EEZ).

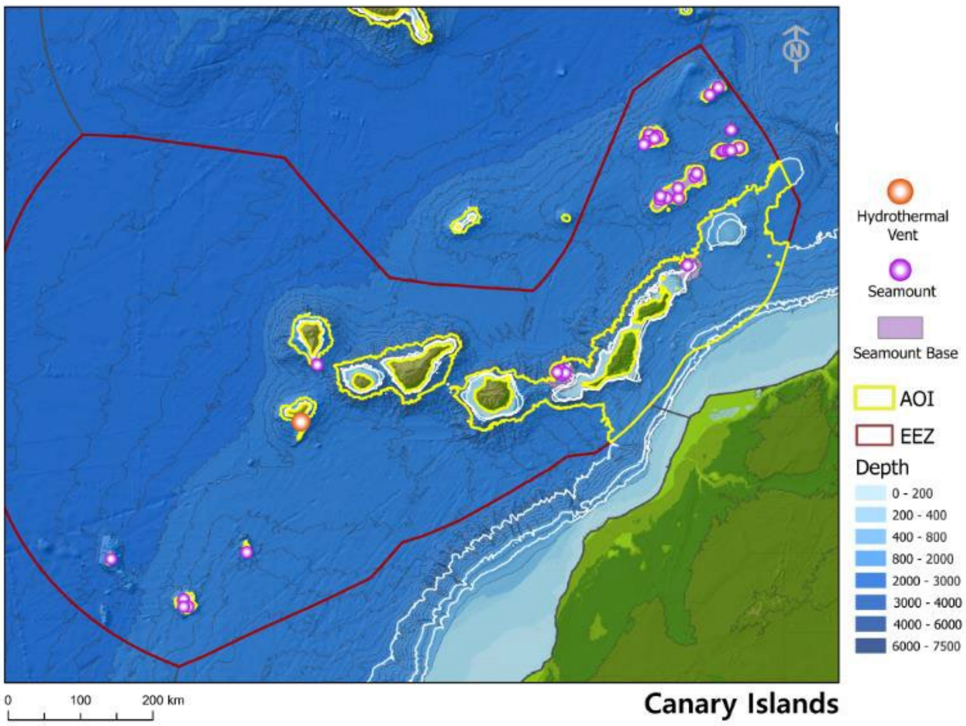

Figure 2.19. Map of the Canary Islands showing the location of seamounts and their bases and known hydrothermal vents within the area of interest (AOI) of waters < 2000 m depth within the Spanish Exclusive Economic Zone (EEZ).

2.3.4 Overview of the local fisheries

There are three identified fleets with a base port within the Canary Islands: Inshore fleet, Tunafish fleet, and African Grounds Fleet (from now on AGF). All of them operate and land in the Canary Islands usually, but AGF also operates on the African grounds, traditionally at Sahara Bank, but also at other more southern African grounds, depending on license availability. The large variety of habitats and types of sea bottom, the marked oceanography, and the reduced continental shelf influence the nature of the fleet, both in the fishing gears used and in the type of vessels operated. The official number of fishing units is 741 (https://www.gobiernodecanarias.org/pesca/, 2022), with an average age of over 40 years, average power of 62 KW, average GT (gross tonnage) of 25 t, and average length < 10 m.

Fishing activity is typically artisanal and family operated. In many places, there is a need to beach boats close to home, resulting in an enormous number of beaches acting as docks. These many small landing spots make monitoring difficult, although the control and monitoring of these landings has improved significantly in the last 15 years with the gradual implementation of a First Sale Spot System.

In parallel to the deep-water fishery, other fishing gears are used in the Canary Islands but are not described in detail here as they don't deep-sea fish. They include purse seine for small pelagics, gillnets specially for parrotfish, eel traps for shallow morays, and a wide range of handlines with different characteristics depending on the targets, depth, and whether they fish at the surface or the bottom, etc. Pole lines are also used for tunafish, trolling lines for Wahoo, amberjacks and tunafish, drifting longlines for Black Scabbardfish, among other minor local methods and instruments.

2.3.5 Deep-sea fishing activity in the Canary Islands

The main deep-sea fishing gear is a handline called "aparejo del alto". Its main target is Alfonsino (*Beryx splendens*), but other target species are European Hake, Wreckfish, Blackspot Seabream, scorpionfishes and others. Tackle is composed of towing rope, swivel, monofilament mainline, finishing with a sinker. From the mainline hang gangions every 1-1.5 m, joined to a mainline by triple swivels. The number of gangions (and hooks) is variable (7-20). Some fishermen add a light stick at the beginning of mainline to attract fish. Even though it is currently deployed and recovered with an electric reel and its size (number of hooks) is similar to a vertical longline, it is never used in the same way, but as a handline, during fishing time. Fishing is made with the boat hove to, letting the current ('marea' or 'aguaje') draw it to the fishing spot ('pesquero', 'piedra' or 'puesto'), correcting to initial position after each cast ('remontar'). Fishing depths vary with target species, but are always over 400 m up to 1000 m. Seasonality also depends on the target species. Alfonsinos and other target species are caught the whole year. European Hake is caught primarily in winter and at the beginning of spring. Handline contact with the bottom is almost null, since the sinker rarely touches the bottom, as alfonsinos are a species found tens of meters above the bottom.

Additionally, in a study assessing sea-bed litter at Banco de La Concepción made by Incera *et al*. (2024) plastic was by far the most abundant category found (83.1%), mainly consisting of fishing lines, both monofilaments and entangled longlines. The study of the interactions of marine litter with fauna showed that less than 20% of the items presented an interaction with benthic organisms. The sponge *Asconema setubalense* accounted for more than half (57.4%) of all interactions, but only 5% of all *A. setubalense* specimens showed physical damage on the seafloor.

Bottom horizontal longlines are made out of a mainline, from which 100-500 gangions hang every 3 m, joined to a mainline by swivels, and ending with a hook. The mainline is provided, every 10-20 gangions, with alternate weights ('pandullos') and floats to keep a horizontal structure. Sinking is made with a big stone or cement sinkers, or else with small grapnels or grappling hooks at the mainline ends, joined with buoys using 4-5 mm wide twisted multifilament ropes. Deployment is made from the boat at low speed. When the boat is equipped with a longline boxes system, deployment speed can reach 6-7 knots. Lifting can be made in two ways: lifting the longline from one of the ends and recovering all the mainline until the other end is reached; or lifting one end, tying the mainline end to a buoy, and lifting the other end, and then, recovering all the mainline to the floating end. Lifting can be made manually or with an electric longline winch, depending on the place. As it's lifted, the longline is placed in boxes or baskets to be ready for the next cast. It's a littoral and somewhat offshore fishing, depending on the depth (and target species), that can vary from 30 to 1000 m. Longlines are used all the year, although some species such as European hake are taken seasonally. Other deep-sea species targeted by this fishery are alfonsinos, scorpionfishes, offshore rockfish, deep morays, European Conger, Wreckfish, etc. Bottom longlines, while fishing, have static sinkers touching the bottom that could produce some impact on the bottom when the longline is recovered, with a potential dragging effect, depending on the position of the boat relative to the gear end. This potential dragging effect is minimized by the fishers when possible, since they don't want to lose the gear.

Fish traps are a passive fishing gear, with a metal structure maintaining the shape (squared or circular), covered by wire mesh, with one or two entrances ('mataderos') for the fish to come in, and a door to introduce bait and to extract catch. Entrance shape is elbow-like. A float is tied to the trap by a twisted nylon rope ('cala'). Trap size varies depending on the target species or fisher preferences. Normally they are set individually, although sometimes it is an assembly of several traps (variable number) joined by ropes. They are normally deployed for one to three days, although because of bad weather they can stay on the bottom for weeks. Fish traps are used at littoral, up to 200 m depth, during the whole year. Among deep-sea species, they target *Dentex* spp., amberjacks, scorpionfishes, offshore rockfish and deep morays. To fish shrimp, traps are the same as a fish trap but with a smaller mesh size and truncated cone-like entrances. Size varies but normally they are under 2 m of diameter (circular) or side (squared), and used especially in summer and up to the same depth. Fish traps, while fishing, have a direct static contact with the bottom, and could produce some impact on the bottom when the trap is recovered, with a potential dragging effect, depending on the position of the boat related to the trap. This potential dragging effect is avoided by the fishers since they do not want to lose the gear.

2.3.6 Methodology caveats and consequences for artisanal fisheries of potential deep-sea closures in the Canary Islands

The Canary Islands small-scale fisheries (SSF) comprise the vast majority of the professional fishing fleet. It is a polyvalent fleet with small boats, passive gears that target multiple species. It is not very high tech, and most of its activity is inshore requiring low energy costs and capital input. SSF are seasonal, and landings are sold locally, sustaining local economies, with individual or community ownership, supporting social and cultural values. This SSF exhibits 12 out of the 17 SSF features described by Gibson and Sumaila (2017) in its British Columbia, Canada SSF description.

There are currently no vessel monitoring systems (VMS) in place for this fleet. This means that there is no fisheries footprint *per se*. The Canary Islands Government is slowly working on establishing a VMS system, but there is uncertainty on when this system will be operative. Several suppletory methods have been applied to obtain a proxy of fishing effort spatial distribution which are valid to illustrate here, and could be used to assess in some way the geographical distribution. The data were collected for the maps shown here were collected with a higher spatial resolution (c-square 0.01 degree) than the one used by the ICES benchmark process (c-square

0.05 degree). However, it should ***not be used as raw data to map the fisheries footprint*** for management purposes since it has a number of issues which make it unreliable for that purpose. The reasons why these methods produce these caveats are the following:

- Interviews: Fishermen point in a map where they fish following their geographical interpretation of where they fish, by memory, subjectively influenced by:
    - the different degree of profit;
    - the time lapse between the interview and the last time to visit each zone;
    - the reluctancy to identify certain fishing spots.

The measurement unit is the number of boats visiting anytime in each c-square within a year (from mid-2022 to mid-2023) and there isn't a fishing intensity measurement.

- Portable GPS: It can be used to depict the geographical behaviour of an average fishing day of some fishing gears at some of the fishing grounds. A limited number of fishing days were monitored with portable GPS devices, depending on:
    - The total amount of devices (20-30);
    - The level of confidence skipper-scientific staff;
    - The willingness of the fishers to have a specific fishing day monitored (they are able to turn off-on the device as many times as they want).
- Onboard observation: It's a great method to depict the fisheries activities. All the information in the fisheries description section for the Canary Islands of this report comes from this type of field work. A limited number of fishing days were monitored with onboard observation, depending on:
    - Budget limitations (it's a very expensive way to monitor data limited fisheries);
    - Reluctancy of fishers to embark observers on their boats to witness their fishing activity;
    - The quality of the built-up confidence relationship between the scientific staff and the fishers. With compulsory measures you will get "fake" fishing days when the observer is onboard.

In the Figures 2.20 to 2.22, we can see the proxy to the spatial distribution of fishing effort of the three fishing gears that are mainly used in the Canary Islands < 400 m depth. This information comes from the on-site interviews to the fishermen performed by scientific staff.

A potential deep-sea closure to fishing < 400 m could displace these fisheries with unintended economic and biological consequences. To evaluate the proportion of the fishing area (derived from Figure 2.20, 2.21 and 2.22) that could be displaced under this scenario, the full spatial extent of each of the fisheries in terms of the number of c-squares (0.01 degrees) showing fishing ground occupation, the number of those c-squares occurring < 400 m, and the percentage of the last, were tabulated for the full fleet and by island for each gear type (Table 2.2). Such a closure would displace almost half of the fishing spatial occupation where handlines are deployed, varying from 33% at La Palma and 68% at Tenerife. In the case of fishing with traps, the average percentage is 14% (from 2% of potential spatial displacement in La Gomera to 26% in Tenerife). Finally, for longlines, the average displacement is 15%, ranging from a 0% in small islands where this fishing gear is not used, to 31% in Gran Canaria. Lanzarote, Fuerteventura and La Graciosa are treated as the same island unit. In the cases of trap and handline fisheries, there are specific gears and fleet subtypes dedicated only to deep-sea target species, which means that the big traps targeting deep species and the "*aparejo del alto*" (handline with electric reel for deep species) would have even greater spatial restrictions which cannot be estimated since the data is not disaggregated by fishing gear subtypes. This would not apply to longline fisheries.

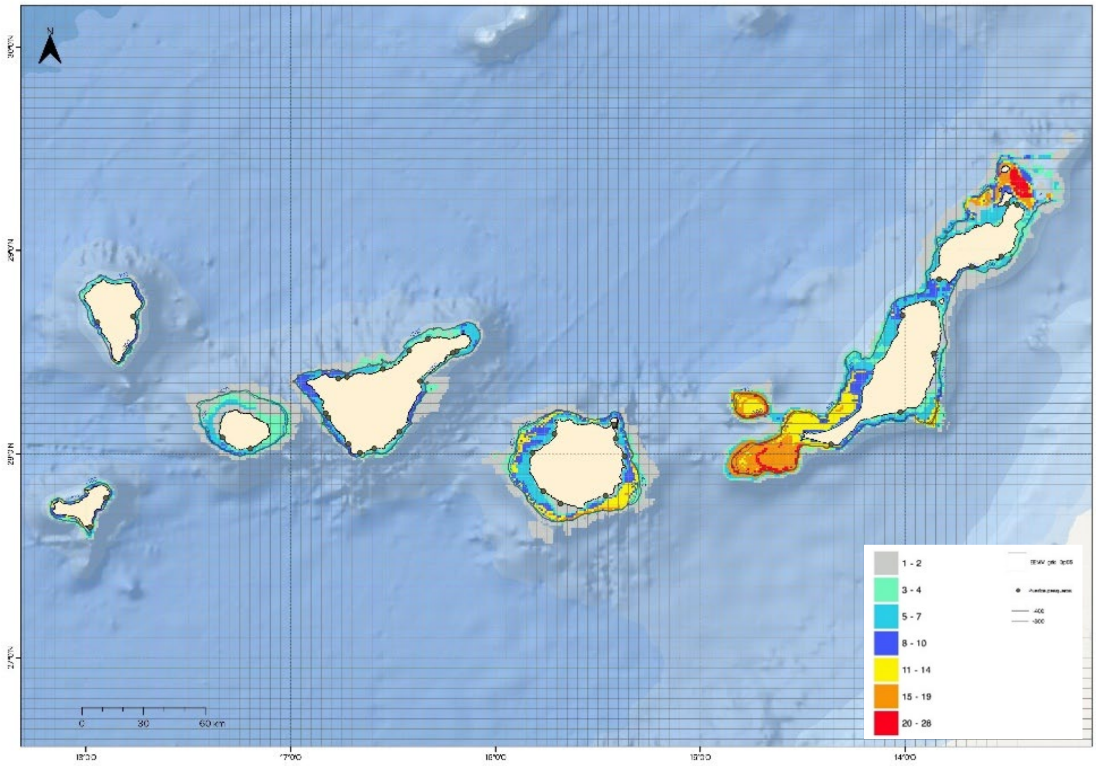

Figure 2.20. Proxy of the spatial distribution of effort with handlines in the Canary Islands determined from interviews with fishers. Source: Human Activities Ecology Group (MSFD Canary Islands, Spain).

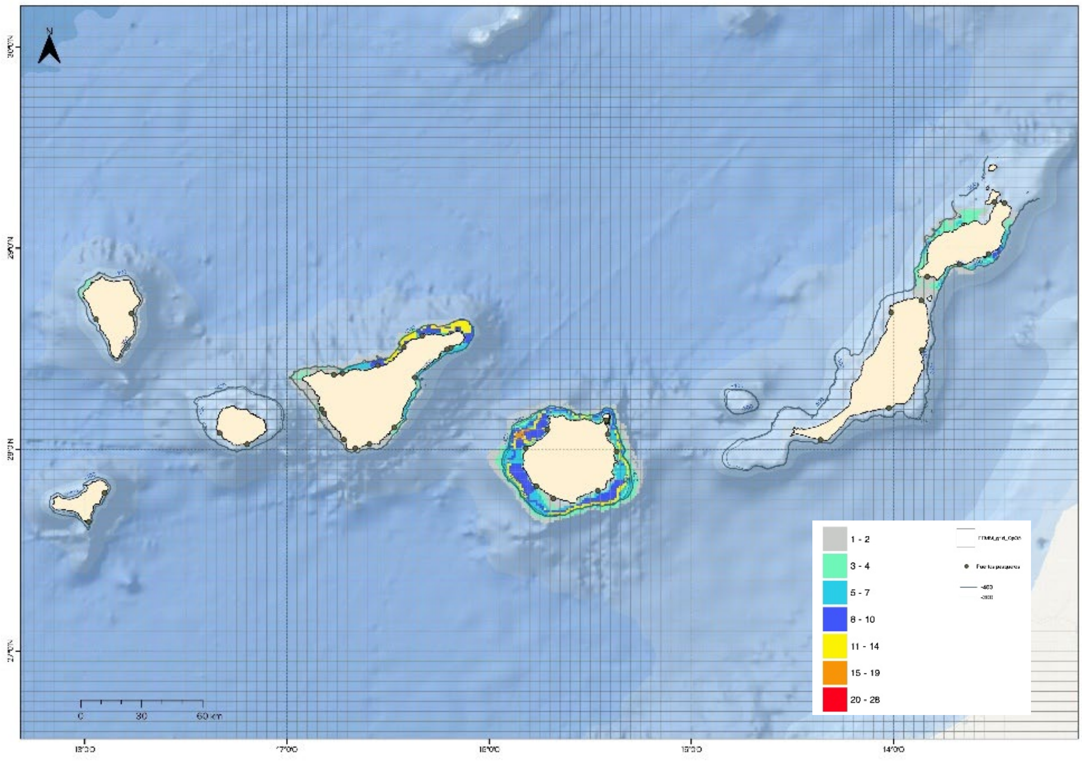

Figure 2.21. Proxy of the spatial distribution of effort with longlines in the Canary Islands determined from interviews with fishers. Source: Human Activities Ecology Group (MSFD Canary Islands, Spain).

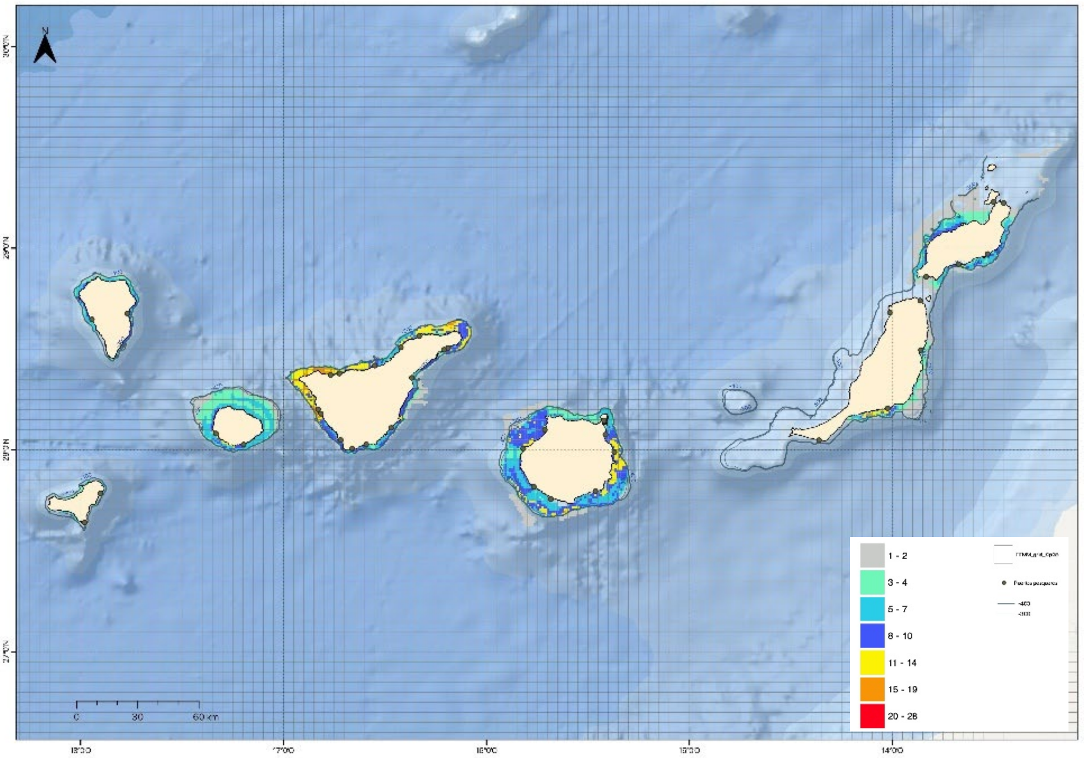

Figure 2.22. Proxy of the spatial distribution of effort with traps in the Canary Islands determined from interviews with fishers. Source: Human Activities Ecology Group (MSFD Canary Islands, Spain).

Table 2.2. The proportion of c-squares (0.01 degree resolution) affected by a hypothetical ban on fishing < 400 m derived from a fishing footprint established through interviews with fishers. (Pot. Disp.= potential displacement).

Island	Handlines			Traps			Longlines		
	No. C-sq < 400 m	Total No. C-sq	% Foot-print Pot. Disp.	No. C-sq < 400 m	Total No. C-sq	% Foot-print Pot. Disp.	No. C-sq < 400 m	Total No. C-sq	% Foot-print Pot. Disp.
La Palma	85	255	33	30	275	11	41	160	26
El Hierro	156	295	53	3	67	4	0	0	0
La Gomera	475	1150	41	16	700	2	0	0	0
Tenerife	850	1250	68	140	540	26	155	700	22
Gran Canaria	875	2000	44	230	1355	17	625	2000	31
Lanzarote-Fuer-teventura-La Graciosa*	1600	4100	39	250	1050	24	65	600	11
Total	4041	9050	46	669	3987	14	886	3460	15

*** Combined island unit**

2.3.7 Economic importance of potential deep-sea closures to fishing in the Canary Islands

Essentiality index: definition and components

Small-scale fisheries (SSFs) are often overlooked and marginalized in policy processes, although they play an important role in contributing to food security, nutrition, livelihoods, and local and national economies. As conventional fisheries assessment is not valid for SSFs, Dorta and Martín-Sosa (2022) put forward several mathematical indices to numerically qualify the state of certain SSFs so that the economic impact could be factored into management decisions prior to implementation. They developed a new concept termed '**Essentiality**' and applied it in the Canary Islands. Essentiality measures the relative importance of certain species from an economic perspective. The time dedicated to the capture of a species, the number of units that fish it, and the economic yield obtained from the sale of the catch: Frequency, Fleet Recruiting and Income, define Essentiality. Estimating the Essentiality of a fishery enables characterization of different fishing communities, and allows the data-limited SSF manager the option of introducing management measures to change the behaviour of the fishery and move towards a situation of greater Essentiality, and therefore, of greater economic viability. This in turn leads to a reduction in the pressure that is focused on a limited number of specific fishing resources. The Essentiality of a fishery is a plausible alternative method of assessment and management of a fishery to the traditional evaluation methods used for industrial fisheries.

SSFs discards are usually almost non-existent, unlike the case for industrial fisheries. However, not all species of fishing interest have the same importance for the stable and profitable maintenance of SSFs. Catch compositions depend on availability, market, and vulnerability to fishing gear. The concept of target species in an SSF is something to consider, but it does not always indicate the importance of the species in question within a general fishing context. The essential characteristics that identify and differentiate an SSF from a certain locality are the result of the fishing intensity of each species caught by that fishery, and that intensity depends on a series of ecological, biological, fishing, and commercial factors. Dorta and Martín-Sosa (2022) analyzed fishing and commercial aspects in their study.

Species of fishing interest can be divided into three categories: essential, fundamental, and complementary species. The first two are basic target species for the maintenance of fishing activity; usually consisting of no more than 15 per fishing community and generating around 85% of the economic income from fishing. These species determine local fishing strategies and support the intensity and generation of income from fishing activities. Complementary species are those that are usually landed together with other more important species, or those that, whilst targeted at a given moment, do not make up a significant share of the income derived from fishing (Dorta & Martín-Sosa 2022).

The essential species are those that characterize the fishing strategies of each fishing community, and fleets, fishing gears, and fishers' behaviour are conditioned by them. They usually represent between 60 to 70% of the economic income from fishing and often do not exceed half a dozen species. The stability and income generated from fishing is based on these types of resources; that vary according to fleet polyvalence, with an abundance that depends on the state of their habitat and their level of exploitation; and essential because if they are lacking, the fragile balance that regulates seasonality in fishing strategies is broken, leading to an increase of effort towards other species that have already been, or indeed will be fished, throughout the year (Dorta & Martín-Sosa 2022).

The essentiality index measures the relative importance of a certain species, or group of species, within an SSF. It should not be understood as a measure of effort, or a biological measure. Rather, it is an economic measure characterizing the type of fishing, a qualitative measure of fishing exploitation. The index quantifies income generation and gauges the intensity with which a species is fished, with the greater the income generation, vulnerability to fishing, and availability of the resource, the higher the fishing intensity. This is due to the fact that the typical versatility of SSF fleets always tends to lead to profit-orientated fishing strategies (Dorta & Martín-Sosa 2022).

> "There are three factors of utmost importance in understanding or quantifying the fishing intensity that is exerted on a species: the time dedicated to the capture of a species, the number of units that fish it, and the economic yield obtained from the sale of the catch: Frequency, Fleet Recruiting and Income.
>
> - **Frequency** (F) is the number of days in which a certain species is fished, divided by the total number of days of fishing activity of the entire fleet and all species.
> - **Fleet Recruiting** (R) is the number of boats that fish a species, with income rates for the species in question greater than a certain threshold (5 or 10%) of that boat's total earnings; so, we are adding an essentiality character to this parameter.
> - **Income** (P) could be calculated by dividing the economic value obtained from the sale of one species by the total income of all species. However, in many multi-species fisheries it is common for none of the species to exceed 40% of the earnings, which leads to P values very close to 0. The combination of these absolute values with those of frequency and fleet recruiting would produce very low essentiality figures. A preferred approach is to estimate relative incomes, dividing the income generated by each species by the income obtained from the species that generate the highest income levels. In order to quantify the value that a given species has for fishers, which is the fundamental goal of the model, the biological parameter of biomass is left out.
>
> Thus, the parameters that numerically determine the importance of a species can be calculated from F, R and p. F quantifies the presence of the resource and the intensity with which it is fished, contributing a component of biological abundance to the indices. R measures the ability of the fleet to incorporate a certain fishing strategy, and p measures economic value as a fundamental element that leads fishers to prioritize the exploitation of resources that generate the highest income levels, regardless of their biomass." (Dorta & Martín-Sosa 2022).

The Essentiality index, made up of the three above-mentioned components, can be expressed as:

$$\exists_t^{sp} = \frac{p^{0.6} + 0.25 * \ln(i + 0.018) + 1}{2}$$

where ∃ is the essentiality index of a species, or a determined group of species, for a period of time t; *i* is the fishing intensity obtained by multiplying π by the fleet recruiting (R) squared and by the frequency (F), and then dividing by 3: $i = (\pi\ R\text{^}2\ F)/3$; and p is the income rate index. Thus, when ∃ ≥0.5, we can say that the species is essential; for ∃ ≥ 0.3 and < 0.5, the species is categorized as fundamental and ∃ values below 0.3 correspond to complementary species.

For the whole fishery, the essential capacity $C_\exists$ combines the total of the essential indices of the species fished at a specific fishery. It is obtained as a weighted sum of essentiality indices:

$$C_\exists = \sum_{\exists \geq 0.5} \exists * 100 + \sum_{0.5 > \exists \geq 0.3} \exists * 50 + \sum_{\exists < 0.3} \exists$$

$C_\exists$ will allow managers to assess the effectiveness of measures that have been implemented with the aim of increasing fishing essentiality, since by testing the annual trend of $C_\exists$, the negative or positive effects of fishery management measures can be determined (Dorta & Martín-Sosa 2022).

2.3.8 Essentiality put into practice: Some illustrative examples from the Canary Islands

Playa Blanca is a small fishers' guild (20 boats) (*Cofradía*) located on the southern coast of Lanzarote, on the north-eastern side of the archipelago (Figure 2.23). In 2019, 74 species were landed with 10 species generating the highest income levels responsible for 72% of the landings and 76% of the income (Dorta & Martín-Sosa 2022). The fleet has two basic fishing strategies, 1) fishing several demersal coastal rockfish species with hook and lines, especially during winter months, and to a lesser extent during autumn, and 2) fishing with shallow traps especially during spring and summer. Figure 2.24 shows Essentiality parameters for the top 10 most essential species. From those top 10 species, six are categorized as essential, and three as fundamental. Playa Blanca's $C_{\exists}$ value during 2019 is 499, which is categorized by the authors as high (Dorta & Martín-Sosa 2022).

Gran Tarajal is a medium size fishers' *Cofradía* (45 boats) located on the south-eastern coast of Fuerteventura, in the SE Canary Islands (Figure 2.23). The total number of landed species during that year was 70, with 10 of those species generating the highest income levels responsible for 81% of both landings and income. The fleet catches several demersal coastal rockfish species with hook and lines, especially during summer months, and with traps from November to April (when this gear is permitted). Moreover, the fishery is supported by the exploitation of deep-sea resources with electric reel hook and lines throughout the year, and by fishing seasonal tunafish when available. Essentiality parameters for the top 10 most essential species are presented in Figure 2.24. From the top 10 species, only two are categorized as essential, and one as fundamental. Gran Tarajal $C_{\exists}$ value during 2019 is 139, which is a low value (Dorta & Martín-Sosa 2022).

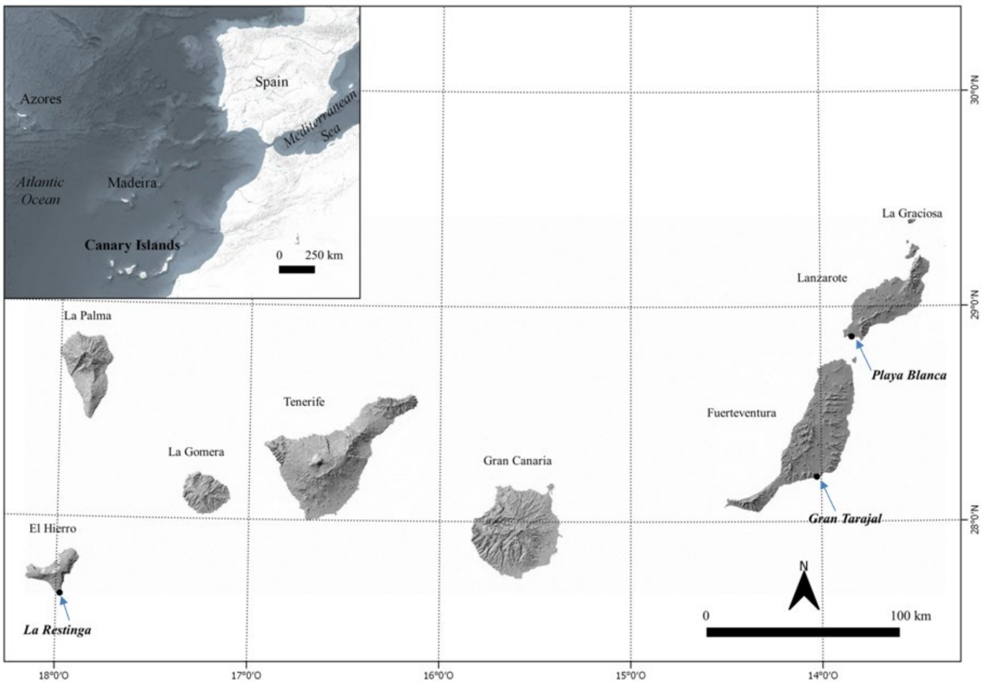

Figure 2.23. A map of the Canary Islands with location of illustrative examples used in the Essentiality analyses (Dorta & Martín-Sosa 2022).

La Restinga, located on the southern coast of El Hierro, in the SW Canary Islands (Figure 2.23), is a small size fishers' *Cofradía* (28 boats). During 2019, 57 different species were landed at La Restinga. The top 10 species contributed 92% of total landings and 86% of total income. The fleets direct a large amount of fishing effort towards tuna during the summer months, and a mixture of fishing tactics are used throughout the year, aimed at both coastal and deep demersal resources (Dorta & Martín-Sosa 2022). Usual fishing gears in the Canary Islands are complemented with exclusive gears from El Hierro such as 'puyón' (snorkelling hook and line) and 'vara de petos' (harpoon for wahoo). Figure 2.24 represents the Essentiality parameters for the top 10 essential species landed in 2019. Of those, three are categorized as essential and five as fundamental. La Restinga $C_{\exists}$ value during 2019 was 312, a medium value (Dorta & Martín-Sosa 2022).

Deep-sea closures would not affect the essential capacity for Playa Blanca, at least with using data from 2019, since it is a fishery based on coastal resources, and it bases its economic viability on many species (6 essential, 4 fundamental sp.). On the other hand, La Restinga and Gran Tarajal, are partially supported by the fishing of several deep-sea species. For example, in the case of Gran Tarajal, with a tunafish species as the only essential one, and with one of the four fundamental species being a deep-sea species (*B. splendens*, plus other three deep-sea species -*Serranus* spp., *Dentex macrophthalmus* and *Merluccius merluccius*- among the top ten of Essentiality), a potential closure to fishing under 400 m would mean a very high degree of economic support potentially displaced to coastal resources, most of them with a certain degree of overexploitation (*P. pagrus*, *Mullus* spp., *Dentex gibbosus*, *Balistes capriscus* or *Pagrus auriga*). Further, deep-sea species are normally better valued in local markets. Overall, a deep-sea closure < 400 m in the Canary Islands could mean an increase in the level of exploitation of coastal resources and a higher concentration of bottom fishing gears in shallower waters.

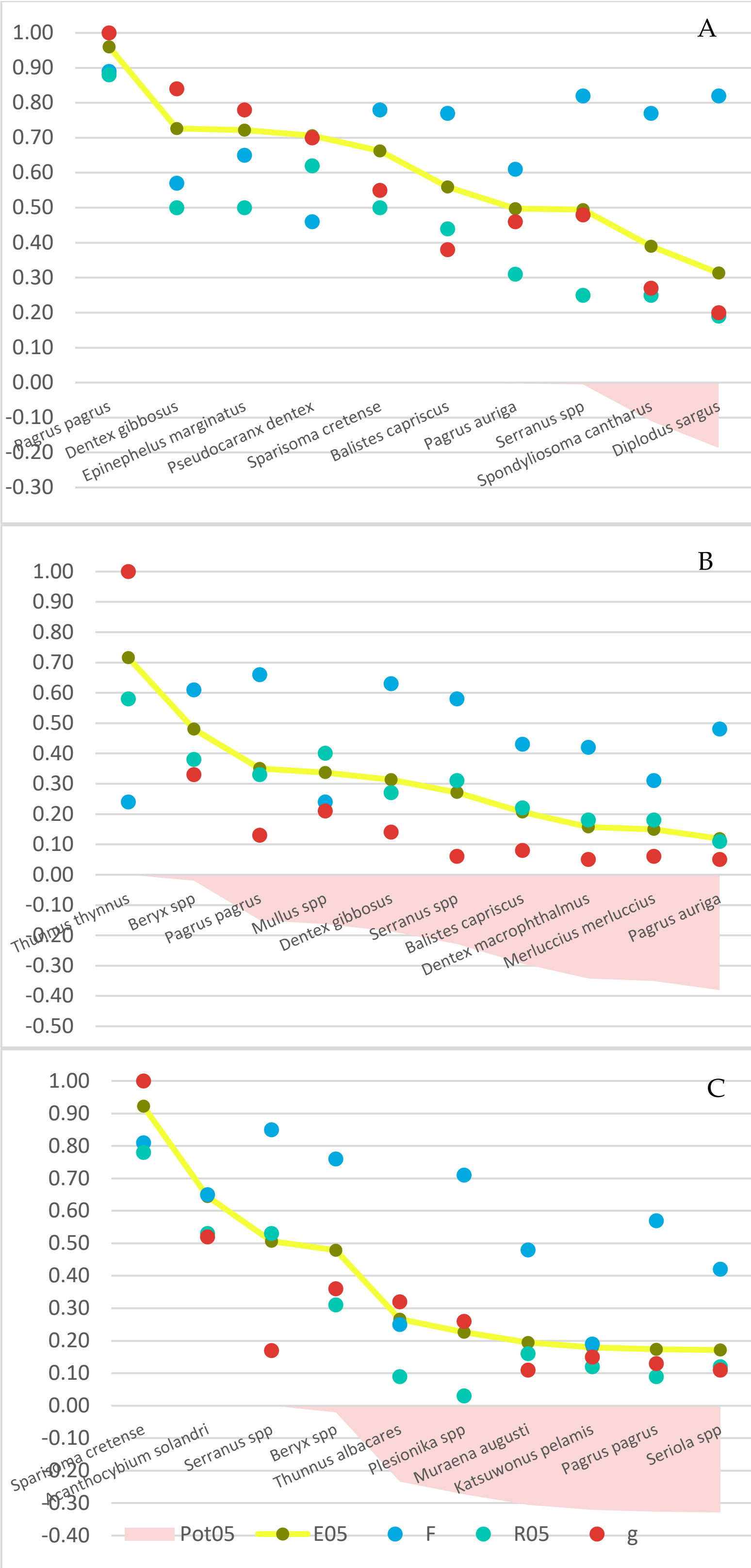

Figure 2.24. Essentiality graphical figures for the three examples. A. Playa Blanca, B. Gran Tarajal, C. La Restinga. F = Frequency; R05 = Fleet Recruiting estimated with a 5% profit threshold; p = Income rate; Pot05 = Essential Potentiality esti-mated with R05; E05 = Essentiality estimated with R05 (see Dorta & Martín-Sosa (2022) for details).

2.3.9 List of deep-sea fish species for the Canary Islands

Scientific Name	FAO Code	Local Name	Land-ings (kg)	IUCN Status
Beryx splendens	BYS	Fula colorada	132370	Least Concern
Seriola spp	AMX	Medregales	82969	
Conger conger	COE	Congrio	53980	Least Concern
Serranus spp. (most of it *S. atricauda,* also *S. cabrilla*, both deep species)	BAS	Cabrilla negra Cabrilla reina	50658	
Merluccius merluccius	HKE	Pescadilla Merluza	31613	Least Concern
Muraena helena	MMH	Morena	30399	Least Concern
Dentex macrophthalmus	DEL	Antoñito Dientón	18688	Least Concern
Plesionika edwardsii	LKW	Camarón soldado rayado	16082	
Mora moro	RIB	Merluza del país	11642	Least Concern
Gymnothorax polygonius	AGI	Papuda Morena	11436	Least Concern
Helicolenus dactylopterus	BRF	Gallineta Boca Negra	11390	Least Concern
Phycis spp (most of it *P. phycis,* also *P. blennoides,* both deep species)	FOX	Brota Agriote	9947	
Beryx decadactylus	BXD	Colorado anchete	8328	Least Concern
Gymnothorax maderensis	AGD	Morena verde	6437	
Aristeopsis edwardsiana	SSH	Gamba carabinero Carabinero	6409	
Lepidopus caudatus	SFS	Pejesable	4606	Data Deficient
Triakidae *(Mustelus mustelus, Galeorhynus gaelus, Galeus melastomus,* all of them deep)	TRK	Cazones Tollos	4358	
Scorpaena spp (*S. scrofa, S. elongata, S. porcus,* all of them deep)	SCS	Cantareros	3928	
Polymixia nobilis	PXV	Barbudo Salmón de lo alto	3079	Least Concern
Ruvettus pretiosus	OIL	Escolar Escolar rasposo	2987	Least Concern

Scientific Name	FAO Code	Local Name	Land-ings (kg)	IUCN Status
Polyprion americanus	WRF	Cherna Cherne Romerete	2575	Data Deficient
Lepidocybium flavobrunneum	LEC	Escolar negro,Escolar chino	2436	Least Concern
Epigonus telescopus	EPI	Candil, Pez diablo	2313	Least Concern
Pontinus kuhlii	POI	Obispo, Volón	1938	Data Deficient
Pagellus bogaraveo	SBR	Voraz, Goraz	1867	Near Threatened
Aristaeomorpha foliacea	ARS	Gamba roja	1305	
Aphanopus carbo	BSF	Conejo diablo	1052	Least Concern
Lepidorhombus boscii	LDB	Gallo	814	Least Concern
Promethichthys prometheus	PRP	Conejo	719	Least Concern
Dentex maroccanus	DEM	Calé, Sama, Marroquí	699	Least Concern
Argyrosomus regius	MGR	Corvina	586	Least Concern
Schedophilus ovalis	HDV	Pampano	467	
Zenopsis conchifer	JOS	Gallo plateado	383	Least Concern
Lophius piscatorius	MON	Rape blanco	368	Least Concern
Chaceon affinis	KEF	Cangrejo rey	321	
Schedophilus ovalis	HDV	Rufo imperial	258	
Raja clavata	RJC	Raya de clavos	226	Near Threatened
Zeus faber	JOD	Gallo San Pedro, Gallo Bar-bero	184	Data Deficient
Sthenoteuthis pteropus	OFE	Pota De Luz	156	Least Concern
Ommastrephes bartramii	OFJ	Pota Saltadora	152	Least Concern

2.3.10 List of VME Indicator Species for the Canary Islands

'X' means direct evidence fitting to the criteria, '(X)' is inferred from the literature on other species; '?' means no information available; and blank cell means that the criterion was not met. New representative species proposed by IEO (pink fill) and OCEANA (green and *) based on information collected during recent field campaigns are marked in different colours. Traits values come from IEO agreed data.

VME Habitat Type	Representative Taxa	Uniqueness	Functional Significance	Fragility	Life History	Structural Complexity
1. Cold-water coral reef						
(a) Lophelia pertusa [sic. Desmophyllum pertusum] reef	CARYOPHYLLIDAE					
	Lophelia pertusa [sic. Desmophyllum pertusum]		X	X	X	X
	BATHYPORIDAE					
	Madrepora oculata		X	X	X	X
(b) Solenosmilia variabilis reef	CARYOPHYLLIDAE					
	Solenosmilia variabilis		X	X	X	X
2. Coral garden						
(a) Hard bottom coral garden						
(i) Hard bottom gorgonian gardens	CHRYSOGORGIIDAE					
	Metallogorgia melanotrichos	X	X	X	X	X
	Chrysogorgia quadruplex	X	X	X	X	X
	Iridogorgia cf. *pourtalessi*	X	X	X	X	X
	CORALLIIDAE					
	Hemicorallium niobe	X	X	X	X	X
	Hemicorallium tricolor	X	X	X	X	X
	Paragorgia cf. *johnsoni*	X	X	X	X	X
	ELLISELLIDAE					
	Viminella flagellum		X	X	X	X
	Ellisella paraplexauroides		X	X	X	X

VME Habitat Type	Representative Taxa	Uniqueness	Functional Significance	Fragility	Life History	Structural Complexity
	Nicella granifera			X	X	X
	EUNICELLIDAE					
	Eunicella verrucosa		X	X	X	X
	KERATOISIDIDAE					
	Acanella arbuscula		X	X	X	X
	Keratoisis grayi	X		X	X	X
	Lepidisis sp	X		X	X	X
	PARAMURICEIDAE					
	Bebryce mollis			X	X	X
	Villogorgia bebrycoides		X	X	X	X
	Placogorgia coronata		X	X	X	X
	Paramuricea biscaya		X	X	X	X
	Dentomuricea meteor	X	X	X	X	X
	Muriceides spp.*	?	(X)	(X)	(X)	(X)
	Paramuricea grayi		X	X	X	X
	Placogorgia spp.		X	X	X	X
	Acanthogorgia hirsuta		X	X	X	X
	Acanthogorgia armata		X	X	X	X
	PLEXAURIDAE					
	Swiftia dubia			X	X	X
	PRIMNOIDAE					
	Callogorgia verticillata		X	X	X	X
	Candidella imbricata		X	X	X	X
	Narella bellissima		X	X	X	X
	Narella versluysi		(X)	(X)	(X)	(X)
	*Paracalypthrophora josephinae**	?	(X)	(X)	(X)	(X)
	SIPHONOGORGIIDAE					

VME Habitat Type	Representative Taxa	Uniqueness	Functional Significance	Fragility	Life History	Structural Complexity
	Siphonogorgia spp.*	?	(X)	(X)	(X)	(X)
	OCTOCORALLIA *incertae sedis*					
	*Daniela koreni**	?	(X)	(X)	(X)	(X)
(ii) Hard bottom black coral gardens	ANTIPATHIDAE					
	Stichopathes gracilis		X	X	X	X
	Stichopathes gravieri	X		X	X	X
	*Antipathes dichotoma**		(X)	(X)	(X)	(X)
	Antipathes furcata		X	X	X	X
	Stichopathes setacea		X	X	X	X
	Allopathes sp.*		(X)	(X)	(X)	(X)
	APHANIPATHIDAE					
	Phanopathes erinaceus	X	X	X	X	X
	Elatopathes abietina		X	X	X	X
	CLADOPATHIDAE					
	Trissopathes sp.*		(X)	(X)	(X)	(X)
	LEIOPATHIDAE					
	Leiopathes glaberrima		X	X	X	X
	MYRIOPATHIDAE					
	Antipathella wollastoni		X	X	X	X
	Tanacetipathes spp.		X	X	X	X
	SCHIZOPATHIDAE					
	Bathypathes patula		X	X	X	X
	Parantipathes hirondelle		X	X	X	X
	*Parantipathes larix**		(X)	(X)	(X)	(X)
(iii) Hard bottom scleractinian gardens	BATHYPORIDAE					
	Madrepora oculata		X	X	X	X
	CARYOPHYLLIDAE					

VME Habitat Type	Representative Taxa	Uniqueness	Functional Significance	Fragility	Life History	Structural Complexity
	Anomocora fecunda		X	X	X	X
	Desmophyllum pertusum		X	X	X	X
	Desmophyllum dianthus	X		X	X	X
	Solenosmilia variabilis		X	X	X	X
	DENDROPHYLLIIDAE					
	Dendrophyllia cornigera		X	X	X	X
	Dendrophyllia alternata	X	X	X	X	X
	Dendrophylia ramea		X	X	X	X
(iv) Hard bottom stylasterid gardens	STYLASTERIDAE					
	Errina spp.	X	X	X	X	X
	Crypthelia spp.			X	X	X
(v) Soft coral aggregations	CORALLIIDAE					
	Anthomastus grandiflorus			X	X	
	Anthomastus canariensis			X	X	
	*Pseudoanthomastus spp.**			(X)	(X)	
(b) Soft-bottom coral gardens						
(i) Cup-coral fields	CARYOPHYLLIDAE					
	Stephanocyathus moseleyanus				X	
	DELTOCYATHIDAE					
	Deltocyathus moseleyi				X	
	FLABELLIDAE					
	Flabellum (Flabellum) chunii				X	
3. Deep-sea sponge aggregations						
(a) Hard-bottom sponge gardens						
(i) Lithistid sponge gardens	AZORICIDAE					
	Leiodermatium lynceus		X		X	X
	Leiodermatium pfeifferae				(X)	(X)

VME Habitat Type	Representative Taxa	Uniqueness	Functional Significance	Fragility	Life History	Structural Complexity
	*Leiodermatium tuba**				(X)	(X)
	CORALLISTIDAE					
	Neophrissospongia nolitangere	X	X		X	X
	MACANDREWIIDAE					
	Macandrewia spp.				X	
	PHYMARAPHINIIDAE					
	*Exsuperantia archipelagus**				(X)	
	THEONELLIDAE					
	Discodermia spp.*				(X)	?
(i) Other sponge gardens	CLASS DEMOSPONGIAE					
	AXINELLIDAE					
	Axinella polypoides		X	X	X	X
	BUBARIDAE					
	Phakellia robusta		X	X	X	X
	Phakellia ventilabrum		X	X	X	X
	GEODIIDAE					
	Geodia megastrella		X	X	X	X
	Geodia spp.		X	X	X	X
	Penares helleri		X	X	X	X
	HALICHONDRIIDAE					
	Topsentia levivaceletorum		X	X	X	
	PACHASTRELLIDAE					
	Characella tripodaria		X	X	X	X
	Pachastrella monilifera		X	X	X	X
	PHLOEODICTYIDAE					
	Oceanapia sp.*			(X)	(X)	?
	VULCANELLIDAE					

VME Habitat Type	Representative Taxa	Uniqueness	Functional Significance	Fragility	Life History	Structural Complexity
	Poecillastra compressa		X	X	X	X
	CLASS HEXACTINELLIDA					
	ROSSELLIDAE					
	Asconema setubalense		X	X	X	X
	Sympagella nux			X	X	
(b) Soft-bottom sponge aggregations	THENEIDAE					
	Thenea muricata			X	X	
(c) Deep glass sponge communities	APHROCALLISTIDAE					
	Aphrocallistes beatrix			X	X	X
	AULOCALYCIDAE					
	*Rhabdodyctium delicatum**			(X)	?	?
	EUPLECTELLIDAE					
	Redagrella phoenix	X	X	X	X	X
	*Heterotella midatlantica**			(X)	?	(X)
	FARREIDAE					
	Farrea cf. *occa*	X	X	X	X	X
	*Farrea foliascens**			X	X	X
	PHERONEMATIDAE					
	Pheronema carpenteri	X	X	X	X	X
4. Sea pen fields	FUNICULINIDAE					
	Funiculina quadrangularis		X	X	X	X
	PENNATULIDAE					
	Pennatula spp.		X	X	X	X
	Pteroeides griseum			X	X	X
	VERETILLIDAE					
	Veretillum cynomorium		X	X	X	X
	VIRGULARIIDAE					

VME Habitat Type	Representative Taxa	Uniqueness	Functional Significance	Fragility	Life History	Structural Complexity
	Virgularia mirabilis			X	X	X
5. Tube-dwelling anemone patches	CERIANTHIDAE					
	Cerianthus membranaceus			X	X	X
	ARACHNACTIDAE					
	Arachnanthus sp.*			(X)	(X)	(X)
	Isaranachnanthus sp.*			(X)	(X)	(X)
6. Mud- and sand-emergent fauna	XENOPHYOPHOROIDEA					
	PSAMMINIDAE					
	Syringammina fragilissima	X		(X)	?	
7. Bryozoan patches	BUGULIDAE					
	Kinetoskias cf. *sileni*	X		(X)	?	
8. Mesophotic zone	*Antipathella wollastoni*		X	X	X	X
	Antipathes furcata		X	X	X	X
	Stichopathes gracilis		X	X	X	X

2.3.11 Metadata of relevant data sources available for the Canary Islands

The data in the table listed as in preparation from IEO is potentially available to a subsequent workshop.

Type	Data Source	Data Description	Data Format	Native Resolution	Collection Date(s)	Data Publically Available?	Contact for Data if not Public
VMEs	Martín-García et al. 2022a (Concepción)	DM of 6 VME bathyal communities	polygon .shp file (or gpkg), WGS84 UTM zone 28N	20 m	2010 -12	In preparation	IEO P. Martín-Sosa
VMEs	Martín-García et al. 2022b (FV)	DM of 3 VME bathyal communities	polygon .shp file (or gpkg), WGS84 UTM zone 28N	20 m	2011 -12	In preparation	IEO P. Martín-Sosa
VMEs	EEMM datasets	DM of x communities (in progress)				long term preparation	IEO P. Martín-Sosa
VME Indicators	IEO 2013a Concepción	Locations of VME species (abundance)	data point, WGS84 UTM zone 28N	200 m	2010-12	already shared	
VME Indicators	IEO 2013b	Locations of VME species (abundance)	data point, WGS84 UTM zone 28N	200 m	2010-12	In preparation	IEO P. Martín-Sosa
VME Indicators	Martín-García et al. 2022c (*A. setubalense*)	SDM of *Asconema setubalense*	.shp file (or gpkg), WGS84 UTM zone 28N	20 m	2018	Yes	

Type	Data Source	Data Description	Data Format	Native Resolution	Collection Date(s)	Data Publically Available?	Contact for Data if not Public
VME Indicators	OCEANA Amanay and Banquete	ROV Oceana Grid species abundance data	Transect data. WGS84 UTM	precise point		already shared	
VME Indicators	Under the Pole DEEPLIFE expedition	Location of black coral species (25 -200 m depth)	excel file	precise point	2022	in preparation	Marie Maillot / Lucas Terrana / Francisco Otero Ferrer
VME Elements	GEBCO	GEBCO grided bathymetric data	Raster (Geotiff)	15 arc second (~500m at equator)	2023	https://www.gebco.net/data_and_products/gridded_bathymetry_data/gebco_2023/	
VME Elements	World Seamount Database	Seamounts	Vector (Shapefile, Point = Peak, Polygon = Base)	derived from 30 arc second resolution (~1km at equator)	2021	https://doi.pangaea.de/10.1594/PANGAEA.921688	
VME Elements	GEBCO	Steep Flanks	Vector (Shapefile, Polygon)	15 arc second (~500m at equator)	2023	https://www.gebco.net/data_and_products/gridded_bathymetry_data/gebco_2023/	
VME Elements	InterRidge Global Database of Active Submarine Hydrothermal Vent Fields 3.4	Hydrothermal Vents	Vector (Shapefile, Polygon)	1 arc minute (~2km at equator)	2020	https://doi.pangaea.de/10.1594/PANGAEA.917894	
VME Elements	Geomorphology of the Oceans	Submarine Canyons	Vector (Shapefile, Polygon)	derived from 30 arc second	2020	https://bluehabitats.org/ https://doi.org/10.1016/j.margeo.2014.01.011	

Type	Data Source	Data Description	Data Format	Native Resolution	Collection Date(s)	Data Publically Available?	Contact for Data if not Public
				resolution (~1km at equator)			
Fishing	Interviews	Hooks, Longlines, Fish traps		1x1 km	Mid 2022-Mid 2023		Spanish framework of Marine Strategy
Fishing	GPS loggers	Hooks, Longlines, Fish traps		GPS tracks	2023		Spanish framework of Marine Strategy
Fishing	Observers at sea	Hooks, Longlines, Fish traps		GPS tracks	2023		Spanish framework of Marine Strategy

2.4 Mayotte

Mayotte is an island of volcanic origin in the northernmost Mozambique Channel (Figure 2.25, and is part of the Comoro Islands, and like them was created as a result of a former hot spot, the oldest of the Comoros archipelago, formed about 7.7 mya. Mayotte has an area of 374 km^2, and a coastline of length 185.2 km. The outer slopes range from 4° to 20° in inclination (up to 88° on some western flanks) and extend to 1000 m depth from the barrier reef in the north and east, and connect to the abyssal plain through two plateaus in the south and west. The slopes are characterized by geomorphological and substrate complexity, composed of a network of canyons surrounding all islands, plateaus, cliffs, volcanic cones and other rugged areas (Hanafi-Portier 2021). The Northern Mozambique Channel represents a homogeneous ecological biogeographic subunit characterized by a strong dynamic of gyres and eddies contributing to a high level of ecological connectivity and biodiversity between the islands, creating what is termed the Coral Triangle of the Western Indian Ocean. The Northern Mozambique Channel was declared an EBSA in 2015 (CBD 2015a). The Mayotte Natural Marine Park was established in 2010, and covers the entirety of Mayotte's territorial waters and exclusive economic zone (Figure 2.25). Coral reefs, seagrass meadows and open ocean fall under its protection. Commercial fishing is allowed within the park although oceanic tuna fishing vessels are not allowed to fish within 24 miles of the coast.

Mayotte is a marine region with high faunal diversity (Obura 2012). However, to date, the diversity of the deep-sea fauna is still poorly documented. An exploration program, Tropical Deep Sea Benthos (TDSB), led by the French National Natural History Museum (Muséum national d'Histoire naturelle; MNHN) and the French National Research Institute for Sustainable Development (Institut de Recherche pour le Dévelopement; IRD) established a geographically and taxonomically non-exhaustive inventory of benthic species from areas along the outer slopes of Mayotte dominated by hard bottom types. Biodiversity data on the Comoros archipelago are scarce. However, there was a dedicated expedition (BENTHEDI - Thomassin 1977) with sampling gears deployed down to 3700 m, and a further underwater camera survey consisting of five transects obtained during the BioMaGlo expedition in 2017 (BIOMAGLO - Corbari *et al.* 2017). Details of both surveys can be found in the MNHN BasExp database (Muséum national d'Histoire naturelle, Référentiel Campagnes). In Mayotte, there is currently a particular interest in mesophotic reefs and underwater caves, but data is still very preliminary and fragmentary (see for instance the Corcoma programme https://www.deep-blue-exploration.com/corcoma).

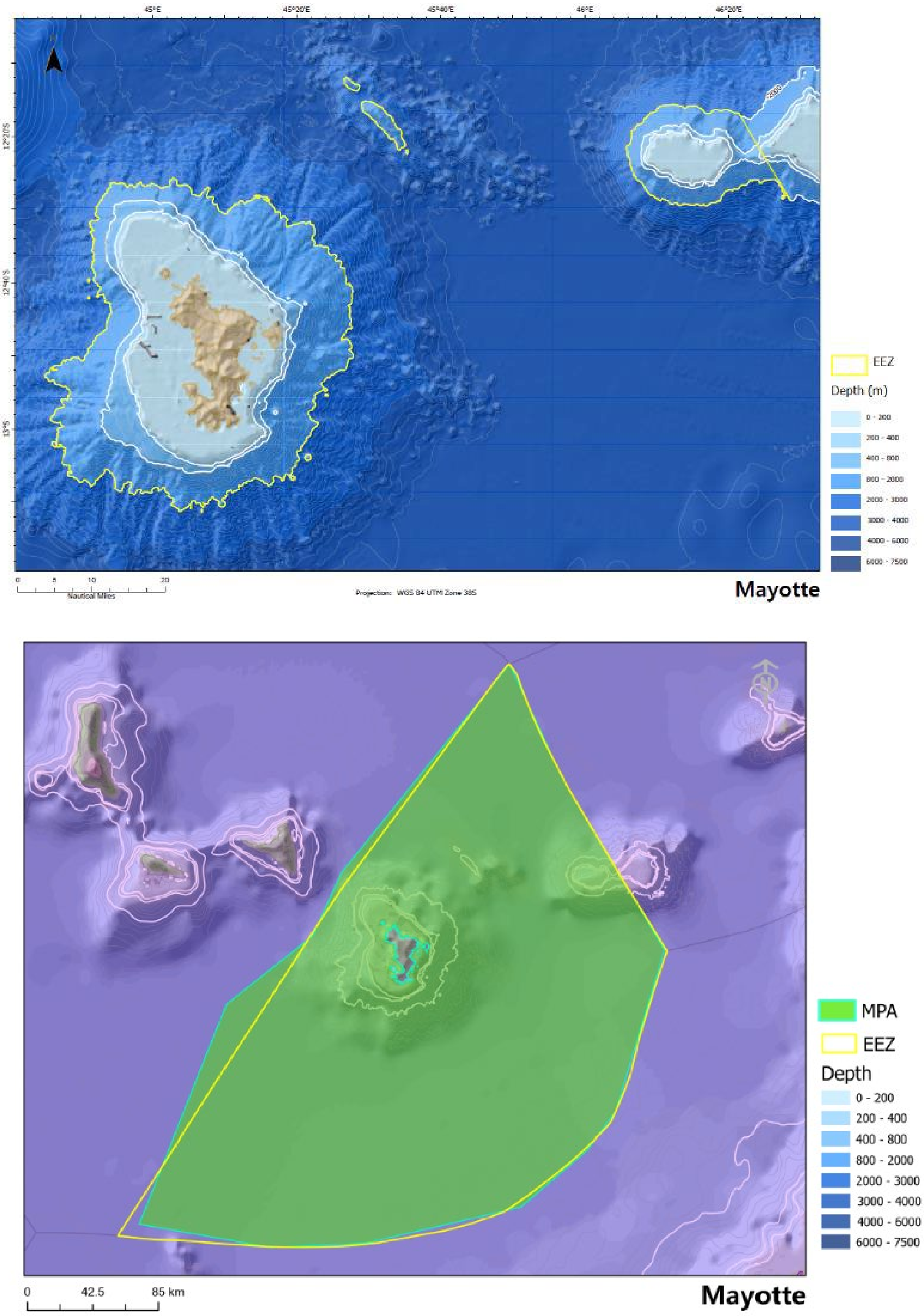

Figure 2.25. (Upper panel) Map of Mayotte showing the 400 m, 800 m and 2000 m depth contours (white) within the French Exclusive Economic Zone (EEZ). (Lower panel) Map of the location of the protected area covering the Mayotte EEZ.

2.4.1 VMEs likely to occur

The more recent BioMaGlo survey acquired seabed images (and data) in three slope areas: 1) the northwestern slopes characterized by a plateau at 600 m depth and covering 100 km^2 then surrounded by deeper crater-like or volcano network features, 2) the southwestern slopes with a deeper and larger plateau at 750 m covering 250 km^2, and 3) the eastern slopes, extending continuously down to 1000 m depth and characterized by shallower volcanic cones. In images along the volcanic island slopes, the fauna was typically dominated by cnidarians and poriferans. Cnidarians and poriferans represent key groups in the benthic ecosystem functioning, because they can host a large diversity of associated fauna. They are also highly vulnerable to anthropogenic impacts due to their low resilience (Schlacher *et al*. 2010) and thus are good vulnerable marine ecosystem (VME) indicators.

The Tropical Deep Sea Benthos (TDSB), led by the French National Natural History Museum (Muséum national d'Histoire naturelle; MNHN) and the French National Re-search Institute for Sustainable Development (Institut de Recherche pour le Dévelopement; IRD) – MNHN database BasExp - Référentiel Campagnes were consulted as advised from the Data Call (Section 1.5). They yielded data on benthic taxa collected in 1977 and in 2017 (Figures 2.26 and 2.27 respectively). The lists of unique species were provided and included VME indicator taxa.

Recent explorations of caves and mesophotic zones have brought to light organisms belonging to VME groups, but few real taxonomic identifications have been made so far, and some species (sponges, for example) are clearly new to science (T. Pérez, in progress).

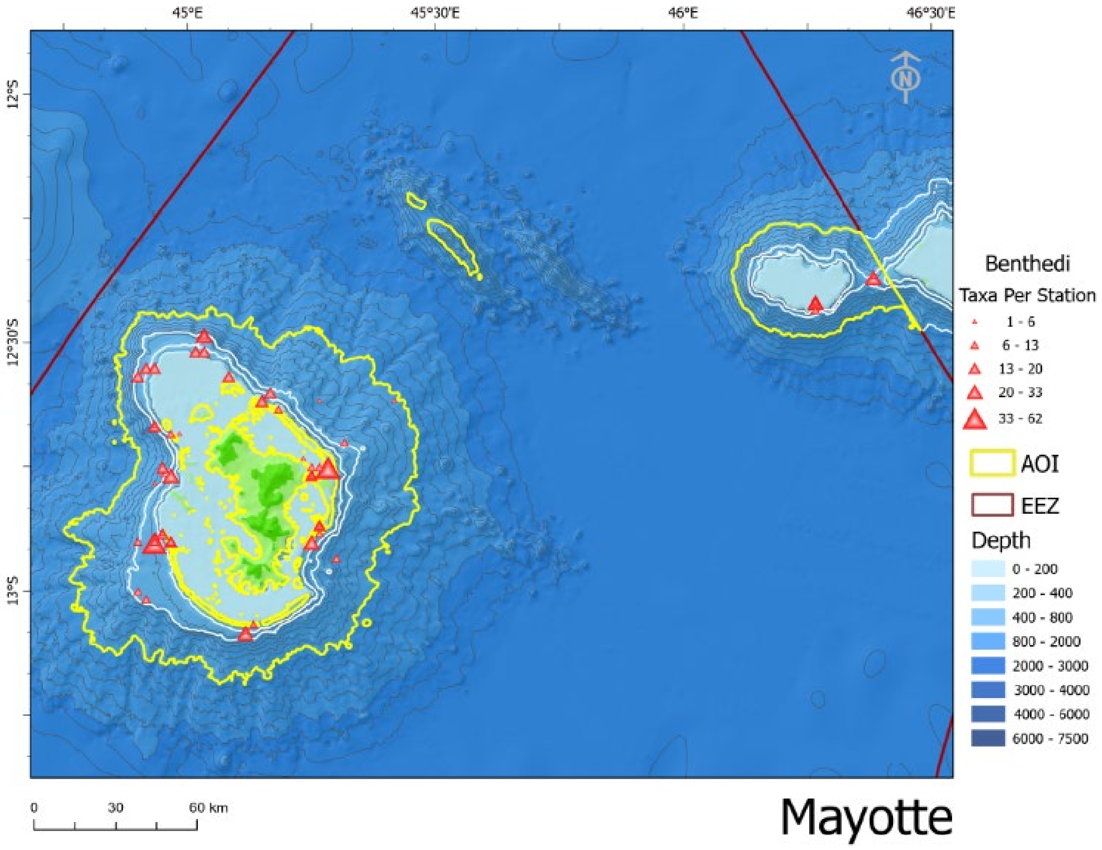

Figure 2.26. Map of Mayotte showing the number of benthic taxa per station collected in 1997 (N= 563) and deposited in the Muséum national d'Histoire naturelle (MNHN) databases. The 400 m, 800 m and 2000 m depth contours within the French Exclusive Economic Zone (EEZ) (the Areas of Interest) are indicated.

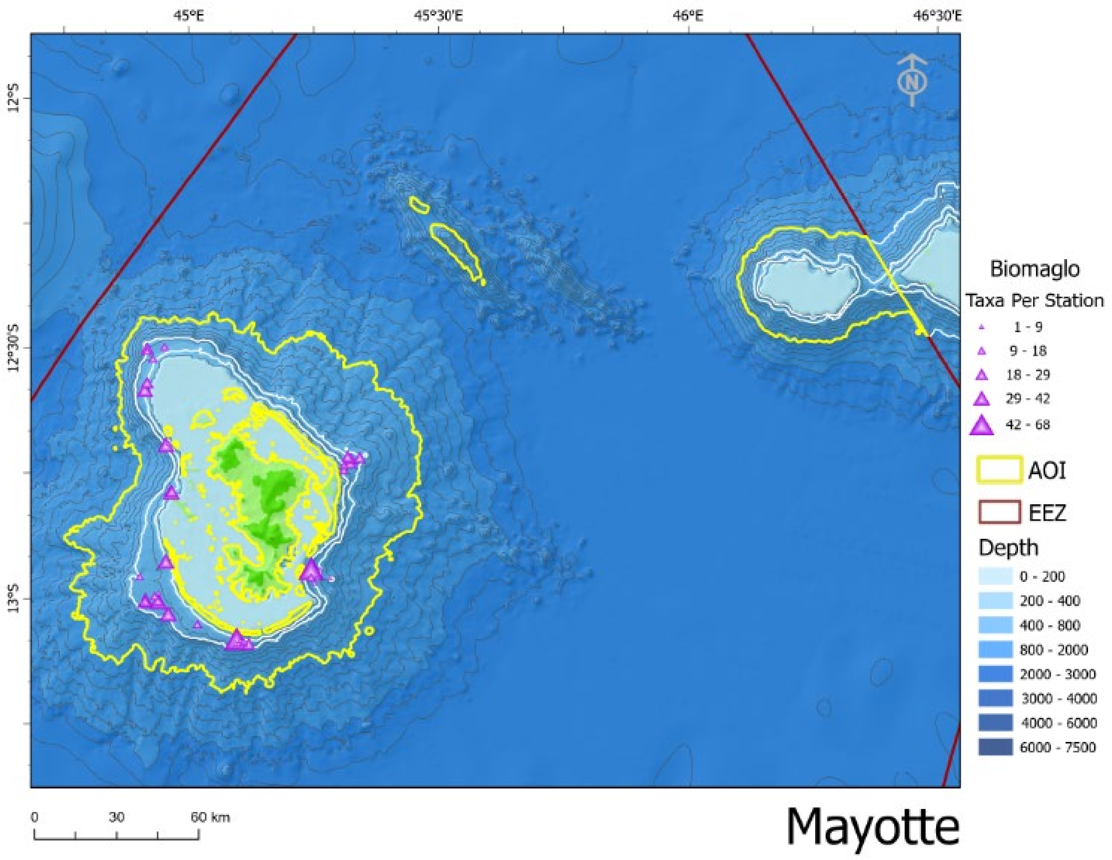

Figure 2.27. Map of Mayotte showing the number of benthic taxa per station collected in 2017 (N= 678) and deposited in the Muséum national d'Histoire naturelle (MNHN) databases. The 400 m, 800 m and 2000 m depth contours within the French Exclusive Economic Zone (EEZ) (the Areas of Interest) are indicated.

2.4.2 VME Elements

Steep flanks with slopes > 6.4° are prevalent in around Mayotte (Figure 2.28), while canyons (Figure 2.29) and seamounts (Figure 2.30) were also identified from the online open access databases (Section 1.7).

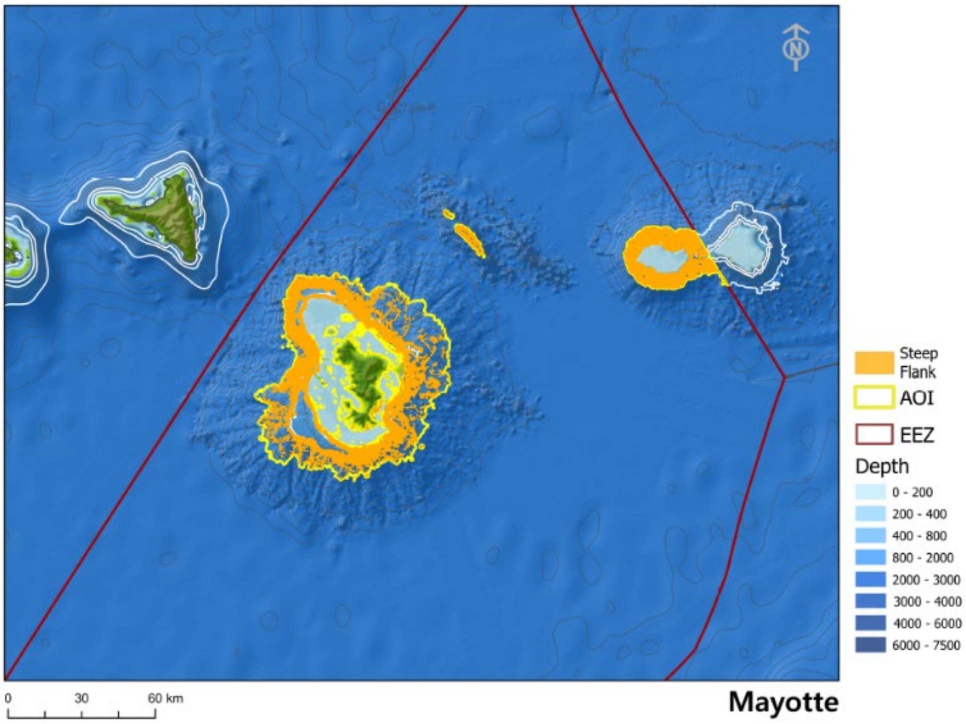

Figure 2.28. Map of Mayotte showing the location of steep flanks with slopes > 6.4° within the area of interest (AIO) of waters < 2000 m depth within the French Exclusive Economic Zone (EEZ).

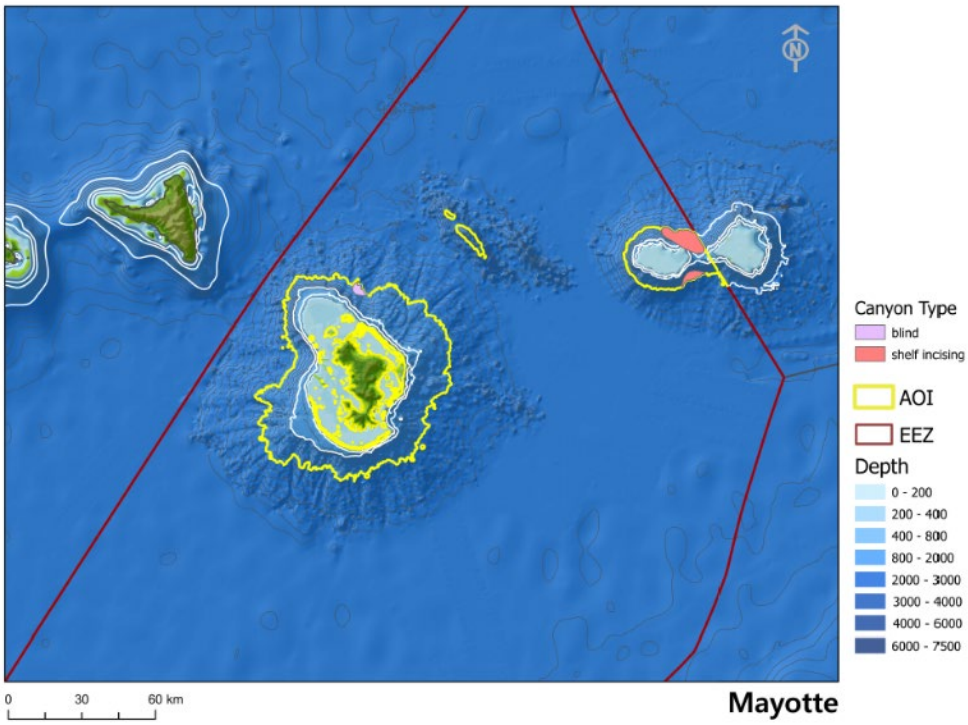

Figure 2.29. Map of Mayotte showing the location of shelf-indenting and blind canyons within the area of interest (AIO) of waters < 2000 m depth within the French Exclusive Economic Zone (EEZ).

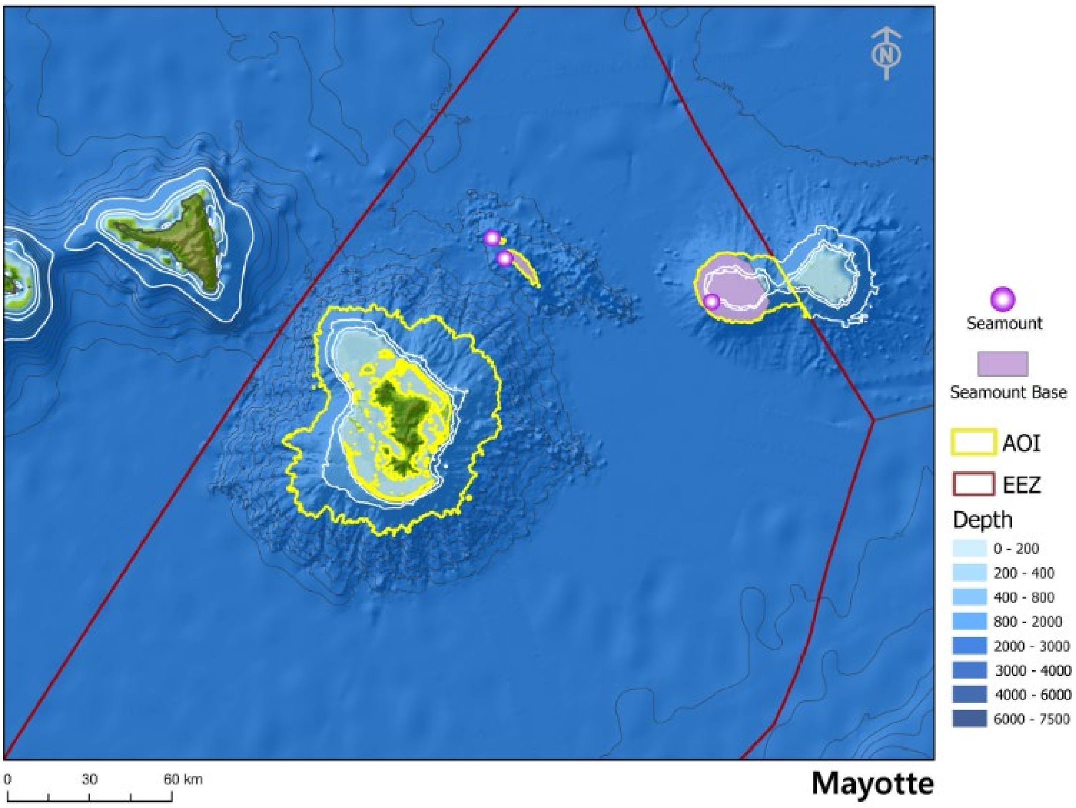

Figure 2.30. Map of Mayotte showing the location of seamounts and their bases within the area of interest (AIO) of waters < 2000 m depth within the French Exclusive Economic Zone (EEZ).

2.4.3 Overview of the local fisheries

In Mayotte, the professional coastal fishery is performed with small boats less than 10 meters. The two main fishing gears used for demersal fish are handlines (93 % of landings) and net (7 % of landings).

The Mayotte professional fleet is made of three active longliners and 137 small boats (with only a hundred actually active). In addition there is a non-professional fleet composed of around 400 small boats (with unknown activity level), and 700 canoes with motors and non-motored.

Estimations for 2021 suggest that about 684 t of fish were landed by small-scale professional and demersal fisheries for an estimated value of about 4019 euros (IFREMER 2022). Illegal and irregulated fishing uses the same vessels or pirogues which practice almost the same type of fishing (gear, effort, etc.). The fishery is non-selective and exploits almost 150 to 175 species (Wickel *et al*. 2014).

Additionally, there are three active longliners less than 12 meters that fish swordfish and tunas, outside the lagoon. Estimations for 2022 suggest that 33 t of fish were landed by these longliners (Bonhommeau *et al*. 2023).

2.4.4 Deep-sea fishing activity in Mayotte

There is no deep-water fishing operating deeper than 400 m as most of the fishing activity occurs in shallow waters. No trawling occurs in Mayotte. Three longliners are active down to around 200 m. One fisherman operates hooks with an electric reel at depths from 150 to 350 m. Additionally, some small units get snappers (*Etelis* sp.) during July and August as the water gets cooler, allowing deeper species to go into shallower depths.

Information regarding the deeper fishing activities was available through observer at-sea projects. The ICES WKOUTVME questionnaire was filled by the local staff of the Office Français de la Biodiversité and provided maps at the 5x5 km resolution (Figure 2.31). No fishermen responded to the questionnaire but local field observers will try to get some answer through *in situ* interviews.

Fishing activities in Mayotte do not seem to interact or interfere with VMEs because it seems that fishermen don't fish in deep water, or at least not at 400 m. Interactions may occur between deep-water fish species moving into shallower waters as noted for the snappers. More research is needed to anticipate the development of this fishing method by fishers and the effect on the environment.

Information on deep-sea species

The initial species list was locally updated and summarized below. Data were collected through the Data Collection Framework following the protocol set by IFREMER. Conventions exist between IRD (French institute for Research and Development) and PNMM (Mayotte National Marine Park) to collect data for local research studies. Since January 2024 on longliners, additional data are collected: species data (target catch, bycatch), biological parameters, genetic samples.

PNMM has had projects on demersal species including deep-water species:

- Demerstock: 1 year sampling (Sept 2022 – Sept 2023) to collect data on six species in Mayotte, including two deep-water species: *Aphareus rutilans* and *Etelis carbunculus*. *Etelis carbunculus* was found locally by genetics to be a mix between two species : *E. carbunculus* and *E. boweni* (the last a new species to science that is currently being prepared for publication).
- Prospecting of deep demersal resources around Mayotte – campaign between July 2004 and June 2005 (Herfaut 2005).
- Monitoring fishery activities in Marine Natural Park of Mayotte. Summary of data collected with the programme SONDPAL (using Temperature Depth Recorders) in longliners (Bauchet 2015).

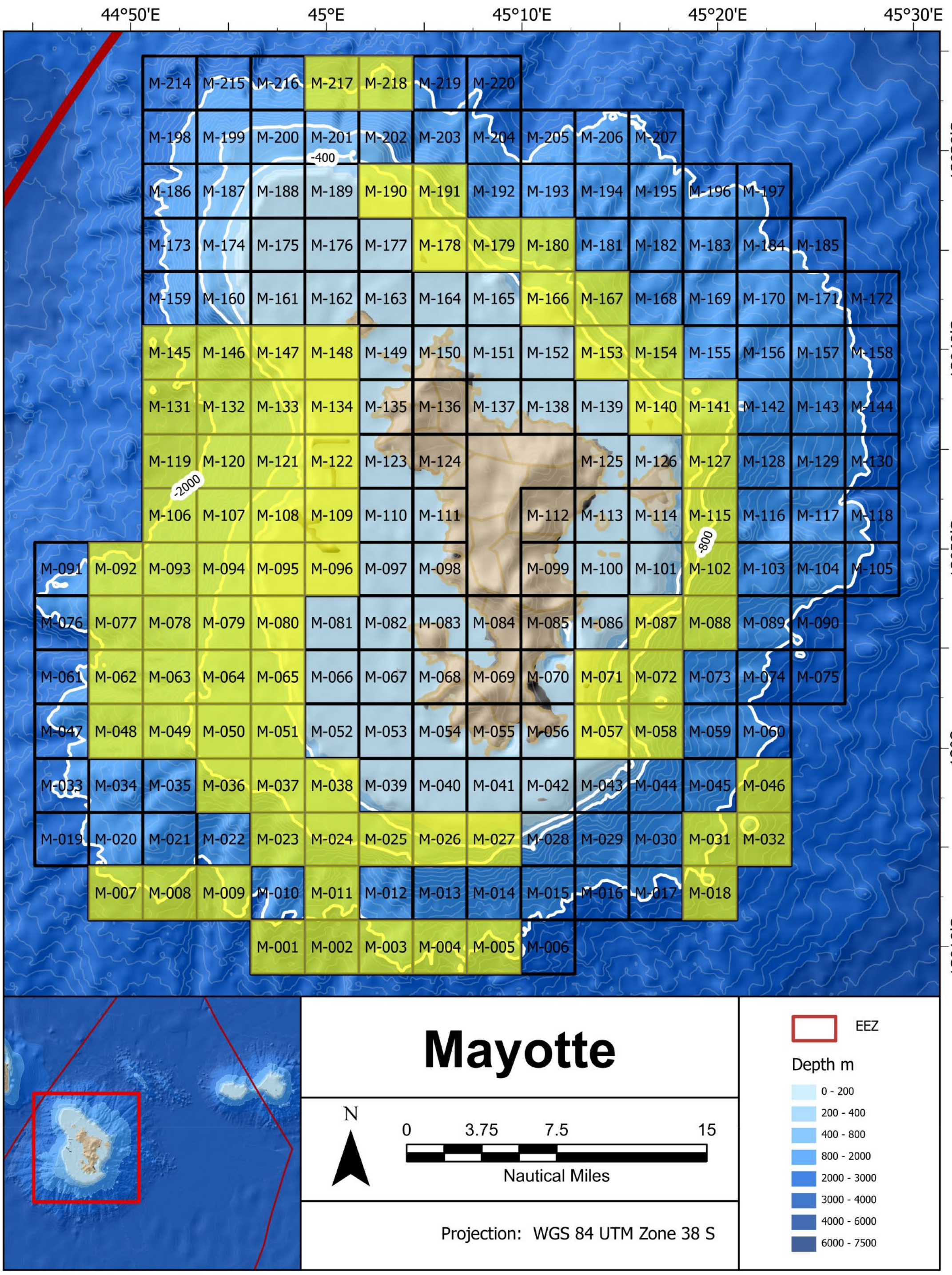

Figure 2.31. Map of fishing activity based on responses to the ICES WKOUTVME questionnaire.

2.4.5 List of deep-sea fish species for Mayotte

Order	Species	FAO Code	Name in Country	Local Name	Depth (m)	IUCN status
Aulopiformes	Alepisaurus ferox	ALX	Lancier longnez		0 - 1830	Least Concern
Beryciformes	Beryx decadactylus	BXD	Béryx commun		110-1300	Least Concern
Beryciformes	Beryx splendens	BYS	Béryx long		180-1300	Least Concern
Carangiformes	*Decapterus* spp.	SDX	Comètes	Makro, Hanale	0 - 550	
Carangiformes	Tetrapturus angustirostris	SSP	Makaire à rostre court	Mbasi	0 - 1830	Data Deficient
Carangiformes	Rachycentron canadum	CBA	Cobia		0 - 1200	Least Concern
Carangiformes	Xiphias gladius	SWO	Espadon	Mtwaro, msokotalaya	1 - 800	Near Threatened
Carcharhiniformes	Carcharhinus albimarginatus	ALS	Requin pointe blanche	Papa	1 - 800	Vulnerable
Carcharhiniformes	Prionace glauca	BSH	Requin peau bleue	Papa	0 - 1082	Near Threatened
Carcharhiniformes	Triaenodon obesus	TRB	Requin corail	Papa	0 - 330	Vulnerable
Carcharhiniformes	Galeocerdo cuvier	TIG	Requin tigre commun	Papa	0 - 800	Near Threatened
Carcharhiniformes	Sphyrna lewini	SPL	Requin-marteau hali-corne	Papa	0 - 1043	Critically Endangered
Carcharhiniformes	Sphyrna mokarran	SPK	Grand requin marteau	Papa	0 - 300	Critically Endangered
Carcharhiniformes	Centrophorus moluccensis	DGX	Squale-chagrin cagaou		125 - 823	Vulnerable
Carcharhiniformes	Squalus megalops	DOP	Aiguillat nez court		30 - 750	
Eupercaria/misc	Cephalopolis aurentia	CFZ	Vieille dorée	Tsehele	40 - 300	
Eupercaria/misc	Branchiostegus doliatus	UGY	Malacanthe à rayures		90 - 612	
Eupercaria/misc	Aphareus rutilans	ARQ	Vivaneau rouillé	Molé moro	0 - 330	Least Concern
Eupercaria/misc	Etelis carbunculus	ETA	Vivaneau rubis	Mdugui	90-400	Least Concern
Eupercaria/misc	*Etelis boweni*		Vivaneau barrique	Mdugui	??	
Eupercaria/misc	Etelis coruscans	ETC	Vivaneau flamme	Mdugui	45 - 400	Least Concern
Eupercaria/misc	Etelis radiosus	EEW	Vivaneau ti dents	Mdugui	90-360	
Eupercaria/misc	Pristipomoides argyrogram-micus	LRY	Colas orné	Jaune thomas	0 - 350	Least Concern
Eupercaria/misc	Pristipomoides auricilla	LWA	Colas drapeau		90 - 360	Least Concern
Eupercaria/misc	Pristipomoides filamentosus	PFM	Colas fil	Mdugui	40 - 400	Least Concern
Eupercaria/misc	Pristipomoides multidens	LRI	Colas à bandes dorées	Mdugui	40 - 350	Least Concern
Eupercaria/misc	Pristipomoides zonatus	LWZ	Colas bagnard	Jaune thomas	70 - 300	Least Concern
Eupercaria/misc	Heteropriacanthus cruenta-tus	HTU	Beauclaire de roche	Anliati	0 - 300	Least Concern

Order	Species	FAO Code	Name in Country	Local Name	Depth (m)	IUCN status
Lamniformes	*Isurus spp.*	MAK	Requins taupes	Mako, Papa	0-750	
Lampriformes	*Lampris guttatus*	LAG, RRG	Opah		0 - 500	Least Concern
Mulliformes	*Parupeneus heptacanthus*	RQF	Capucin à tache rouge	Mhudraji, Ndzilashé	0 - 350	Least Concern
Myliobatiformes	*Pteroplatytrygon violacea*	PLS	raie		1 - 381	
Myliobatiformes	*Taeniura meyeni*	RTE	Pastenague éventail		1 - 500	
Ophidiiformes	*Brotula multibarbata*	WBM	Mostelle tropicale		0 - 650	Least Concern
Ophidiiformes	*Spectrunculus grandis*	OSG	Abadèche boulotte		800 - 4300	Least Concern
Perciformes Serranoidei	*Epinephelus chlorostigma*	EFH	Mérou pintade	Tsehele	4 - 300	Least Concern
Perciformes Serranoidei	*Epinephelus magniscuttis*	EEJ	Mérou grandes écailles	Tsehele	0 - 300	Least Concern
Perciformes Serranoidei	*Epinephelus morrhua*	EEP	Mérou comète	Tsehele	80 - 370	
Perciformes Serranoidei	*Epinephelus tauvina*	EPT	Mérou loutre	Tsehele	0 - 300	Data Deficient
Perciformes Serranoidei	*Variola louti*	VRL	Croissant queue jaune	Kutsi mshia dzindzano	3 - 300	Least Concern
Scombriformes	*Eumegistus illustris*	EBS	Brème noire	Castagnole	1 - 620	
Scombriformes	*Taractichthys steindachneri*	TST	Brème à longues nageoires		0 - 700	
Scombriformes	*Promethichthys prometheus*	PRP	Escolier clair		80 - 800	Least Concern
Scombriformes	*Gempylus serpens*	GES	Escolier serpent		0 - 600	Least Concern
Scombriformes	*Ruvettus pretiosus*	OIL	Rouvet	Niesa	100 - 975	Least Concern
Scombriformes	*Thyrsitoides marleyi*	THM	Escolier gracile	Muhudana	0 - 400	
Squaliformes	*Alopias vulpinus*	ALV	Renard		0 - 800	Vulnerable
Squaliformes	*Isistius brasiliensis*	ISB	Squalelet féroce		0 - 3700	Least Concern
Tetraodontiformes	*Mola mola*	MOX	Poisson lune		0 - 1515	Vulnerable
Carangiformes	*Caranx lugubris*	NXU	Carangue noire	Kawa ndzidu	12 - 354	Least Concern
Carangiformes	*Seriola dumerilli*	AMB	Seriole couronnee	Kawa langisi	1 - 385	
Perciformes Serranoidei	*Epinephelus tukula*	EWL	Merou patate	Tsehele	10 - 400	Least Concern

2.4.6 List of VME Indicator Species for Mayotte

X' means direct evidence fitting to the criteria; blank cell means that the criterion was not met.

	VME Representative Taxa	Functional Significance	Fragility	Life History	Structural Complexity
Hard-bottom sponge gardens	AGELASIDAE	X	X		X
	Callyspongia spp.	X	X		X
	PETROSIDAE including *Xestospongia testudinaria*	X	X		X
	APLYSINIDAE	X	X		X
	Astrosclera willeyana	X			X
Submarine caves	*Astrosclera willeyana*	X			X
	OSCARELLIDAE		X	X	
	PLAKINIDAE		X	X	
	CLATHRINIDAE		X	X	
	LEUCALTIDAE		X	X	
	GRANTIIDAE		X	X	
	Plectroninia spp.		X	X	

2.4.7 Metadata of relevant data sources available for Mayotte

Type	Data Source	Data Description	Data Format	Native Resolution	Collection Date(s)	Data Publicly Available?	Contact for Data if not Public
VME	Hanafi-Portier et al. 2023	Benthic megafaunal assemblages from the Mayotte island outer slope: a case study illustrating workflow from annotation on images to georeferenced densities in sampling units	csv, pdf	500 – 1100 m		https://www.seanoe.org/data/00860/97234/	
VME Indicators	Mulochau et al. 2019	Inventory of species between 50m and 150m in Mayotte (1rst campaign)	pdf	50 – 150 m	2018 - 2019	https://hal.science/hal-03201991/file/rapport%20MesoMay%201.pdf	thierry mulochau biorecif@gmail.com
VME Indicators	Mulochau et al. 2022	Inventory of species between 50m and 150m in Mayotte (3rd campaign)	pdf	50-150 m	2021		thierry mulochau biorecif@gmail.com
VME Indicators	Audru et al. 2006	Bathymay : la structure sous-marine de Mayotte révélée par l'imagerie multifaisceaux	pdf		2004	https://www.sciencedirect.com/science/article/pii/S1631071306002288	
VME Indicators	CORCOMA DEEP BLUE EXPLORATION	Mesophotic dives, species inventory	photos, videos			no	Heloize Rouze, Deep Blue Ocean rouzeh@triton.uog.edu
VME Indicators	Sponge course	Cave dives	photos, samples	data point		not yet, data to be published	T. Pérez & E. Corse
VME Elements	GEBCO	GEBCO grided bathymetric data	Raster (Geotiff)	15 arc second (~500m at equator)	2023	https://www.gebco.net/data_and_products/gridded_bathymetry_data/gebco_2023/	

Type	Data Source	Data Description	Data Format	Native Resolution	Collection Date(s)	Data Publicly Available?	Contact for Data if not Public
VME Elements	World Seamount Database	Seamounts	Vector (Shapefile, Point = Peak, Polygon = Base)	derived from 30 arc second resolution (~1km at equator)	2021	https://doi.pangaea.de/10.1594/PANGAEA.921688	
VME Elements	GEBCO	Steep Flanks	Vector (Shapefile, Polygon)	15 arc second (~500m at equator)	2023	https://www.gebco.net/data_and_products/gridded_bathymetry_data/gebco_2023/	
VME Elements	Geomorphology of the Oceans	Submarine Canyons	Vector (Shapefile, Polygon)	derived from 30 arc second resolution (~1km at equator)	2020	https://bluehabitats.org/ https://doi.org/10.1016/j.margeo.2014.01.011	
Habitat	Dupont *et al.* 2016	Habitat type of Mayotte, Geyser and Zélée	shp, WGS 84 / UTM zone 38S (EPSG:32738)	3 m	2009-2015	http://dx.doi.org/10.12770/9ae71d6e-5659-4a25-82d7-91d88814cf54	pascal.mouquet@ird.fr
Geomorphology	Dullo *et al.* 1998	Morphology and sediments of the fore-slopes of Mayotte, Comoro Islands : direct observations from a submersible	pdf			Submitted by PNMM	
Fishing	Observer at sea project	Longlines		5x5 km	2015-2019,2024		L'Office français de la biodiversité (OFB)
Fishing	Observer at sea project	Hooks with electric reel		5x5 km	2024		L'Office français de la biodiversité (OFB)

2.5 Réunion

Réunion is an island off southern Africa, in the Indian Ocean, east of Madagascar (Figure 2.32). It is an active basaltic shield volcano, 220 km in diameter, rising ~7000 m from the Indian Ocean floor. The island is constructed on Paleocene oceanic crust and is considered to be the surface expression of a hotspot (Duncan 1990). The submarine flanks of Réunion are mainly debris avalanche deposits (Oehler *et al*. 2008).

La Pérouse is an extinct volcano rising from the abyssal plain (5000 m depth) up to the surface euphotic zone. Its formation is thought to have occurred 8 – 10 million years ago, in the same epoch as Réunion (Marsac *et al*. 2020) as a result of an intraplaque hotspot. La Pérouse is well-known by recreational fishers who venture to the seamount from Réunion, and by professional fishers operating the Réunion-based longline fleet (Marsac *et al*. 2020). A Natural Marine Reserve is located around the island in shallow waters. Created in 2007, the Natural Marine Reserve extends along 40 km of coastline (20 km of which are coral reef), from Cap La Houssaye in Saint-Paul, to la Roche aux Oiseaux in Etang-Salé. This ecosystem provides shelter to more than 3500 marine species.

A field survey conducted with a ROV submarine system was carried out between 100 and 400 m deep on the volcanic slopes of Réunion Island (Durville *et al*. 2009). Twenty dives were conducted on the south-east of the island on volcanic lava flows, and 13 dives were conducted on the west coast, associated with older geological substrates. Pillow-lavas were recorded at a depths of 250 m on the 2007 lava flows, revealing that lava has erupted at these depths. The substrate at these depths remains unstable. Concerning the benthic communities, 66 species of fish, 16 species of cnidarian, eight species of arthropods and seven species of echinoderms were noted. Some of them not recorded before off Réunion Island.

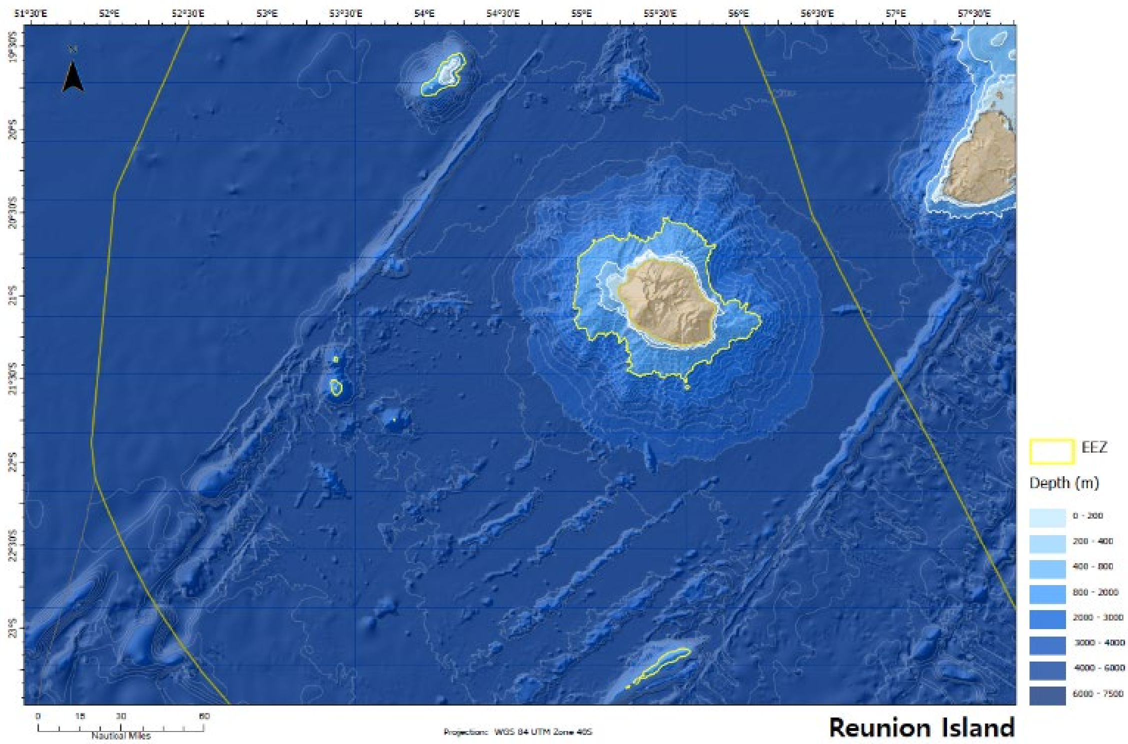

Figure 2.32. Map of Réunion Island showing the 400 m, 800 m and 2000 m depth contours (white) and the French Exclusive Economic Zone (EEZ).

2.5.1 VME Elements

Steep flanks with slopes > 6.4° are prevalent in around Réunion (Figure 2.33) and seamounts are present (Figure 2.34). In Réunion, there is currently a particular interest in mesophotic reefs and underwater caves, but data is still very preliminary and fragmentary. A few cave explorations in the perimeter of the Natural Marine Reserve have already revealed several new sponges belonging to the VMEs, and new descriptions are in progress. Réunion likely has many more caves carved out of lava flows.

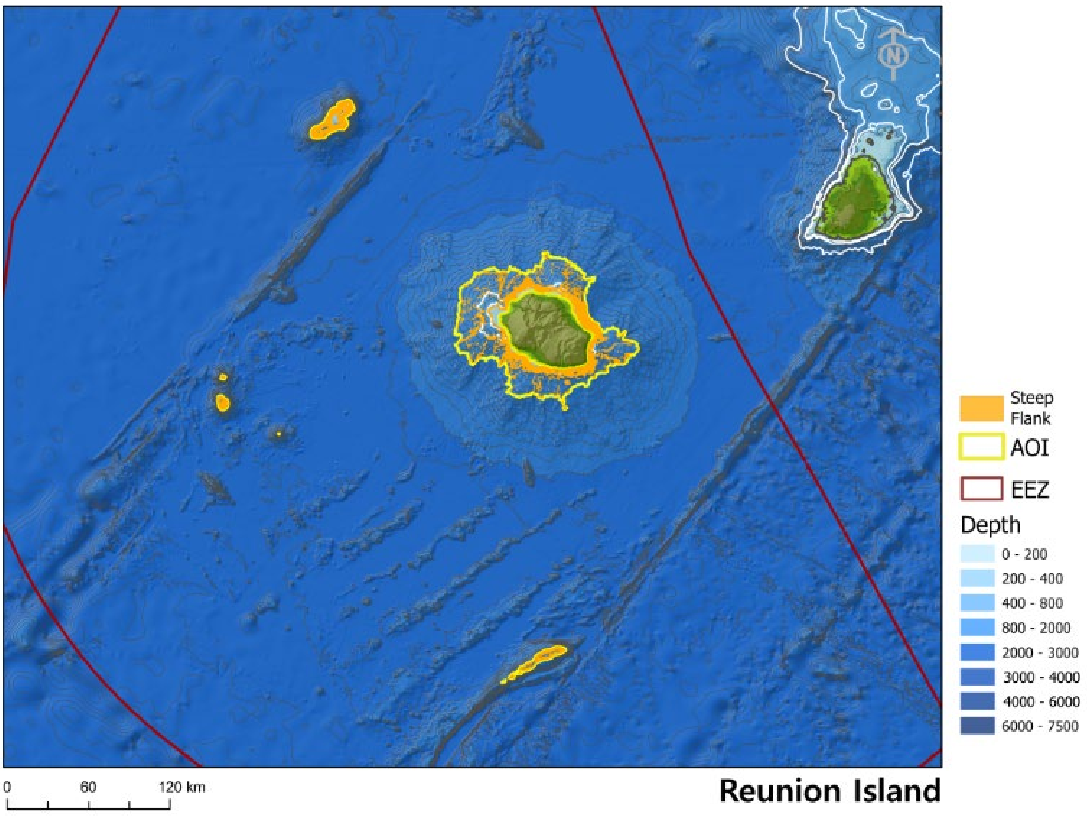

Figure 2.33. Map of Réunion showing the location of steep flanks with slopes > 6.4° within the area of interest (AOI) of waters < 2000 m depth within the French Exclusive Economic Zone (EEZ).

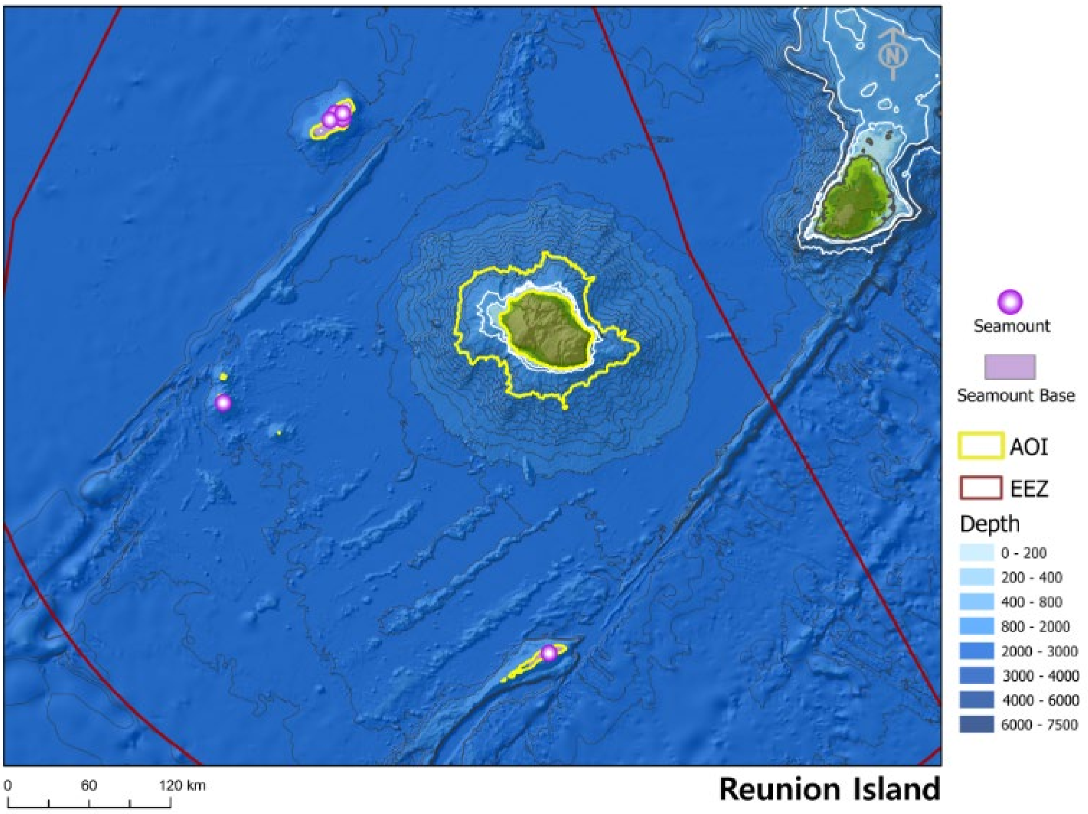

Figure 2.34. Map of Réunion showing the location of seamounts and their bases within the area of interest (AOI) of waters < 2000 m depth within the French Exclusive Economic Zone (EEZ).

2.5.2 Overview of the local fisheries

Réunion's fleet is made up of three fleets: offshore longliners, coastal longliners and coastal small-scale fishing. Together catches of ~ 2600 t of pelagic and demersal fish per year are taken (1700 t for offshore longline, 500 t for coastal longline and 400 t for small-scale coastal fishing).

Offshore longliners in Réunion Island

Active since the early 1990s, this fleet targets swordfish using the surface drifting longline technique. The longline consists of a monofilament nylon mother line on which 12 to 20 m long leaders are attached with quick-release fasteners. The leaders are spaced dozens of meters apart and carry a hook at their end (tuna, straight and/or circle hooks are generally mixed on the same line), which is baited with squid or mackerel. Maximum fishing depth is generally between 30 and 150 meters. Depending on the size of the vessel, the length of the mother line varies from 20 to 100 km. Landings by the semi-industrial longline fleet for the period 2000-2022 are shown in Figure 2.35 and Table 2.3 presents an extract of landings data for the last 5 years (2016 - 2022). Apart from a slight peak in 2005, there has been a gradual decline in catches (from 3300 t in 2007 to 1664 t in 2021), with variable effort ranging from around 3 to 4 million hooks. The specific composition of catches for the main commercial species in 2021 is 48% Swordfish, 19% Yellowfin Tuna, 9% Bigeye Tuna and 10% Albacore (Figure 2.35).

Table 2.3 Landings (in tonnes) by species (or species group) and annual fishing effort (millions of hooks) of the Réunion offshore longline fleet (LOA > 12 m) for the period 2015 - 2022 in the IOTC area of competence.

Year	Swordfish	Yellowfin Tuna	Albacore	Bigeye Tuna	Other	Total	Effort (*10^6 hooks)
2015	692	302	263	362	193	1812	3.53
2016	771	322	232	343	217	1885	4
2017	500	199	151	187	134	1171	3.1
2018	533	253	193	154	149	1282	3.3
2019	668.5	302.4	193.3	132	123.7	1419.9	4.05
2020	771.3	338.9	207.6	149.5	145.0	1613.0	3.69
2021	793.9	316.6	230.6	154.2	168.4	1663.6	3.42
2022	843.8	275.1	400.1	117.8	139.3	1776.1	3.61

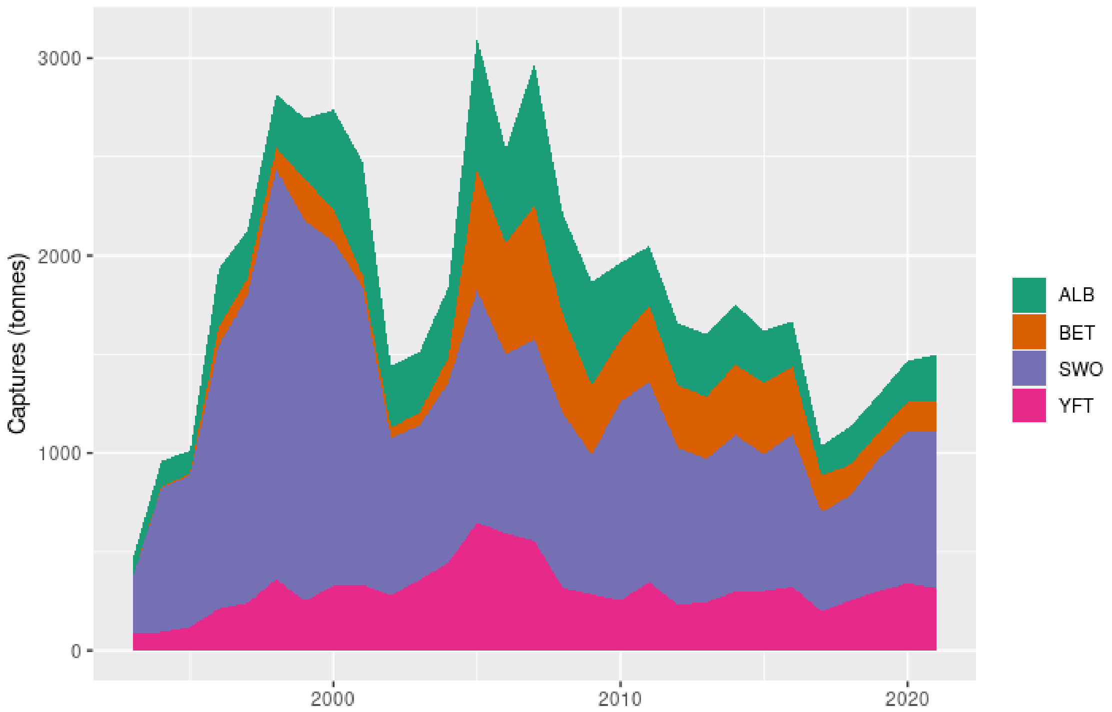

Figure 2.35. Historical annual catches by species by the Réunion longline fleet (LOA > 12 m) in the IOTC area.

Coastal longliners less than 12 m.

Coastal longliners (21 units) operate in a zone between 12 and 20 miles from the coast, using a similar fishing technique to offshore longliners. Catches are relatively stable, with a drop in 2017. In 2020, fishing effort amounted to 0.488 million hooks for an estimated landed production of 388.6 t, reflecting a decrease compared to 2018 of 29% and 5%, respectively (Table 2.4). Swordfish is the main species targeted and accounts for 32% of landings.

Table 2.4. Landings (in tonnes) by species (or species group) and annual fishing effort (millions of hooks) of the Réunionese coastal longline fleet (LOA < 12 m) for the period 2015 - 2022 in the IOTC area of competence.

Year	Swordfish	Yellowfin Tuna	Albacore	Bigeye Tuna	Other	Total	Effort (*10^6 hooks)
2015	145.1	102.7	75.2	29.2	76.1	428.3	0.662
2016	161.4	94.5	73.7	19.8	93.5	442.9	0.614
2017	116	61	53	12	63	305	0.733
2018	144	95	65	19	84	407	0.688
2019	159.9	85.3	55	14.6	61.9	376.7	0.521
2020	125.4	102.2	60.4	14.5	86.2	388.6	0.488
2021	120.4	110.0	90.1	22.1	100.4	443.0	0.454
2022	157.4	118.6	111.8	22.5	91.6	501.9	0.601

Small-scale coastal fishing

Small-scale inshore fishing (109 units) operates within the 12-mile limit. Most of these vessels are engaged in line fishing (trolling lines, handlines, mechanized lines, drifting or set longlines). The landings data presented for Réunion's small-scale inshore fisheries (Table 2.5) are derived from estimates based on landings surveys and the activity of the fishing units surveyed. This fleet catches 70% large pelagics, 15% small pelagics and 15% demersal fish.

Table 2.5. Landings (in tonnes) by species of small-scale coastal fisheries in Réunion for the period 2015 - 2022 in the IOTC area of competence.

Year	Yellowfin Tuna	Albacore	Listao	Marlins	Mahi	Wahoo	Other	Total
2015	222.4	30.3	8.2	62.1	108.1	41.4	22	494.5
2016	310.7	13.3	17.5	67	154.4	68.8	2.9	634.6
2017	277.1	67.2	28.3	86.1	158.2	55.3	4.4	676.6
2018	275.5	18.7	34.5	186.7	157.5	104.1	4.1	781.1
2019	166.3	20.6	15.3	75.5	104.2	81.1	4.75	467.75
2020	208.1	17.8	23.5	189.7	52.8	45.1	2.1	539.4
2021	235.2	16.5	30.3	82.7	101.7	38.0	11.2	515.6
2022	114.7	21.0	8.9	32.7	78.1	14.6		274.1

2.5.3 Deep-sea fishery in Réunion

Fishing gears operating deeper than 300 m in Réunion Island are limited to electric rod and reel. The maximum depth for this fishing fleet is 600 m. It is one of the métiers used by the local small-scale fishery. This gear is used by 70-80 boats of less than 12 m length which realize ~1800 fishing trips a year and land 40-50 tonnes of fish every year. This fleet is also seasonal, and catches mostly pomfrets (EBS, TST), jobfish, and snappers. There are no known specific impacts of the fishing gears on the bottom. Most of the other fishing gears in Réunion are at the surface (longline, trolling) or at shallow depth (rod and reel, beach seine). No trawling occurs in Réunion Island.

There was no response from the WKOUTVME questionnaires apparently due to some communication/transmission difficulty, therefore the minimum spatial scale for reporting on the fishing footprint is currently restricted to local statistical sectors from the Fishery Information System from IFREMER, which have a lower resolution than 5 x 5 km and cover large depth bands. Vessel census is carried out every year and sampling of landings and effort is carried out at the harbour.

2.5.4 List of deep-sea fish species for Réunion

The initial species list was locally updated. Data were collected through the Data Collection Framework following the protocol set by IFREMER.

Order	Species	FAO Code	Name in Country	Local Name	Depth (m)	IUCN status
Beryciformes	*Beryx decadactylus*	BXD	Béryx commun		110-1300	Least Concern
Beryciformes	*Beryx splendens*	BYS	Béryx long		180-1300	Least Concern
Carcharhiniformes	*Centrophorus moluccensis*	DGX	Squale-chagrin cagaou	Requins zépines aiguillats	125 - 823	Vulnerable
Carcharhiniformes	*Squalus megalops*	DOP	Aiguillat nez court	Requins zépines aiguillats	30 - 750	Vulnerable
Carcharhiniformes	*Emissoles*	TRK			0 - 400	Vulnerable
Eupercaria/misc	*Cephalopholis aurentia*	CFZ	Vieille dorée	Rouge bâtard, Ananas bâtard, Rouge peau dure	40 - 300	Least Concern
Eupercaria/misc	*Branchiostegus doliatus*	UGY	Malacanthe à rayures	Jacquot, Sangol, Cabot mauricien	90 - 612	
Eupercaria/misc	*Aphareus rutilans*	ARQ	Vivaneau rouillé	Vivaneau lantanier, Largenté, Lantanier argenté	0 - 330	Least Concern
Eupercaria/misc	*Etelis carbunculus*	ETA	Vivaneau rubis	Gros tête, Vivaneau rouge, Vivaneau rubis	90-400	Least Concern
Eupercaria/misc	*Etelis coruscans*	ETC	Vivaneau flamme	La Flamme	45 - 400	Least Concern
Eupercaria/misc	*Etelis radiosus*	EEW	Vivaneau pâle	Ti dents	90-360	Least Concern
Eupercaria/misc	*Pristipomoides argyrogrammicus*	LRY	Colas orné	Cerf volant, Jaune thomas	0 - 350	Least Concern
Eupercaria/misc	*Pristipomoides auricilla*	LWA	Colas drapeau	Vivaneau cendré	90 - 360	Least Concern
Eupercaria/misc	*Pristipomoides filamentosus*	PFM	Colas fil	Vivaneau blanc, Kalbal	40 - 400	Least Concern
Eupercaria/misc	*Pristipomoides multidens*	LRI	Colas à bandes dorées	Gros Zecail	40 - 350	Least Concern
Eupercaria/misc	*Pristipomoides zonatus*	LWZ	Colas bagnard	Jaune thomas, Jaune de creux, Vivanveau rayé	70 - 300	Least Concern
Eupercaria/misc	*Cookeolus japonicus*	CJN	Beauclaire longues ailes	Boclair de creux	0 - 400	Least Concern
Holocentriformes	*Ostichthys kaianus*	HWK	Soldat japonais rayé	Cardinal de creux, Brosse,	180 - 640	Least Concern

Order	Species	FAO Code	Name in Country	Local Name	Depth (m)	IUCN status
				Tabouret, Cardinal tambour		
Perciformes Scorpaenoidei	*Neoscorpaena nielseni*	QRF		Grondin, Rascasse de creux	40 - 507	Data Deficient
Perciformes Scorpaenoidei	*Setarches guentheri*	SVG	Rascasse serran	Grondin, Rascasse de creux	150 - 850	Least Concern
Perciformes Serranoidei	*Epinephelus morrhua*	EEP	Mérou comète	Cabot de fond	80 - 370	Least Concern
Perciformes Serranoidei	*Epinephelus radiatus*	EZR	Mérou zébré	Cabot rayé, Cabot de fond	18 - 383	Least Concern
Perciformes Serranoidei	*Hyporthodus octofasciatus*	EWO	Mérou huit raies	Plate de creux, Cabot sale	150 - 300	Least Concern
Polymixiiformes	*Polymixia berndti*	QIJ	Barbe	Barbu de creux	0 - 640	Least Concern
Scombriformes	*Eumegistus illustris*	EBS	Brème noire	Zombas, Machong, Castagnole, Bigue noire	1 - 620	
Scombriformes	*Taractichthys steindachneri*	TST	Brème à longues nageoires	Zombas, Machong, Zirondelle	0 - 700	
Scombriformes	*Lepidocybium flavobrunneum*	LEC	Escolier noir	Escolier	200 - 1100	Least Concern
Scombriformes	*Promethichthys prometheus*	PRP	Escolier clair	Snoek	80 - 800	Least Concern
Scombriformes	*Rexea prometheoides*	RXP	Escolier royal	Snoek	100 - 975	
Scombriformes	*Ruvettus pretiosus*	OIL	Rouvet	Thon l'huile, Thon la chiasse, Saptille, Fuka, La misik	100 - 975	Least Concern
Scombriformes	*Thyrsitoides marleyi*	THM	Escolier gracile	Barracuda de creux, Snoek	0 - 400	
Perciformes Scorpaenoidei	*Pontinus* spp.	PZM				

2.5.5 List of VME Indicator Species for Réunion

'X' means direct evidence fitting to the criteria; blank cell means that the criterion was not met.

	VME Representative Taxa	Functional Significance	Fragility	Life History	Structural Complexity
Hard-bottom sponge gardens	AGELASIDAE	X	X		X
	AXINELLIDAE				
	Callyspongia spp.	X	X		X
	PETROSIDAE including *Xestospongia testudinaria*	X	X		X
	APLYSINIDAE	X	X		X
	Astrosclera willeyana	X			X
Submarine caves	*Astrosclera willeyana*	X			X
	OSCARELLIDAE		X	X	
	PLAKINIDAE		X	X	
	CLATHRINIDAE		X	X	
	LEUCALTIDAE		X	X	
	GRANTIIDAE		X	X	
	Plectroninia spp.		X	X	

2.5.6 Metadata of relevant data sources available for Réunion

Type	Data Source	Data Description	Data Format	Native Resolution	Collection Date(s)	Data Publicly Available?	Contact for Data if not Public
Habitat	Mouquet et al. 2016a	Bottom type of Réunion lagoon	Raster, WGS 84 / UTM zone 40S (EPSG:32740)	0.4 m	2015-05	http://dx.doi.org/10.12770/7a2bea43-2ec9-4e66-a2d3-42871fc35a4b	pascal.mouquet@ird.fr
Habitat	Nicet et al. 2016	Habitat type of Réunion lagoon	Shp, RGR92 / UTM zone 40S (EPSG:2975)		2009-2015	https://sextant.ifremer.fr/ocean-indien/Acces-aux-donnees/Acces-au-catalogue?owscontext=https%3A%2F%2Focean-indien.ifremer.fr%2Fdepot%2FSEXTANT_CONTEXTES%2FSEXTOI%2FNouveau_site%2FTypo_RNMR%2FCarte-z15-c6148080.707184672--2402606.635151419.xml#/metadata/15d65c1a-86c4-4814-baa0-e34f59bf5c31	jbenoit.nicet@gmail.com
Habitat	Sextant	All data on water quality (biology, chemical, physical data)	RGR92 / UTM zone 40S (EPSG:2975)			https://sextant.ifremer.fr/ocean-indien/Acces-aux-donnees/Acces-au-catalogue#/metadata/c143b443-894e-4046-8cd3-159ad9062e3b	magali.duval@ifremer.fr
Geomorphology	Mouquet & Touria 2014	Bathymetry	Raster, WGS 84 (EPSG:4326)	1 m	2009	http://dx.doi.org/10.12770/0d177ff9-d802-4d10-8a00-3a46e0ef0735	pascal.mouquet@ird.fr
Geomorphology	Sextant	Geomorphological and hydrodynamical features of Réunion lagoons	EPSG:2975			https://sextant.ifremer.fr/ocean-indien/Acces-aux-donnees/Acces-au-catalogue#/metadata/c7ee4039-5dec-4bbe-a9b0-4f2d7e9d950b	info@reservemarineRéunion.fr
Biodiversity	Sextant	Information on marine turtles (migration, genetics, abundance)				https://sextant.ifremer.fr/ocean-indien/Acces-aux-donnees/Acces-aux-cartes-interactives/Tortues-marines	jerome.bourjea@ifremer.fr
Biodiversity	Sextant	Cetacean inventory	EPSG:4326			https://sextant.ifremer.fr/ocean-indien/Acces-aux-donnees/Acces-au-	globice@globice.org

Type	Data Source	Data Description	Data Format	Native Resolution	Collection Date(s)	Data Publicly Available?	Contact for Data if not Public
						catalogue#/metadata/c1ffda82-fb12-4ad7-acd0-a247d04cee00	
Biodiversity	Sextant	Natural Areas with fauna and flora interests			2018	https://www.reunion.developpement-durable.gouv.fr/znieff-r180.html//inpn.mnhn.fr/zone/znieffMer/region/04	florian.rognard@developpement-durable.gouv.fr
VME	Mouquet et al. 2016b	Coral vitality	Raster, WGS 84 / UTM zone 40S (EPSG:32740)	0.4 m	2015-05	http://dx.doi.org/10.12770/64687643-51f8-49e4-a75c-479fae0d1586	pascal.mouquet@ird.fr
VME	Sextant	Stations for the monitoring of reef health (GCRMN)	WGS 84 (EPSG:4326)			https://sextant.ifremer.fr/ocean-indien/Acces-aux-donnees/Acces-au-catalogue#/metadata/9d3e1c3e-3abb-4f48-8da7-e3a328bc5d58	tevamie.rungassamy@reservemarineRéunion.fr
VME indicators	Sextant	All French scientific surveys	WGS 84 (EPSG:4326)			https://sextant.ifremer.fr/ocean-indien/Acces-aux-donnees/Acces-au-catalogue#/metadata/128f43f9-fbd7-4477-a7c8-e901ad0547b7	pascal.mouquet@ird.fr
VME Indicators	Caves in the Natural Marine Reserve	Species descriptions, in situ photos	Data points, sampling stations		2016	Klautau *et al*. 2021 https://doi.org/10.1093/zoolinnean/zlab014	
VME Elements	GEBCO	GEBCO grided bathymetric data	Raster (Geotiff)	15 arc second	2023	https://www.gebco.net/data_and_products/gridded_bathymetry_data/gebco_2023/	
VME Elements	World Seamount Database	Seamounts	Vector (Shapefile, Point = Peak, Polygon = Base)	derived from 30 arc second resolution	2021	https://doi.pangaea.de/10.1594/PANGAEA.921688	
VME Elements	GEBCO	Steep Flanks	Vector (Shapefile, Polygon)	15 arc second	2023	https://www.gebco.net/data_and_products/gridded_bathymetry_data/gebco_2023/	

Type	Data Source	Data Description	Data Format	Native Reso-lution	Collection Date(s)	Data Publicly Available?	Contact for Data if not Public
Fishing		IFREMER statistical sectors (14 grid cells). Annual vessel census + sam-pling of effort and landings from hooks with electric reel at harbour		25 x 50 km	2007-cur-rent		IFREMER

2.6 Martinique, Guadeloupe, Saint Martin

Martinique, Guadeloupe and Saint Martin are islands in the eastern Caribbean forming an arc of approximately 15 small islands (Anguilla, Saint Martin, Antigua, St. Kitts and Nevis, Guadeloupe, Saba, Martinique, Dominica, St. Lucia, Barbados, St. Vincent and the Grenadines, Grenada and Trinidad and Tobago) separating the Caribbean Sea from the Atlantic Ocean and lying just north of the continental shelf off the northeast coast of South America. The islands, including Martinique, Guadeloupe and Saint Martin, constitute the French Lesser Antilles, an area which in 2017 was designated an EBSA (CBD 2015b). The territorial waters and Exclusive Economic Zones (EEZ's) surrounding Martinique, Guadeloupe and its dependencies of Marie Galante, the Saints Archipelago, la Desirade, PetiteTerre, as well as those of St. Barthelemy and St. Martin form the Agoa Sanctuary for the protection of marine mammals (Figures 2.36, 2.37, 2.38). The use of fishing gear which may result in the capture of marine mammals are considered for regulation.

The island of Martinique has a total surface area of about 1,128 km² and is characterized by a large insular shelf of ~1,100 km² most of which is located on the Atlantic side of the island, extending up to 25 km from the coast (Legrand *et al*. 2012) (Figure 2.36). Guadeloupe has 306 km coastline with a relatively narrow shelf extending up to 25 km off the eastern side of the main island (Figure 2.37). By contrast Saint Martin is a much smaller island, with a total surface area of ~90 km² (Figure 2.38).

In these islands, the PACOTILLES campaign (Pérez 2015) focused on exploring underwater caves. To date, Martinique and Guadeloupe are the only islands with truly dark caves, featuring faunas comparable to those found in the deep. Nevertheless, a few enclaves of darkness have also been explored in Saint Martin. More recently, ROV dives have been carried out as part of various development projects. Reports of these dives, totalling just a few dozen hours and not necessarily targeting VMEs, exist for all three islands.

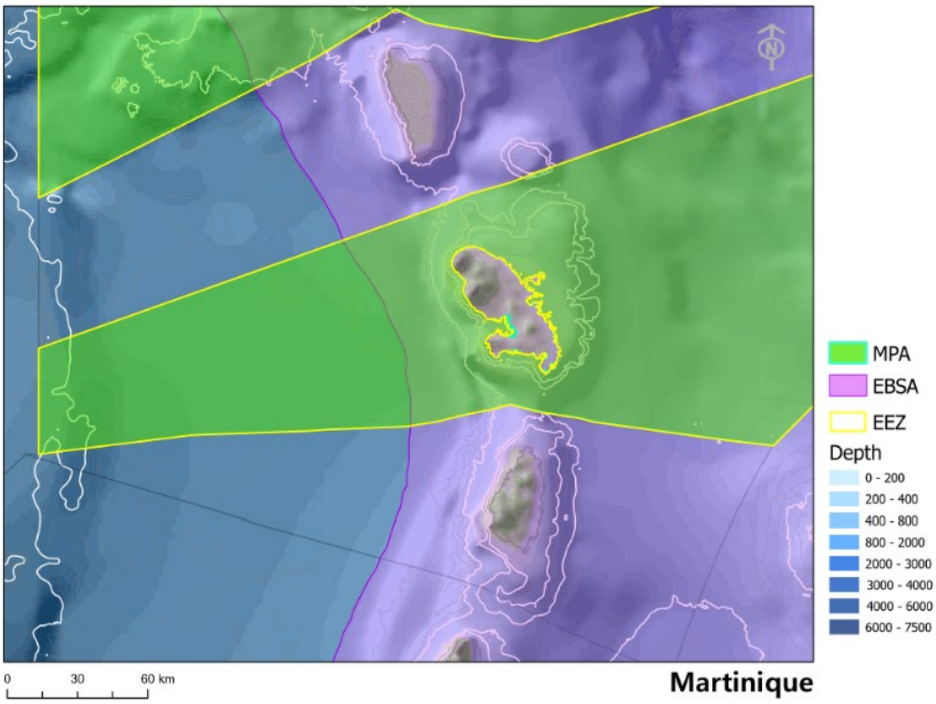

Figure 2.36. Map of Martinique showing the 400 m, 800 m and 2000 m depth contours (white) and the positions of the EBSA and protected area within the French Exclusive Economic Zone (EEZ).

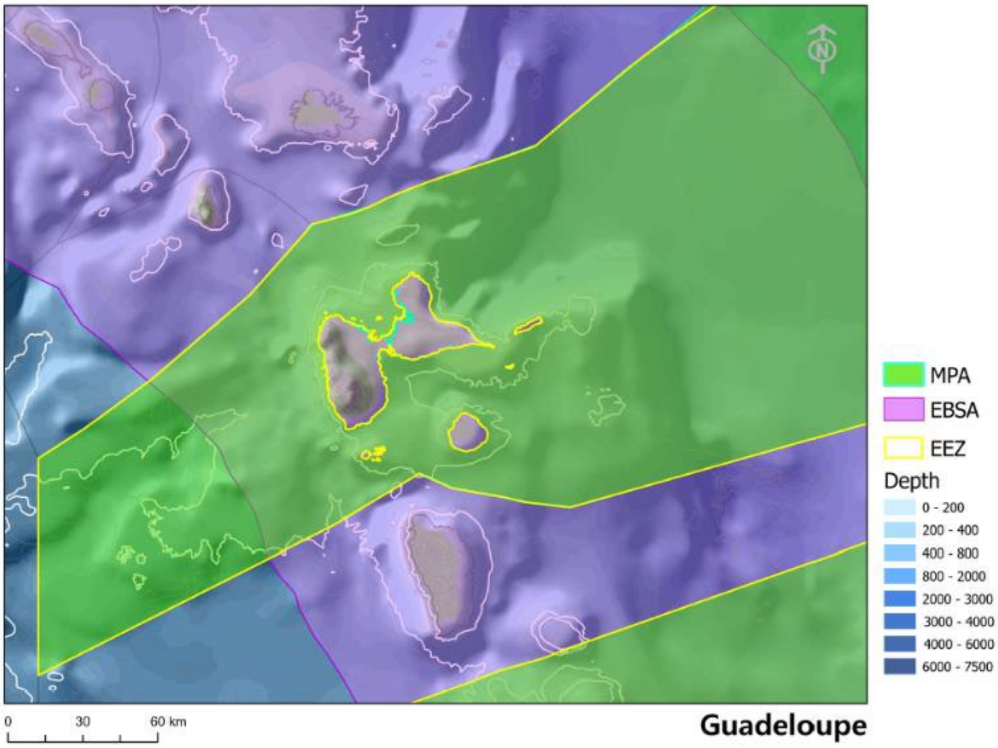

Figure 2.37. Map of Guadeloupe showing the 400 m, 800 m and 2000 m depth contours (white) and the positions of the EBSA and protected area within the French Exclusive Economic Zone (EEZ).

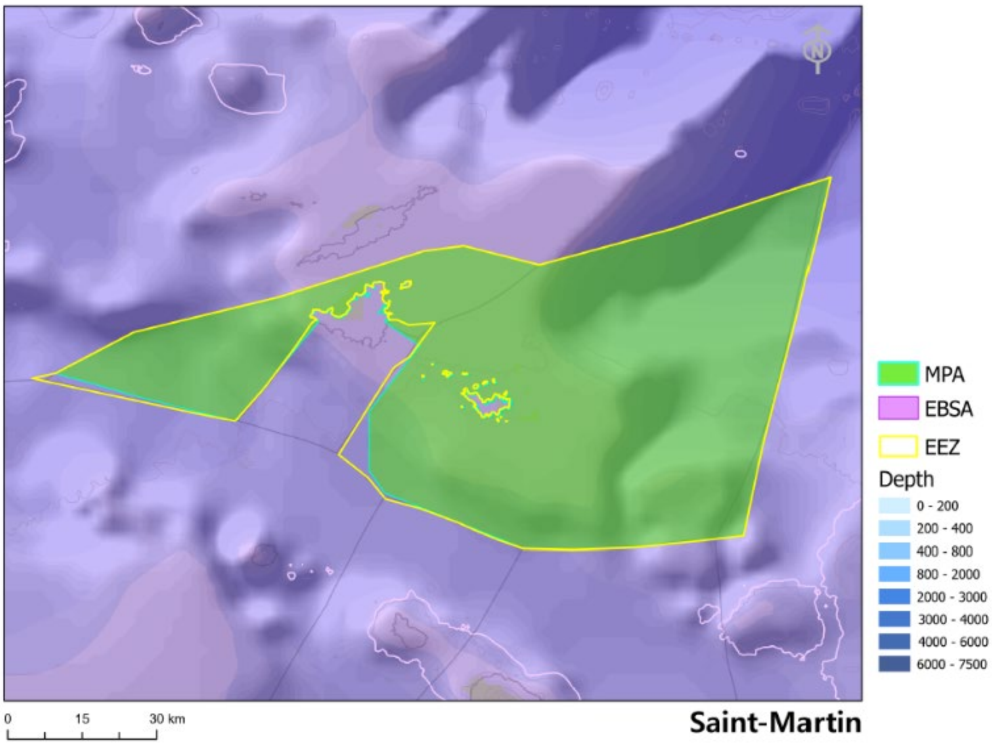

Figure 2.38. Map of Saint Martin showing the 400 m, 800 m and 2000 m depth contours (white) and the positions of the EBSA and protected area within the Exclusive Economic Zone (EEZ).

2.6.1 VMEs likely to occur

Deep-sea studies of the benthos and their habitats appear to be very limited off Martinique, Guadeloupe and Saint Martin, however modelled predictions of suitable habitat for two species of framework forming cold-water corals (*Solenosmillia variabilis* and *Enallopsammia rostrata*) are high for the region (Davies & Guinotte 2011). Furthermore, data submitted by the University of Southampton, National Oceanography Centre as part the Census of Marine Life Initiative (ChEssBase - lifewatch.eu) suggests that important hydrothermal vents, steep slopes and sea mounts exist in the area.

A noteworthy exception, and an important source of recent data on deep-sea species recorded off Guadeloupe, is a benthic survey conducted in 2015 as part of the Tropical Deep Sea Benthos (TDSB) programme led by the French National Natural History Museum (Muséum national d'Histoire naturelle; MNHN) and the French National Research Institute for Sustainable Development (Institut de Recherche pour le Dévelopement; IRD). The survey aimed to create an in-depth inventory of the benthos of the EEZ of Guadeloupe in the bathymetric range of 60 – 600 m (KARUBENTHOS 2). However, given that the primary objective of the survey was to systematically identify, analyse and publish data on the type of benthic invertebrates sampled (most notably taxa belonging to the phyla Crustacea, Mollusca and Pycnogonidae), there has been little corresponding information published on the nature of the deep-sea habitats from which the specimens were collected.

Most recently Under The Pole's DEEPLIFE programme collected data from Guadeloupe between 23 February and 29 April 2023. As described in Section 2.3, the objective of DEEPLIFE is to study the ecological function of Marine Animal Forests through identification of the key engineer species composing the animal forests, a study of the microclimate generated by the forest canopies, and a description and quantification of the associated biodiversity. This programme may generate relevant data in the near future regarding the identification of VME Indicator Species.

2.6.2 VME Elements

Steep flanks with slopes > 6.4° are prevalent in the Lesser Antilles islands (Figures 2.39, 2.40, 2.41) while shelf-indenting and blind canyons were also present (Figures 2.42, 2.43, 2.44). All areas had seamounts or their bases present (Figures 2.45, 2.46, 2.47) while Guadeloupe had a hydrothermal vent present (Figure 2.45).

The PACOTILLES campaign has located several underwater caves in Martinique and Guadeloupe, and has already made it possible to describe a large number of new sponges belonging to VME Indicator groups. Taxonomic work is still in progress, and the various caves explored should soon be the subject of precise descriptions, reporting at the same time occurrences of other indicator taxa.

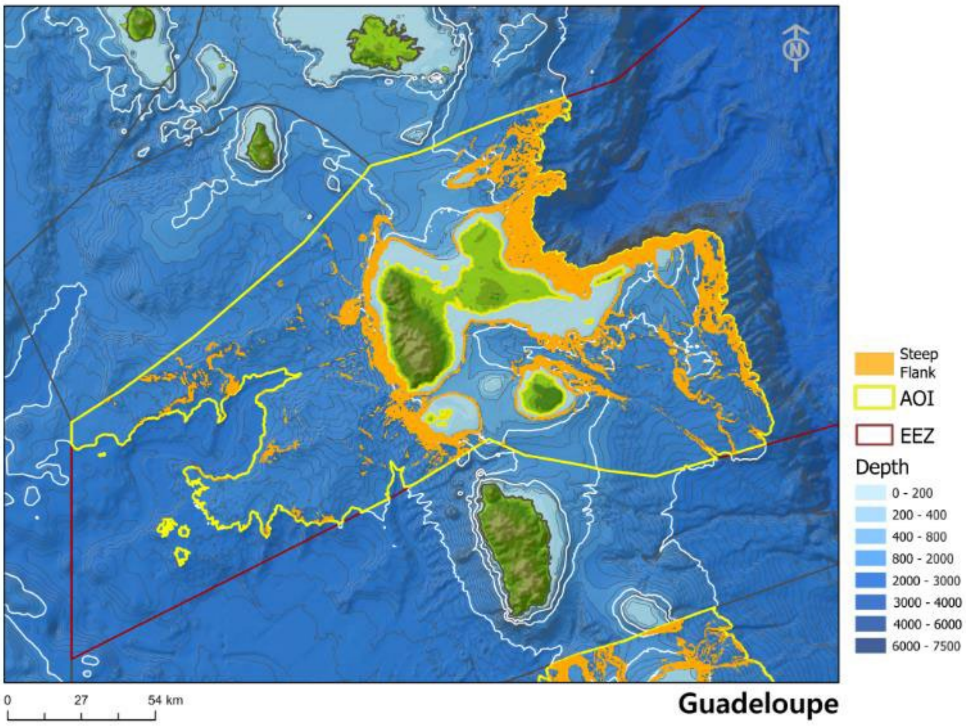

Figure 2.39. Map of Guadeloupe showing the location of steep flanks with slopes > 6.4^o within the area of interest (AOI) of waters < 2000 m depth within the French Exclusive Economic Zone (EEZ).

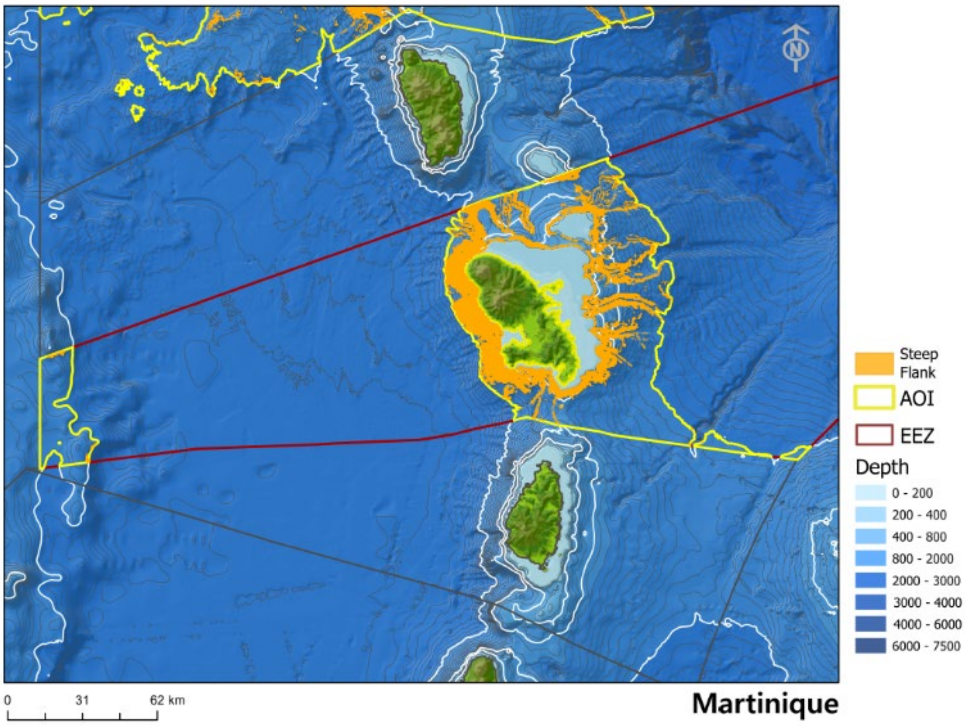

Figure 2.40. Map of Martinique showing the location of steep flanks with slopes > 6.4^o within the area of interest (AOI) of waters < 2000 m depth within the French Exclusive Economic Zone (EEZ).

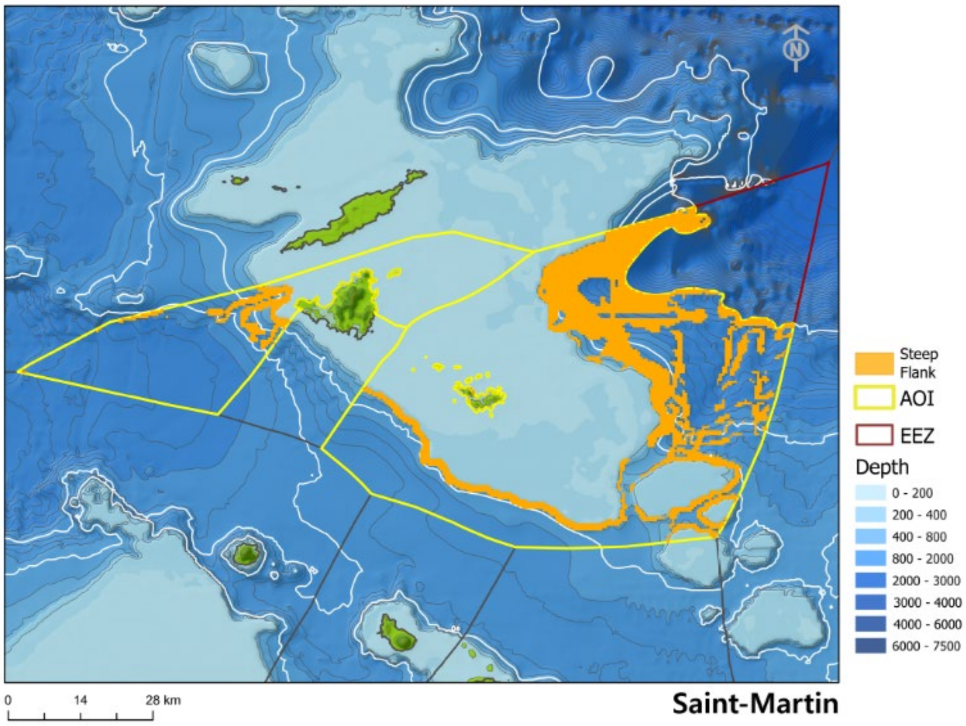

Figure 2.41. Map of Saint Martin showing the location of steep flanks with slopes > 6.4° within the area of interest (AOI) of waters < 2000 m depth within the French Exclusive Economic Zone (EEZ).

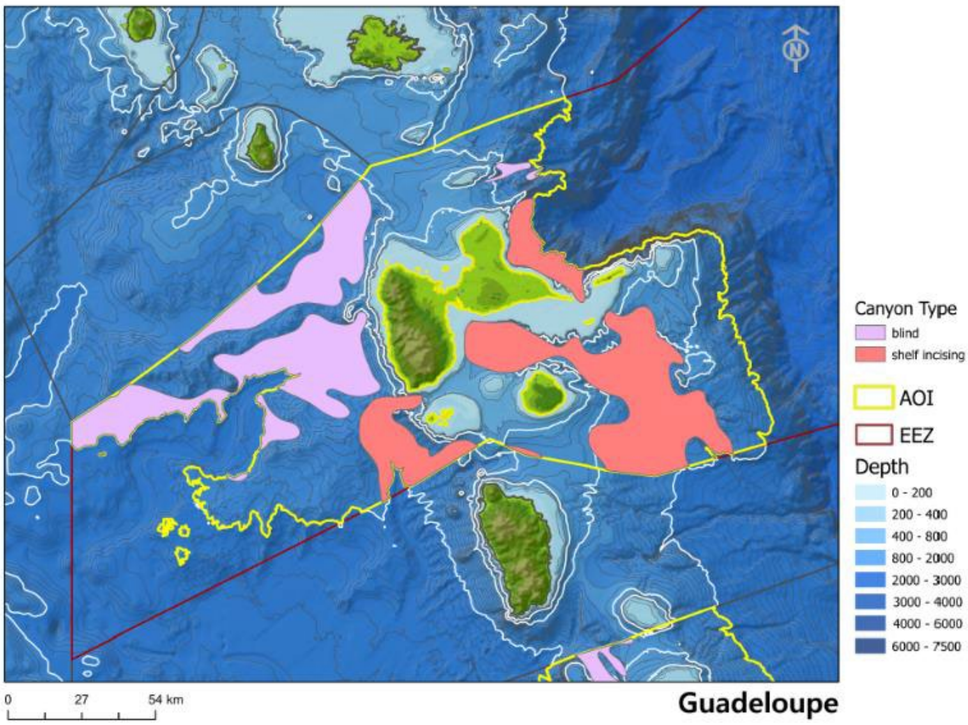

Figure 2.42. Map of Guadeloupe showing the location of shelf-indenting and blind canyons within the area of interest (AOI) of waters < 2000 m depth within the French Exclusive Economic Zone (EEZ).

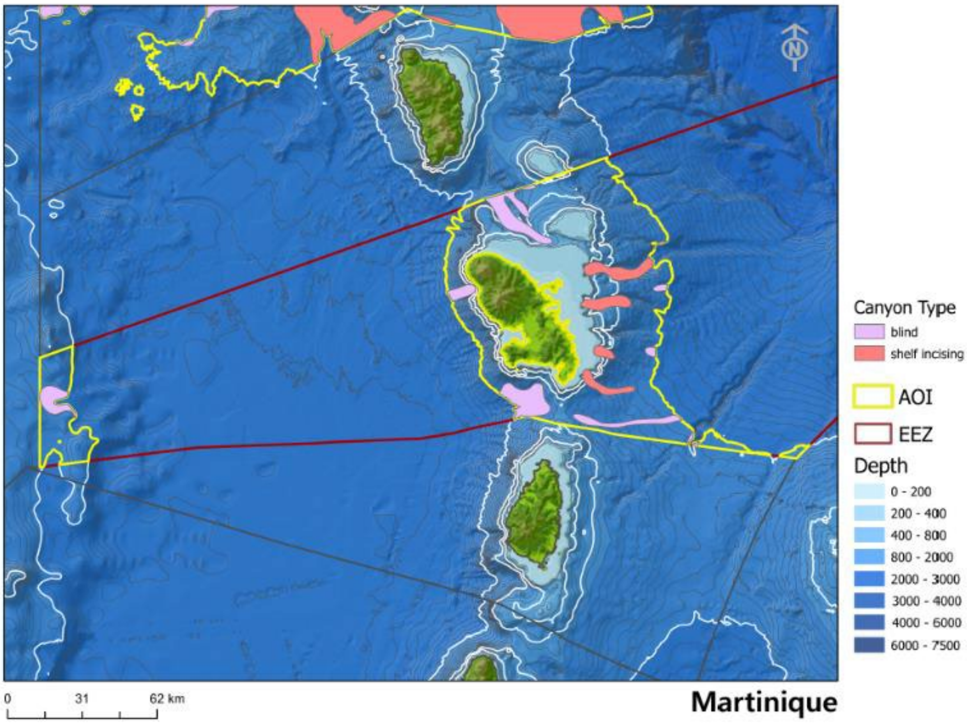

Figure 2.43. Map of Martinique showing the location of shelf-indenting and blind canyons within the area of interest (AOI) of waters < 2000 m depth within the French Exclusive Economic Zone (EEZ).

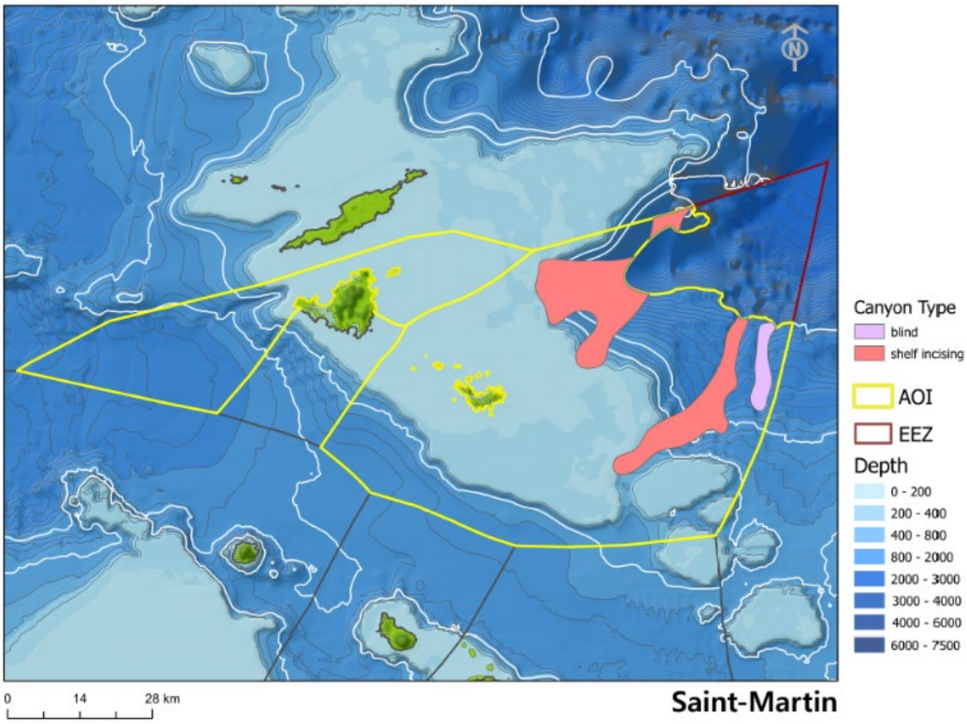

Figure 2.44. Map of Saint Martin showing the location of shelf-indenting and blind canyons within the area of interest (AOI) of waters < 2000 m depth within the French Exclusive Economic Zone (EEZ).

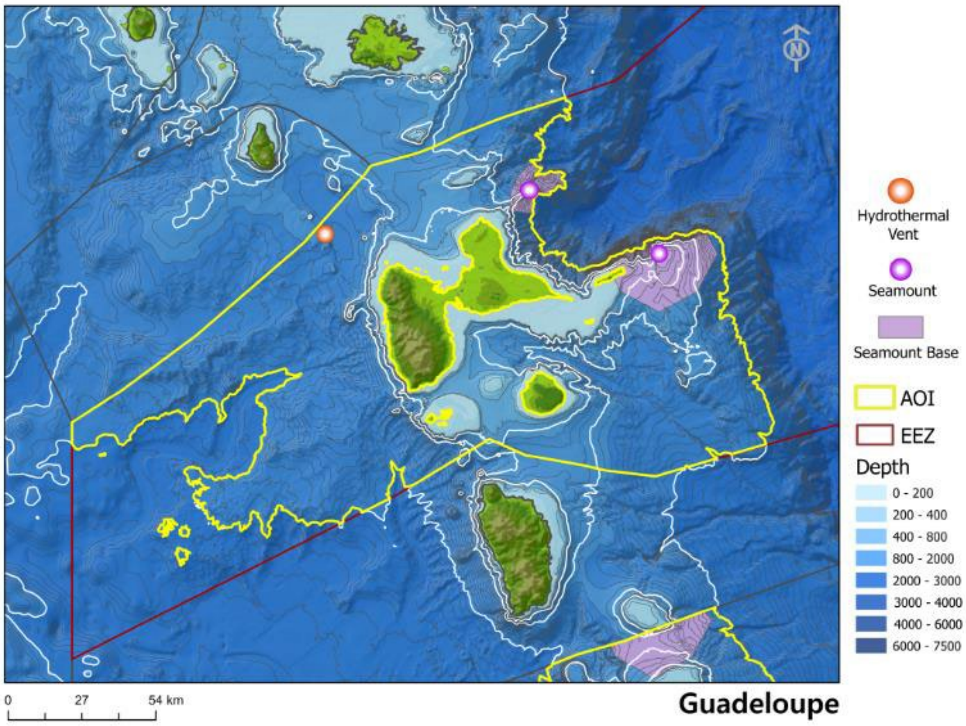

Figure 2.45. Map of Guadeloupe showing the location of seamounts and hydrothermal vents within the area of interest (AOI) of waters < 2000 m depth within the French Exclusive Economic Zone (EEZ).

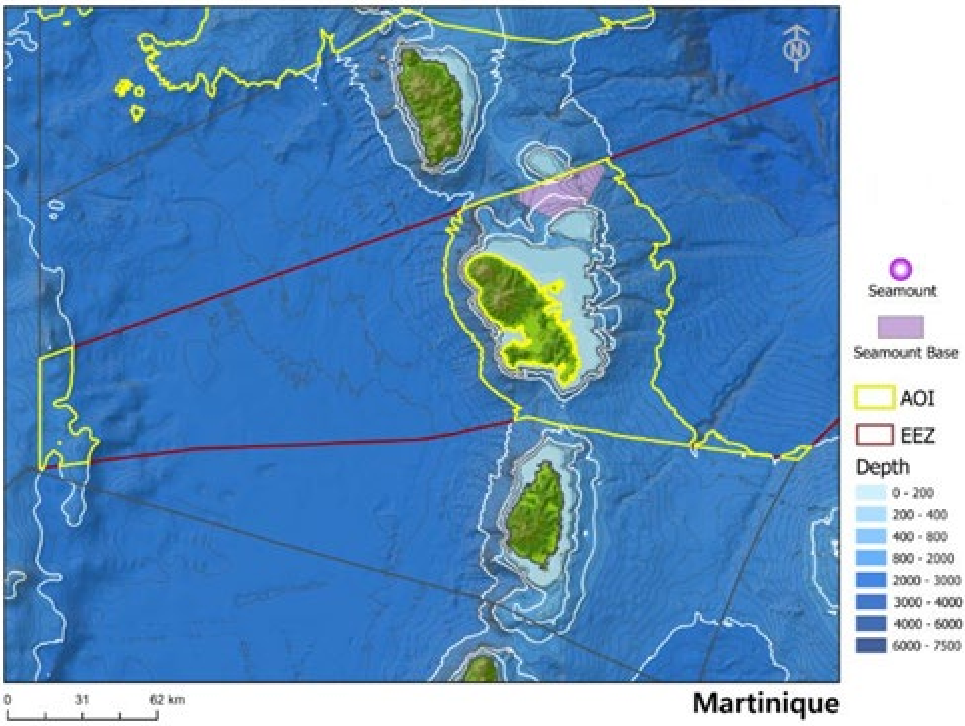

Figure 2.46. Map of Martinique showing the location of the base of a seamount extending into the area of interest (AOI) of waters < 2000 m depth within the French Exclusive Economic Zone (EEZ).

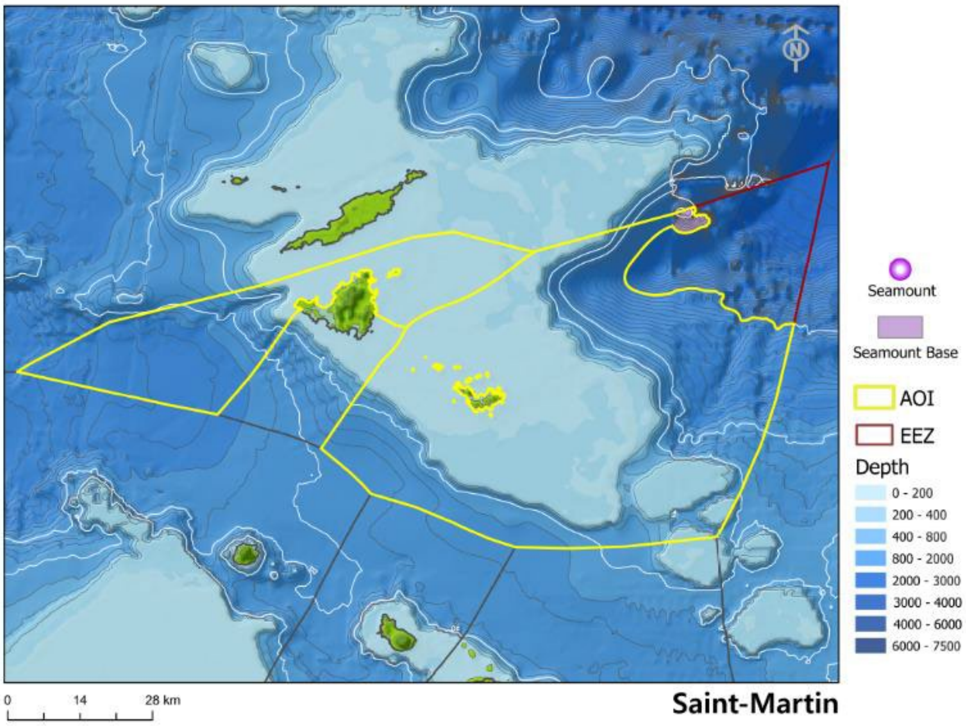

Figure 2.47. Map of Saint Martin showing the location of a seamount base extending into the area of interest (AOI) of waters < 2000 m depth within the French Exclusive Economic Zone (EEZ).

2.6.3 Fishing activity in Martinique

Overview of the local fisheries

Martinique's Exclusive Economic Zone (EEZ) is confined by the proximity of other islands. Owing to its volcanic nature, its insular shelf is very small. These two situations mean that the demersal resources are reduced and that there are problems with fishing pelagic resources, affecting the characteristics of the fleet and the development of fishing (Iborra Martin 2007).

The fishing fleet is made up of 960 boats (IFREMER 2022), only six of which are more than 12 m long operating with one or two people. Boats shorter than 12 m are mainly used for coastal fishing through day trips. They also fish out of sight of the coast (60 miles or ~ 97 km) from quarter 4 to 2 depending on the sea condition. The larger boats generally fish on the continental shelf of French Guiana and struggle to compete with the Venezuelan fleet.

Most boats (59%) are polyvalent in the sense they operate more than one type of fishing gear (on average 1.9; IFREMER 2022), among 12 different types. The most commonly used main gear is pots (60% of boats), followed by handlines (44%) and gillnets (25%).

Moored Fish Aggregating Devices (MFAD) fisheries operate in Martinique (Vallés 2023) and their status and trends are reported in Wilson *et al*. (2020). IFREMER's Moored Fish Aggregating Devices in the Lesser Antilles (MAGDALESA) programme was established in 2006 to research and establish best practices with regards to MFAD fisheries (Diaz et al. 2007). Only 30 MFADs were recently reported in Martinique, 67% of which were privately owned (Wilson *et al*. 2020).

Deep-water fishing activity

There was no response from the WKOUTVME questionnaires apparently due to some communication/transmission difficulty, therefore the minimum spatial scale is currently officially restricted to local statistical sectors from the Fishery Information System from IFREMER, which have lower resolution than 5x5 km and cover large depth bands. Vessel census is carried out every year and sampling of landings and effort is carried out at the harbour. There were however unofficial information collected through discussions with fishermen about a small deepwater activity for diamond squids and deepwater crustaceans. This activity is known to be carried out by two boats on an irregular basis as it is strongly dependant on sea conditions.

Twenty-four boats are known to operate longlines from 60 to 200 m targeting snappers. Two vessels catch crustaceans using deep-water pots from 400 to 600 m. Those vessels target various valued species of crabs and shrimps. This fishery has emerged in the 1990s but has not expanded since then because of existing regulation regarding mesh size.

In parallel, Diamond Squid (*Thysanoteuthis rhombus*) catches have also been reported using drifting jig-lines in deep waters. Only two boats are known to operate in those deep waters. Existing information suggests that fishery occurs in only two areas (Figure 2.48). No trawling occurs in Martinique.

It is worth mentioning that there have been prospective fishing in the 1980s (Ramos *et al*. 2019) using nets between 100 and 300 m. Maximum abundance was obtained between 200-250 m due to high shark yields. Below 250 m catches decreased and were offset by larger catches of bony fish. The catch of snappers (*Lutjanus vivanus*) was the most important between 100 and 150 m and practically nil below 200 m. On the other hand, the "Gros-yeux" (*Etelis oculatus*) became abundant below 200 m and it is probable that it still gives interesting yields beyond 300 m.

However, the exploitation of these resources between 100 and 300 m depth presents a certain number of difficulties which are due to the fact that they are limited and that the capacity of renewal of the stocks is weak at such depth. In addition, many sharks were caught during experimental fishing. These species may cause damage to the gears and their landing price was low. In addition, these species are fragile resources with low reproduction rate and low growth.

Moreover, the depth was considered as a constraint for the identification of the depth of the bottom floor and the handling of fishing gears. The very steep slope in some places could be the cause of fishing gear losses or a decrease in their effectiveness. The hard bottoms, generally rough, cause the hooking of the gear, which complicates the lifting and deteriorates the fishing equipment. Currents are also very strong in some places.

Many species caught were not well known to consumers and the landing prices were low at least during the initial phase. At the end of the study, because of damages caused to the net and debris left on the bottom due to hilly and steep bottoms and strong currents around Martinique, the use of longlines was recommended.

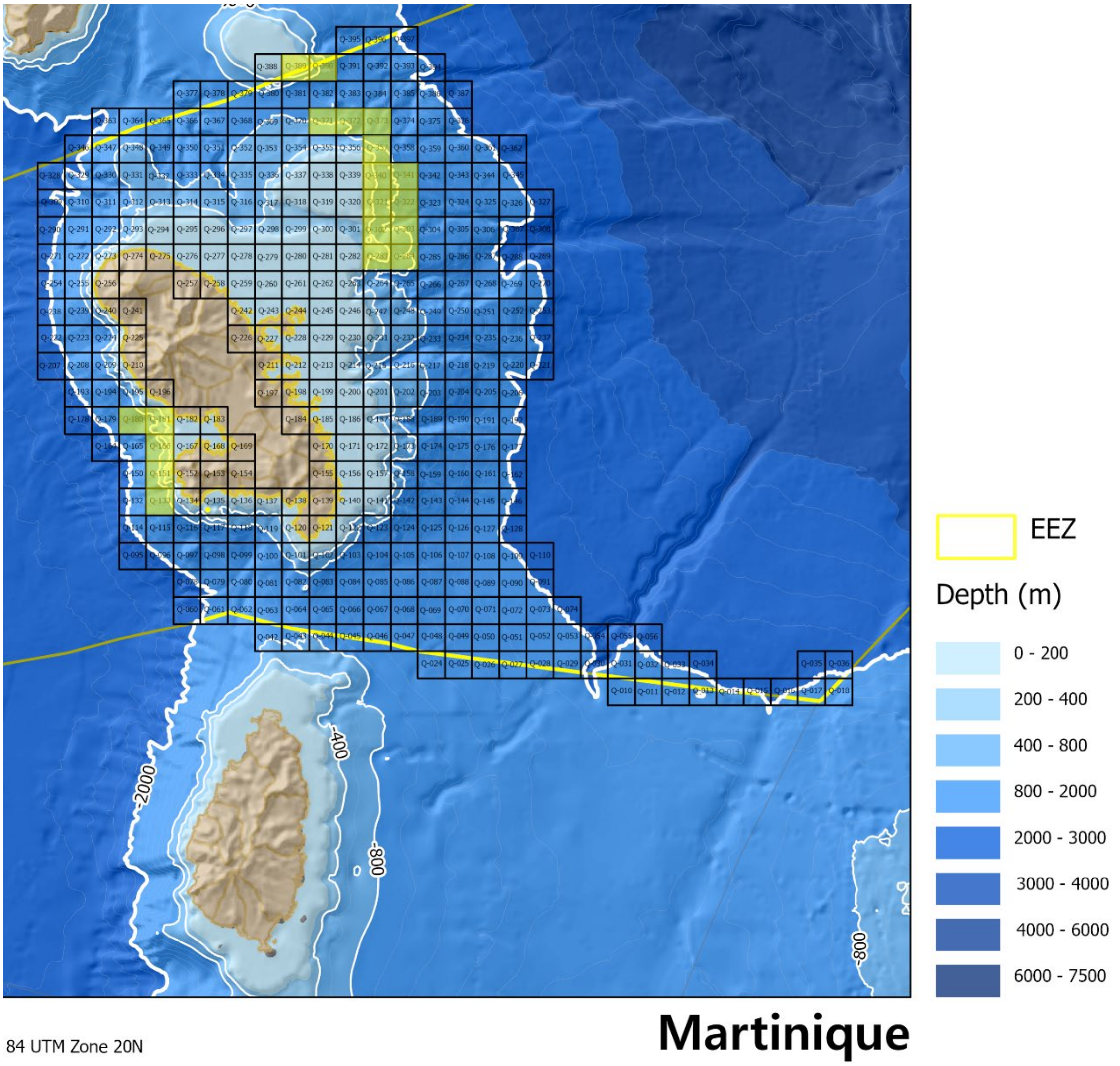

Figure 2.48. Assumed location of some deep-water fishing activity in Martinique as provided through unofficial information collected through discussions with fishermen about a small deepwater activity for diamond squids and deep-water crustaceans.

2.6.4 Fishing activity in Guadeloupe

Overview of the fishery

The archipelago of Guadeloupe lies in FAO area 31. In 2019, the Guadeloupean fleet was composed of 691 vessels, of which 484 were active. Crews usually consist of two people (Weiss *et al*. 2020). Their average size and horsepower were 7.7 m and 172 kW, respectively. Most of the vessel-owners were from Guadeloupe and the ones operating their vessels. Most of vessels are less than 10 m long, open decked with outboard engines and they fished typically during one-day fishing trips. The small-scale vessels operate in coastal fisheries, using pots, gillnets and handlines to target demersal species such as snappers, parrotfish or groupers. Other fisheries operating on the insular shelf target spiny lobsters, conchs and small pelagic fish. There is also a small deep-sea fishery around 200 m deep where snappers are targeted with small longlines and gillnets.

A substantial pelagic fishery exists around private Moored Fish Aggregating Devices (MFADs) and is made of 200 vessels (Guyader 2019). In 2019, total landings of large pelagic species were 1600 tonnes for a total value of 13 million euros. The main target species were Dolphinfish

(*Coryphaena hippurus*) (61%), Yellowfin Tuna (*Thunnus albacares*) (18%), Blue Marlin (*Makaira nigricans*) (8%), Triggerfish (*Canthidermis maculatus*) (7%) and other miscellaneous species like Wahoo (*Acanthocybium solandri*), Rainbow Runner (*Elagatis bipinnulata*) and other tunas (Guyader *et al*. 2013). Trolling lines, surface and drifting vertical baited lines were the main gears used by fishers (Reynal *et al*. 2015). In contrast to Martinique, there are 608 MFADs in Guadeloupe, 99% of which are privately owned (Wilson *et al*. 2020). MFAD fisheries in the insular Caribbean Sea are steadily growing, but they are doing so in a relatively unregulated and data-poor context, raising concerns about their long-term socioeconomic and biological sustainability (Vallés 2023).

As a French Outermost Region, Guadeloupe is part of the European Union and subject to the Common Fishery Policy (CFP). The main CFP rules concern fleet total capacity expressed in vessel horsepower (kW) and a non-constraining national quota derived from a TAC set by ICCAT for Blue Marlin (Guyader *et al*. 2019).

It is worth mentioning experimental programs of geolocation of small-scale vessels called Recopesca (Leblond *et al*. 2008, Leblond *et al*. 2010) were carried in Guadeloupe and Martinique in the 2010s. In each island, it concerned around 10 vessels under 12 meters but mostly vessels between 6-8 and 8-10 meters. Another research programme on Moored Fishing Aggregated Devices (TURFs) was also launched in 2015 (Guyader *et al*. 2015) to follow the distribution of fishing activity at a high resolution scale (1 minute) around MFADs but also in other fisheries harvested by the same multipurpose vessels. The results highlighted the high interest for these devices to improve the following of fishing activity in the different ecosystems around these islands.

Deep-sea fishing activity

There was no response from the WKOUTVME questionnaires apparently due to some communication/transmission difficulty therefore minimum spatial scale is currently restricted to local statistical sectors from the Fishery Information System from IFREMER, which have lower resolution than 5x5 km and cover large depth bands. Vessel census is carried out every year and sampling of landings and effort is carried out at harbour.

Eighteen vessels operate gillnets from 60 to 200 m, 36 vessels use deep-sea fish traps from 60 to 200 m and four vessels catch crustaceans using deep-sea pots from 400 to 600 m. Those vessels target various valued species of crabs and shrimps. This fishery has emerged in the 90s through experimental fishing but has not expanded since then because of existing regulation regarding mesh size. No trawling occurs in Guadeloupe.

It is worth noting there have been additional experimental fishing in Guadeloupe in 2001 (Ramos *et al*. 2019). The main objective was to reduce fishing effort on the overexploited insular shelf by testing the profitability of different fishing technics on “new” (under or unexploited) resources. Deep-sea nets were tested with the aim of targeting Lutjanids between –195 and –410 m in the south of Basse-Terre (Guadeloupe). The target species was the "oeil de boeuf" (*Etelis oculatus*), with 52% of the weight captured for 77.5% of the commercial value. Interesting bycatch of "empereurs" (*Geohyroberyx darwini*) were recorded: 7.5% of commercial value. However, concern was with the ability of the target species stocks to withstand sustained fishing effort.

2.6.5 Fishing Activity in Saint Martin

Overview of the local fisheries

Vessels operating in Saint Martin are generally registered in Guadeloupe which does not ease their identification and tracking of activity. Around 17 vessels (in 2019) are registered. Eight boats and 12 fishermen are known to be active during the year. Vessels are on average 8.3 m long. No fishing vessel above 10 m is known to operate (IFREMER 2022).

As for the other Caribbean islands, those vessels are polyvalent with an average of 2.1 types of fishing gear, the most common gear being longline (used by 63% of the vessels) targeting large pelagics, longlines targeting snappers and sharks (50%), demersal fish and crustacean pots (50%) and handlines (25%). Operating depths are unknown but it is assumed that the 400 m limit is never reached as in the case of the Guadeloupe and Martinique fisheries targeting deep-water snappers.

There was no response from the WKOUTVME questionnaires apparently due to some communication/transmission difficulty, therefore the minimum spatial scale is currently restricted to local statistical sectors from the Fishery Information System from IFREMER which has lower resolution than 5x5 km and covers large depth bands.

To the local experts' knowledge, no deep-water fishing activity is carried out in the vicinity of Saint Martin at least from the French vessels operating in the area. The status of exploitation was not provided regarding the fleet operating in the Dutch part of Saint Martin island.

Some experimental fishing occurred in Saint Martin in the 1980-1990s as part of some experimental fishing project occurring in Martinique and Guadeloupe (Ramos *et al*. 2019). No new development has been known since then.

2.6.6 List of deep-sea fish species for Martinique, Guadeloupe and Saint Martin

The deep-water fish species list was locally updated. This list applies to Martinique, Guadeloupe and Saint Martin. Data were collected through the Data Collection Framework following the protocol set by IFREMER.

Order	Species	FAO Code	Name in Country	Local Name	Depth (m)	IUCN status
Anguilliformes	*Avocettina infans*	ANV			785 - 4580	Least Concern
Aulopiformes	*Bathypterois dubius*	BDU			750 - 1941	Least Concern
Carangiformes	*Rachycentron canadum*	CBA	Mafou	Cobia	0 - 1200	Least Concern
Carcharhiniformes	*Galeocerdo cuvier*	TIG	Requin tigre commun	Tig- Tigre	0 - 800	Near Threatened
Eupercaria/misc	*Etelis oculatus*	EEO	Vivaneau royal	Granzié œil de bœuf	100 - 450	Data Deficient
Lupercalia/misc	*Lutjanus synagris*	SNL	Vivaneau gazou	Brakoum, Sad bondié minyin, Sarde bon dieu	10 - 400	Near Threatened
Eupercaria/misc	*Pagellus bogaraveo*	SBR	Dorade de fond		150 - 300	Near Threatened
Gadiformes	*Coryphaenoides mexicanus*	CPX			110-1600	
Gadiformes	*Macrourus berglax*	RHG	Grenadier berglax		100 - 1000	
Perciformes Scorpaenoidei	*Helicolenus dactylopterus*	BRF	Sébaste chèvre		50 - 1100	Least Concern
Scombriformes	*Lepidopus caudatus*	SFS	Sabre argenté		42 - 620	Data Deficient
Stomiiformes	*Chauliodus sloani*	CDN			200 - 4700	Least Concern
Zeiformes	*Allocyttus verrucosus*	ALL			0 - 1800	Least Concern
Squaliformes	*Scymnodon ringens*	SYR	Squale-grogneur commun		200 - 1600	Vulnerable
Stomiiformes	*Chauliodus sloani*	CDN			200 - 4700	Least Concern
Zeiformes	*Allocyttus verrucosus*	ALL			0 - 1800	Least Concern
Isopoda	*Bathynomus giganteus*		Bathynome géant		400 - …	
Decapoda	*Chaceon eldorado*	ELQ	Crabe Géryon des Antilles		600 - …	
Decapoda	*Eunephrops caddenasi*		Langoustine sculptée		500 - …	
Decapoda	*Plesionika ensis*		Crevette gladiateur rayée		400 - …	
Oegopsida	*Thysanoteuthis rhombus*	YUR	Calmar diamant	Chipiloua	0-2600	Least Concern

Order	Species	FAO Code	Name in Country	Local Name	Depth (m)	IUCN status
Lupercalia/misc	*Lutjanus vivanus*	LTJ	Vivaneau soie		90 - 242	Least Concern
Eupercaria/misc	*Erythrocles monodi*	EYO			90 - 300	
Hexanchiformes	*Hexanchus griseus*		Requin Griset		180 - 1100	
Hexanchiformes	*Hexanchus nakamurai*	HXN	Requin-vache		90 - 600	Near Threatened
Carcharhiniformes	*Scyliorhinus boa*	SYA	Roussette boa		329 - 676	Least Concern
Carcharhiniformes	*Carcharhinus falciformis*	FAL	Requin soyeux		0 - 4000	Vulnerable
Carcharhiniformes	*Sphyrna lewini*	SPL	Requin-marteau halicorne		0 - 1043	Critically Endangered

2.6.7 List of VME Indicator Species for Martinique, Guadeloupe and Saint Martin

'X' means direct evidence fitting to the criteria; blank cell means that the criterion was not met or is unknown.

	VME Representative Taxa	Functional Significance	Fragility	Life History	Structural Complexity
Hard-bottom sponge gardens	GEODIIDAE	X	X	X	X
	ANCORINIDAE	X	X		X
	TETILLIDAE	X	X		X
	All Lithistid sponges (Discordermia, Aciculites, Gastrophanella…)	X			X
Mesophotic zone	AXINELLIDAE	X	X		X
	Agelas spp.	X	X		X
	Callyspongia spp.	X	X		X
	Amphimedon spp.	X	X		X

	VME Representative Taxa	Functional Significance	Fragility	Life History	Structural Complexity
	Niphates spp.	X	X		X
	Xestospongia muta	X	X	X	X
	APLYSINIDAE	X	X		X
Submarine caves	All Lithistid sponges (*Discordermia*, *Aciculites*, *Gastrophanella*)	X			X
	OSCARELLIDAE		X	X	
	PLAKINIDAE		X	X	
	CLATHRINIDAE		X	X	
	AMPHORISCIDAE		X	X	
	GRANTIIDAE		X	X	

2.6.8 Metadata of relevant data sources available for Martinique

Type	Data Source	Data Description	Data Format	Native Resolution	Collection Date(s)	Data Publicly Available?	Contact for Data if not Public
VME	Impact Mer 2023	Sampling cruise down to 1000 m	Videos	data point (sampling station)	2023	Should be	Guillaume Tollu, Impact Mer <gtollu@impact-mer.fr>
VME	Impact Mer 2021	Sampling cruise down to 1000 m	Videos	data point (sampling station)	2024	Should be	Guillaume Tollu, Impact Mer

Type	Data Source	Data Description	Data Format	Native Resolution	Collection Date(s)	Data Publicly Available?	Contact for Data if not Public
							<gtollu@impact-mer.fr>
VME	Pérez 2015	Lesser Antilles: Sampling cruise report-locations of sponge sampling, brief descriptions of underwater caves - related publications	pdf and related publications	data point (sampling station)	May 2015	published papers, data-base, on-going research	T. Pérez (database, on going research)
VME Indicators	Pérez *et al*. 2017	Martinique (Fort de France to Le Diamant): Sponge inventory, distribution per habitat	list of species	data point (sampling station)	Compilation, Dec. 2013 to April 2016	published papers	
VME Indicators	Ruiz *et al*. 2017	Martinique (Fort de France to Le Diamant) : Sponge description, submarine caves	species description and distribution among caves	data point (sampling station)	June 2011 to June 2015	published paper	
VME Indicators	Fontana *et al*. 2018	Martinique (Fort de France to Le Diamant) : Sponge description, submarine caves	species description and distribution among caves	data point (sampling station)	Dec 2013 - June 2015	published paper	
VME Indicators	Pérez & Ruiz 2018	Martinique (Fort de France to Le Diamant), Saint Pierre : Sponge description, submarine caves	species description and distribution among caves	data point (sampling station)	June 2011 to June 2015	published paper	
VME Indicators	Lopes *et al*. 2018	Martinique (Fort de France to Le Diamant): Sponge description, submarine caves	species description and distribution among caves	data point (sampling station)	June 2015	published paper	
VME Indicators	Grenier *et al*. 2020	Martinique (Anse d'Arlet): Sponge description, submarine caves	species description and	data point (sampling station)	June 2016	published paper	

Type	Data Source	Data Description	Data Format	Native Resolution	Collection Date(s)	Data Publicly Available?	Contact for Data if not Public
			distribution among caves				
VME Indicators	Ruiz *et al*. 2022	Martinique (Fort de France to Le Diamant) : Sponge description, submarine caves	species description and distribution among caves	data point (sampling station)	June 2011 to June 2015	published paper	
VME Elements	GEBCO	GEBCO grided bathymetric data	Raster (Geotiff)	15 arc second	2023	https://www.gebco.net/data_and_products/gridded_bathymetry_data/gebco_2023/	
VME Elements	World Seamount Database	Seamounts	Vector (Shapefile, Point, Polygon)	derived from 30 arc second resolution	2021	https://doi.pangaea.de/10.1594/PANGAEA.921688	
VME Elements	GEBCO	Steep Flanks	Vector (Shapefile, Polygon)	15 arc second (~500m at equator)	2023	https://www.gebco.net/data_and_products/gridded_bathymetry_data/gebco_2023/	
VME Elements	Geomorphology of the Oceans	Submarine Canyons	Vector (Shapefile, Polygon)	derived from 30 arc second resolution (~1km at equator)	2020	https://bluehabitats.org/ https://doi.org/10.1016/j.margeo.2014.01.011	
Fishing		IFREMER statistical sectors (>20 grid cells). Annual vessel census + sampling of effort and landings at harbour		min 20x20 km	2007-current		IFREMER 2022
Fishing		IFREMER statistical sectors (>20 grid cells). Annual vessel census + sampling of effort and landings at harbour		min 20x20 km	2007-current		IFREMER 2022

Type	Data Source	Data Description	Data Format	Native Resolution	Collection Date(s)	Data Publicly Available?	Contact for Data if not Public
Fishing		Onboard observation on crustacean deep-sea pots		5 x 5 km	2021-2022		IFREMER 2022

2.6.9 Metadata of relevant data sources available for Guadeloupe

Type	Data Source	Data Description	Data Format	Native Resolution	Collection Date(s)	Data Publicly Available?	Contact for Data if not Public
VME	Pérez 2015	Lesser Antilles: Sampling cruise report- locations of sponge sampling, brief descriptions of underwater caves - related publications	pdf and related publications	data point (sampling station)	May 2015	published papers, data-base, on-going research	T. Pérez (data-base, on going research)
VME Indicators	Ruiz *et al*. 2017	Port-Louis caves: Sponge description, submarine caves	species description and distribution among caves	data point (sampling station)	May 2015	published paper	
VME Indicators	Impact Mer 2015-2018	Off Pointe A Pitre Harbour: Mission à la mer / Océanologie / Prises de vues profondes (-620m maxi)	Videos	data point (sampling station)	2015-2018	Report	Guillaume Tollu, Impact Mer <gtollu@impact-mer.fr>
VME Indicators	Perez & Ruiz 2018	Port Louis, Saintes: Sponge description, submarine caves	species description and distribution among caves	data point (sampling station)	June 2015	published paper	
VME Indicators	Lopes *et al*. 2018	Port-Louis caves: Sponge description, submarine caves	species description and distribution among caves	data point (sampling station)	June 2015	published paper	

Type	Data Source	Data Description	Data Format	Native Resolution	Collection Date(s)	Data Publicly Available?	Contact for Data if not Public
VME Indicators	Ruiz *et al.* 2022	Port-Louis caves: Sponge description, submarine caves	species description and distribution among caves	data point (sampling station)	June 2015	published paper	
VME Indicators	Pérez 2015	Lesser Antilles: Sampling cruise report- locations of sponge sampling, brief descriptions of underwater caves - related publications	pdf and related publications	data point (sampling station)	May 2015	published papers, data-base, on-going research	T. Pérez (data-base, on going research)
VME Elements	GEBCO	GEBCO grided bathymetric data	Raster (Geotiff)	15 arc second (~500m at equator)	2023	https://www.gebco.net/data_and_products/gridded_bathymetry_data/gebco_2023/	
VME Elements	World Seamount Database	Seamounts	Vector (Shapefile, Point = Peak, Polygon = Base)	derived from 30 arc second resolution (~1km at equator)	2021	https://doi.pangaea.de/10.1594/PANGAEA.921688	
VME Elements	GEBCO	Steep Flanks	Vector (Shapefile, Polygon)	15 arc second (~500m at equator)	2023	https://www.gebco.net/data_and_products/gridded_bathymetry_data/gebco_2023/	
VME Elements	Geomorphology of the Oceans	Submarine Canyons	Vector (Shapefile, Polygon)	derived from 30 arc second (~1km at equator)	2020	https://bluehabitats.org/ https://doi.org/10.1016/j.margeo.2014.01.011	
VME Elements	InterRidge Global Database of Active Submarine Hydrothermal Vent Fields 3.4	Hydrothermal Vents	Vector (Shapefile, Polygon)	1 arc minute (~2km at equator)	2020	https://doi.pangaea.de/10.1594/PANGAEA.917894	

Type	Data Source	Data Description	Data Format	Native Resolution	Collection Date(s)	Data Publicly Available?	Contact for Data if not Public
Fishing		IFREMER statistical sectors (>40 grid cells). Annual vessel census + sampling of gillnet effort and landings at harbour		min 20x20 km	2007-current		IFREMER 2022
Fishing		IFREMER statistical sectors (>40 grid cells). Annual vessel census + sampling of fish trap effort and landings at harbour		min 20x20 km	2007-current		IFREMER 2022
Fishing		IFREMER statistical sectors (>40 grid cells). Annual vessel census + sampling of crustacean trap effort and landings at harbour		min 20x20 km	2007-current		IFREMER 2022

2.6.10 Metadata of relevant data sources available for Saint Martin

Type	Data Source	Data Description	Data Format	Native Resolution	Collection Date(s)	Data Publicly Available?	Contact for Data if not Public
Geomorphology	IFREMER	Bathymetry	.shp file, WGS84 projection	50m	Realization of product May 2023	Yes	
VME Indicators	Pérez 2015	Lesser Antilles: Sampling cruise report- locations of sponge sampling, brief descriptions of underwater caves - related publications	pdf and related publications	data point (sampling station)	May 2015	published papers, data-base, on-going research	T. Pérez (data-base, on going research)
VME Indicators	Ruiz *et al.* 2017	Tintamarre ilet: Sponge description, submarine caves	species description and distribution among caves	data point (sampling station)	May 2015	published paper	
VME Indicators	Impact Mer 2022.	Off Saint Martin harbour: Suivi vidéo de la faune profonde de la zone de clapage B2. Etude pour l'Établissement Portuaire de Saint-Martin Videos down to -650 m	videos	data point (sampling station)	Sep-22	Online report	Guillaume Tollu, Impact Mer <gtollu@impact-mer.fr>
VME Indicators	Pérez & Ruiz 2018	Tintamarre ilet & Creole rock: Sponge description, submarine caves	species description and distribution among caves	data point (sampling station)	June 2015	published paper	
VME Indicators	Lopes *et al.* 2018	Tintamarre ilet & Basses Espagnoles: Sponge description, submarine caves	species description and distribution among caves	data point (sampling station)	June 2015	published paper	
VME Elements	GEBCO	GEBCO grided bathymetric data	Raster (Geotiff)	15 arc second (~500m at equator)	2023	https://www.gebco.net/data_and_products/gridded_bathymetry_data/gebco_2023/	

Type	Data Source	Data Description	Data Format	Native Resolution	Collection Date(s)	Data Publicly Available?	Contact for Data if not Public
VME Elements	World Seamount Database	Seamounts	Vector (Shapefile, Point = Peak, Polygon = Base)	derived from 30 arc second resolution (~1km at equator)	2021	https://doi.pangaea.de/10.1594/PANGAEA.921688	
VME Elements	GEBCO	Steep Flanks	Vector (Shapefile, Polygon)	15 arc second (~500m at equator)	2023	https://www.gebco.net/data_and_products/gridded_bathymetry_data/gebco_2023/	
VME Elements	Geomorphology of the Oceans	Submarine Canyons	Vector (Shapefile, Polygon)	derived from 30 arc second resolution (~1km at equator)	2020	https://bluehabitats.org/ https://doi.org/10.1016/j.margeo.2014.01.011	
Fishing		IFREMER statistical sectors (2 grid cells) Longlines		min 15x30 km			IFREMER 2022

2.7 French Guiana

The coast of French Guiana extends 320 km and has a relatively large continental shelf occupying an area of about 38,000 km² which extends from the coast by about 130 km to a depth of between 200 m and 300 m (Figure 2.49). The continental shelf margin consists of steep slopes and flanks bisected by submarine canyons extending to depths of about 3000 m. The deep-sea benthos is therefore predominantly associated with the steep flanks and canyons of the continental slope.

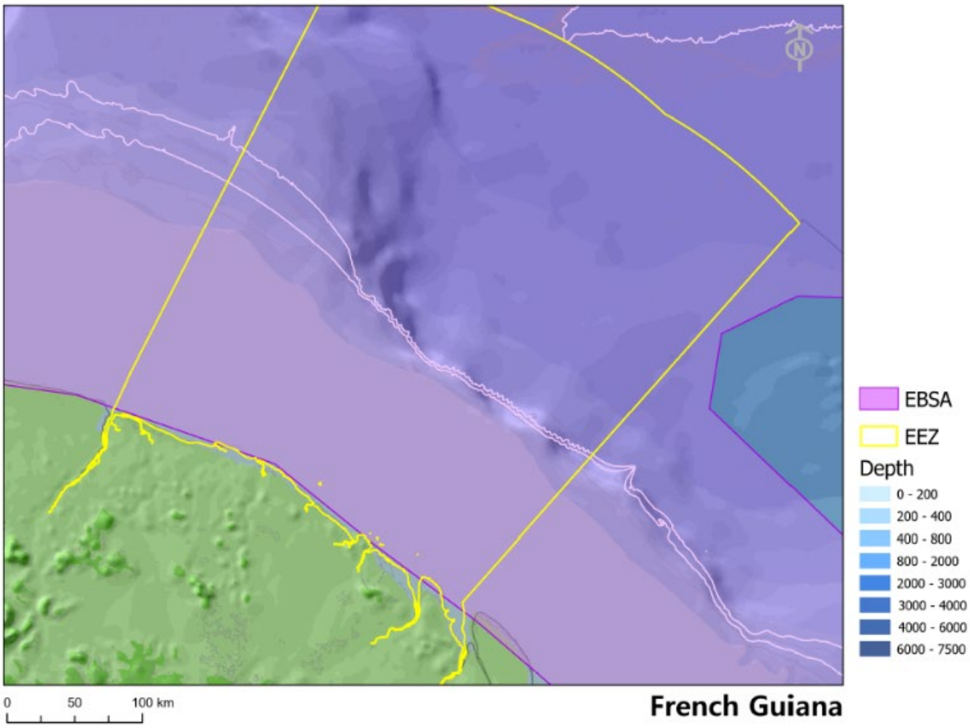

Figure 2.49. Map of French Guiana showing the 400 m, 800 m and 2000 m depth contour (white) and the location of the EBSA within relative to the French Exclusive Economic Zone (EEZ).

The French Guiana EEZ falls within the Amazonian-Orinoco Influence Zone EBSA (CBD 2015c) recognized primarily for its unique coastal ecosystems created by the huge inputs of nutrients and particulate matter (organic and inorganic) from the Orinoco and Amazon rivers which creates the worlds' longest continuous mud coastline (the Guiana coast). Accordingly, much of the continental shelf is composed of fine sediment. However, further offshore and in deeper clearer water (>100 m) sand gradually becomes more prevalent and corals occur (Artigas *et al*. 2003).

Benthic surveys were conducted in 2014 - 2015 as part of the Tropical Deep-Sea Benthos and Planet Revisited programmes (GUYANA 2014). The surveys sampled the benthos of the continental shelf and slope areas between depths of 30 m and 800 m. However, very few results describing the deep-sea habitats and associated fauna have been published.

A year later, a Brazilian oceanographic campaign revealed mesophotic reefs off the mouth of the Amazon (30-120 m depth), which made headlines for their proximity to various projects of geologic exploitation (Moura *et al*. 2016). This discovery has brought to light a new kind of reef, considered by coral reef specialists as marginal reefs, but sparking a new interest in exploring mesophotic zones and their functional role. Several stations were sampled, few of them being actually located off French Guiana.

In the Fall of 2019, the CNRS and Greenpeace conducted a two-week diving expedition on these reefs off French Guiana down to 100 m depth. They found discontinuous reef formations all along the coastline, sampled in five stations, and gathered a great number of images showing a unique assemblage of organisms from both the Caribbean zone and Brazil, belonging both from deep-sea and coastal ecosystems.

2.7.1 VME Elements

Steep flanks with slopes > 6.4° are prevalent off French Guiana (Figures 2.50) while shelf-indenting and blind canyons were also identified (Figure 2.51). The mesophotic reef off the Amazon likely counts among the most remarkable VME in this oceanic region, but their characterization is only starting. The collection of organisms kept at the National Museum of Natural History in Rio de Janeiro contains numerous VME indicator sponges (Moura *et al*. 2016). After the CNRS/Greenpeace expedition, gorgonian sea fans and black corals were among the most remarkable species, but so far, no scientific publication is available yet.

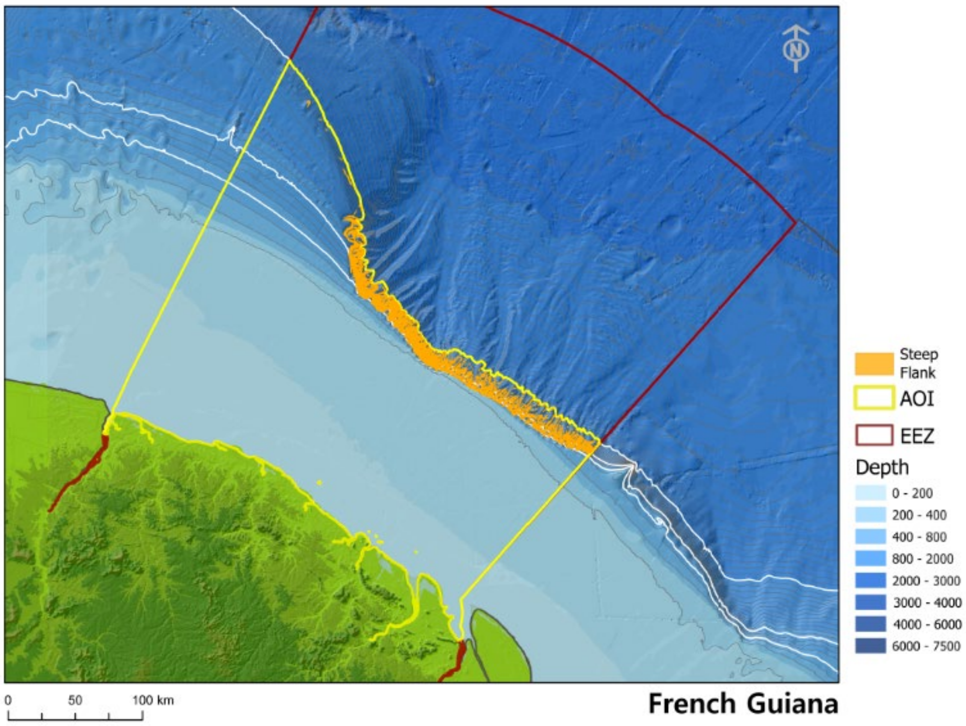

Figure 2.50. Map of French Guiana showing the location of steep flanks with slopes > 6.4° within the area of interest (AOI) of waters < 2000 m depth within the French Exclusive Economic Zone (EEZ).

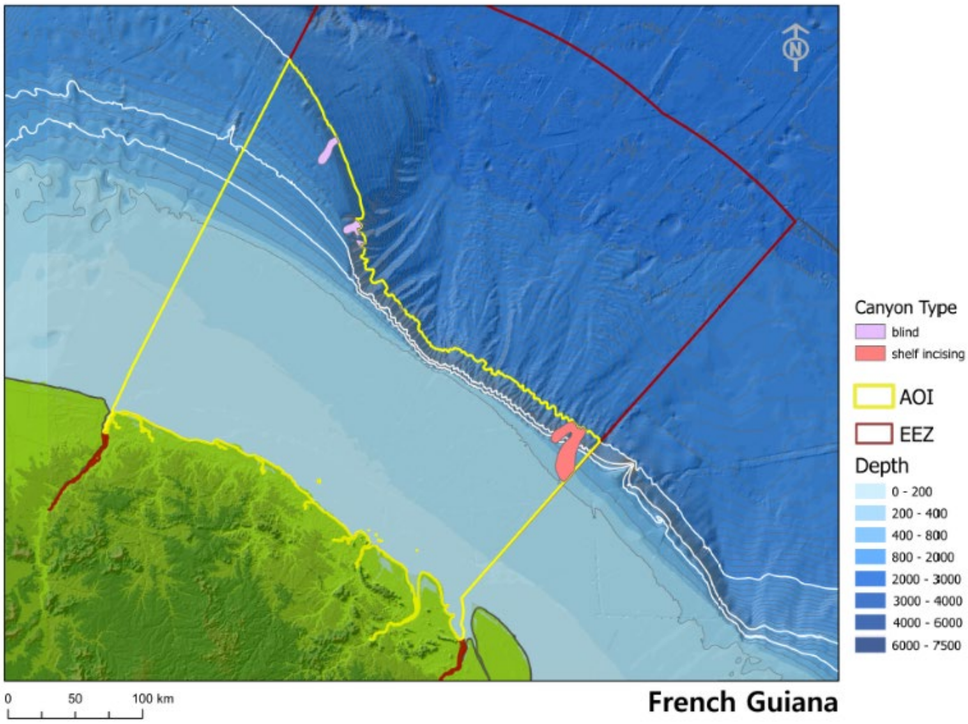

Figure 2.51. Map of French Guiana showing the location of shelf-indenting and blind canyons within the area of interest (AOI) of waters < 2000 m depth within the French Exclusive Economic Zone (EEZ).

2.7.2 Overview of the local fisheries

In French Guiana there are three main types of fisheries:

i) coastal artisanal fisheries with wood boats of < 12 m equipped by drift nets;
ii) commercial handline red snapper fishery predominantly performed by Venezuelan boats;
iii) shrimp trawling on the continental shelf between 30 and 70 m.

Estimations for 2021 suggest that about 2000 t of demersal fish were landed by small-scale fisheries for an estimated value of about 6000 k euros (IFREMER 2022). The fishery is non-selective and exploits more than 30 species (Gomes *et al*. 2021)

The Red Snapper fishery is based on a licence agreement requiring boats to sell 75% of their catch to a processing factory in French Guiana, while the other 25% can be sold abroad. This fishing activity is mostly focused on smaller fish since the international market demands plate-sized fish typically below the size of maturity. This type of size-selective fishery can lead to age truncation if fishing mortality is high (Tagliarolo *et al*. 2021).

In the past, the shrimp fishery constituted a major source of value for French Guiana, where it represented the third export sector accounting for 25% of the total volume. However this activity had a steep decline due to shrimp decline and economic issues and is now sold exclusively in the local market (Diop *et al*. 2018).

2.7.3 Deep-sea fishery in French Guiana

There is no deep-water fishing operating deeper than 400 m as most of the fishing activity occurs in shallow or coastal waters.

There was no response from the questionnaire apparently due to some communication/transmission difficulty. One issue raised by a local expert is the large number of square cells to report due to the extensive continental shelf.

Fine resolution spatial data is available through VMS on 45 authorized Venezuelan vessels targeting Red Snapper (*Lutjanus purpureus*) in French Guiana waters using handlines, which have no contact with the seafloor. Additionally there are one to three vessels from Martinique catching Red Snapper. As those vessels operate in the 50-200 m depth band, the likeliness of impacting deep-water VME is minimal.

2.7.4 List of deep-sea fish species for French Guiana

The deep-water fish species list was locally updated. Data were collected through the Data Collection Framework following the protocol set by IFREMER.

Order	Species	FAO Code	Name in Country	Local Name	Depth (m)	IUCN status
Carangiformes	*Rachycentron canadum*	CBA	Mafou	Cobia	0 - 1200	Least Concern
Carcharhiniformes	*Galeocerdo cuvier*	TIG	Requin tigre commun	Tig- Tigre	0 - 800	Near Threatened
Lupercalia/misc	*Lutjanus synagris*	SNL	Vivaneau gazou	Brakou Sad bondié minyin Sarde bon dieu	10 - 400	Near Threatened
Eupercaria/misc	*Dentex* spp.					
Eupercaria/misc	*Pagellus bogaraveo*	SBR	Dorade de fond		150 - 300	Near Threatened
Mugiliformes	*Mugil curema*	MGU	Mulet blanc	Mulet	0 - 300	Least Concern
Perciformes Scorpaenoidei	*Helicolenus dactylopterus*	BRF	Sébaste chèvre		50 - 1100	Least Concern
Lupercalia/misc	*Lutjanus purpureus*	SNC	Vivaneau rouge		26 - 340	
Eupercaria/misc	*Hyporthodus flavolimbatus*	EEL	Mérou aile jaune		90 - 360	Vulnerable

2.7.5 List of VME Indicator Species for French Guiana

'X' means direct evidence fitting to the criteria; blank cell means that the criterion was not met or is unknown.

	VME Representative Taxa	Functional Significance	Fragility	Life History	Structural Complexity
Hard-bottom sponge gardens	GEODIIDAE	X			X
	ANCORINIDAE	X			X
	TETILLIDAE	X			X
	All Lithistid sponges (Discordermia, Aciculites, Gastrophanella…)	X			X
Mesophotic zone	AXINELLIDAE	X	X		X
	Agelas spp.	X	X		X
	Callyspongia spp.	X	X		X
	Amphimedon spp.	X	X		X
	Niphates spp.	X	X		X
	Xestospongia muta	X	X	X	X
	APLYSINIDAE	X	X		X

2.7.6 Metadata of relevant data sources available for French Guiana

Type	Data Source	Data Description	Data Format	Native Resolution	Collection Date(s)	Data Publicly Available?	Contact for Data if not Public
Habitats	Moura et al. 2016.	Mesophotic reef, habitat description, species inventory				published paper, collection at the National Museum of Rio de Janeiro	Eduardo Hajdu (For sponges) <eduardo.hajdu@gmail.com>
Habitats	Greenpeace CNRS cruise - 2018	Mesophotic reef, habitat description, species inventory. Photos, videos	Point		2019	No	Serge.planes@criobe.pf

Type	Data Source	Data Description	Data Format	Native Resolution	Collection Date(s)	Data Publicly Available?	Contact for Data if not Public
VME Elements	GEBCO	GEBCO grided bathymetric data	Raster (Geotiff)	15 arc second (~500m at equator)	2023	https://www.gebco.net/data_and_products/gridded_bathymetry_data/gebco_2023/	
VME Elements	GEBCO	Steep Flanks	Vector (Shapefile, Polygon)	15 arc second (~500m at equator)	2023	https://www.gebco.net/data_and_products/gridded_bathymetry_data/gebco_2023/	
VME Elements	Geomorphology of the Oceans	Submarine Canyons	Vector (Shapefile, Polygon)	derived from 30 arc second (~1km at equator)	2020	https://bluehabitats.org/ https://doi.org/10.1016/j.margeo.2014.01.011	
Fishing		VMS (hooks)			2008-current	Tagliarolo 2023	
Fishing		VMS (handlines); Venezuelan and Martinique vessels				IFREMER	

3 VME identification and assessment methods

3.1 Policy background

The protection of VMEs through the identification and assessment of areas of VME and likely VME, including an assessment of their vulnerability to mobile bottom contact fishing gears, was first highlighted as a policy requirement in the high seas with the adoption of the United Nations General Assembly Resolution 61/105 (A/RES/61/105). In 2008 the EU transposed the measures outlined in the Resolution, into EU law following the adoption of Council Regulation (EC) 734/2008 on the protection of VMEs in the high seas from the adverse impacts of bottom fishing gears. Subsequently, under the EU Commons Fisheries Policy deep-sea access regulations were adopted setting out the objectives and general rules to manage deep-sea fisheries (EU) 1380/2013 and (EU) 2336/2016. These regulations establish the legal framework for the conservation, management and sustainable exploitation of "living marine biological resources" and marine ecosystems concerned in deep-sea areas.

3.2 Defining characteristics of VMEs

Although no universally agreed definition of VME exists, the characteristics to be used as criteria in the identification of VMEs (both for species and habitat-features which are likely to support VMEs) are provided in the FAO's International Guidelines for the Management of Deep-sea Fisheries in the High-Seas (the FAO DSF Guidelines; FAO 2009). Importantly, the FAO DSF Guidelines recognize that the defining characteristics of VMEs should "be adapted and additional criteria developed as experience and knowledge accumulate".

Since the publication of the FAO DSF Guidelines a considerable body of research has been conducted within the geographic areas of the Outermost Regions of the EU, as well as within the jurisdictions of several of the Regional Fishery Management Organizations (Kenchington *et al*. 2015, Rowden *et al*. 2017, Anderson *et al*. 2016, Rowden *et al*. 2020). This research has helped to develop a better understanding of what constitutes a deep-sea VME, especially where the identification and mapping of deep-sea habitats and VMEs is an important requirement.

Recent research suggests that, at a broad-scale, temperature, chemical energy (food supply) and proximity to slope environments are important drivers of biodiversity in much of the deep-sea, the mesophotic zone, and in the littoral submarine caves, with the availability of food playing an increasingly important role at greater depths (e.g., > 2000 m; Woolley *et al*. 2016, Wei *et al*. 2019).

While it is important to use the full set of criteria in the FAO DSF Guidelines to identify where vulnerable marine ecosystems occur or are likely to occur, as well as for assessing Significant Adverse Impacts (FAO 2009), it is now generally accepted that habitat structural complexity, and the role that benthic macro- and mega-faunal species play in forming such habitat, are common defining characteristics of a deep-sea VME (Danovaro *et al*. 2020). VMEs of potential significance for fish and fisheries tend to possess some level of habitat structural complexity, including the presence of "significant concentrations" of individuals (or biomass), that support a high diversity of organisms which typically cover an area of seabed habitat greater than the space occupied by the VME Indicator Species themselves (Beazley *et al*. 2015).

Although advances have been made in the quantitative determination of what constitutes a "significant concentration" of habitat structural forming VME Indicator Species (Kenchington *et al*. 2015), defining "significant concentrations" of VME Indicator Species in the context of identifying and delineating the extent of VMEs remains a challenge in many regions (Rowden *et al*. 2020), especially for those coastal states with limited deep-sea monitoring and assessment capability and resources.

3.3 VME sampling methods

The Outermost Regions have all undertaken (to varying levels) some monitoring and assessment, using a variety of methods, of deep-sea ecosystems and their living resources. The methods, and the extent to which they are used, however, largely depends on the type of programme and specific survey objectives being addressed, but broadly speaking the sampling methods are associated with one of four important monitoring and assessment programmes, e.g., (i) *fishery independent scientific surveys*, which mainly utilise bottom trawl and long-line gears to assess fish stocks and record bycatch species including VME indicator species, (ii) *fishing vessel observer programmes*, which, on selected vessels, document the composition of commercial catches, including VME Indicator Species, but usually at lower levels of taxonomic precision than fishery independent scientific surveys, (iii) *remotely sensed and modelled oceanographic data sets*; typically open access products that have global or ocean basin scale coverage, such as Global Fishing Watch[19] and GEBCO that document different types of potential fishing activity and sea floor bathymetry, respectively, and (iv) *scientific research and development investigations* which vary considerably in their scope and objectives, but are often the primary source of quantitative data describing the state and function of deep-sea ecosystems.

Ideally, VMEs should be identified by fishery-independent means via direct observations using high quality underwater imagery from ROVs, towed, drop-down and drift camera systems (Beazley *et al*. 2015, Morato *et al*. 2018, de la Torriente *et al*. 2018, Rowden *et al*. 2020, Dominguez-Carrió *et al*. 2021b), or by remote seabed sampling using trawls (Kenchington *et al*. 2015), dredges, corers and grabs (Barrio *et al*. 2012). There also is potential for acoustic methods to be able to remotely delineate these VMEs (Feldens *et al*. 2023). In Guadeloupe and the Canary Islands, the Under The Pole DEEPLIFE programme has successfully used deep-sea diving professionals to conduct photo-transects and collect biological and physical data from the mesophotic zone to depths of 90 m (Figure 3.1; Annex 3). From some of these sampling methods the density or aggregation of the VME Indicator Species can be determined, from which the extent of VME habitat can be inferred (Ardron *et al*. 2014, Kenchington *et al*. 2015). The use of multiple detection methods can improve the mapping precision of VMEs, adding alternatives and advantages over single-method detections. Ideally, these methods should include sampling of organisms to allow precise taxonomic identifications (Annexes 3-5).

Direct observation methods have extremely limited spatial coverage, therefore methods which identify proxies of suitable VME habitat, can provide an effective approach towards identifying likely habitat features supporting potential areas of VME (Kenny *et al*. 2018, Duran *et al*. 2023, Feldens *et al*. 2023). Such proxies (e.g., species/habitat distribution/suitability models, VME Elements) are available for all of the Outermost Regions.

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[19] Global Fishing Watch. 2024. https://globalfishingwatch.org/

Figure 3.1. Deep-sea divers with the Under The Pole DEEPLIFE programme collecting abundance and size data on corals in the Canary Islands.

3.4 VME data identification and multi-criteria assessment framework

WKOUTVME has documented the different sources of data in the Outermost Regions (Section 2), which combined with knowledge of the different sampling programmes and methods used in each region (including specific locations sampled), can be used as the basis for a common framework for the identification, assessment and mapping of VMEs at a regional scale (Figure 3.2). The assessment framework is essentially divided in two parts, i.e., (i) *the data acquisition methods* which are associated with identifying the geomorphological/ VME Elements in combination with the direct sampling of the seabed biota using methodologies that allow scaling-up the spatial assessments, and (ii) *the data assessment methods*, which enable predictive maps of VME suitable habitat and VME Indicators Species distributions to extrapolate and interpolate areas of predicted VME presence. Taken together, the evidence base can then be assessed using multi-criteria assessment methods that combine information on VMEs, VME Indicators Species and VME elements, their vulnerability to bottom-contact fishing gears, and the prevalence of bottom fishing activities, to determine the risk of Significant Adverse Impacts of fishing on the VME (*sensu* FAO 2009). A good example of where such an assessment framework has been applied is in the identification and mapping of VMEs within the Azores EEZ (see Annex 4).

Conclusion: The outlined assessment framework in this report is widely applicable and could be applied as a basis for compiling and assessing VME-relevant information for any of the Outermost Regions.

Details of the four steps (Figure 3.2) leading towards a final assessment follow:

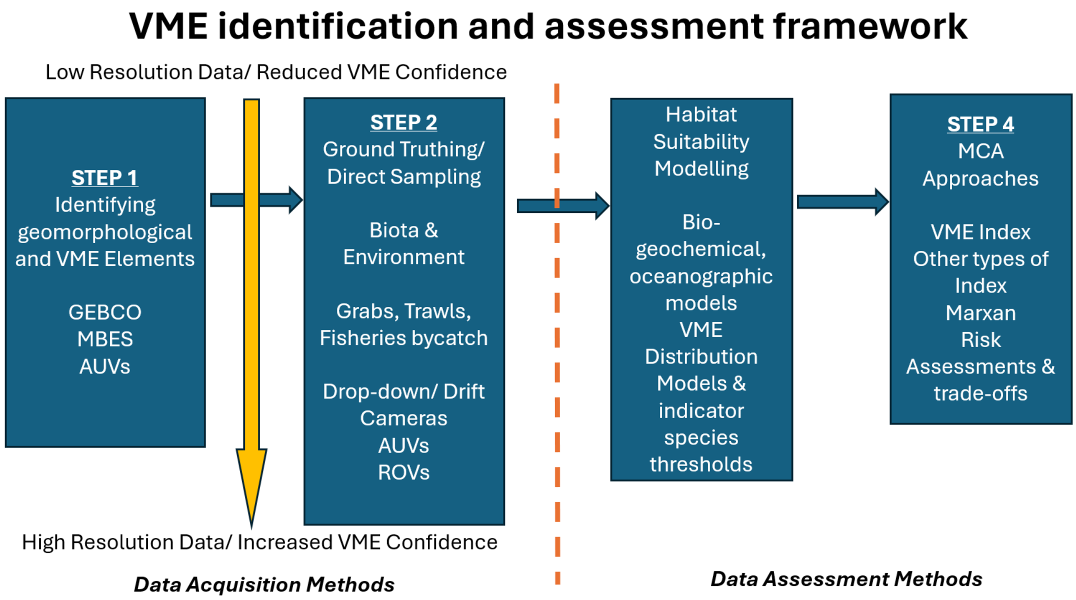

Figure 3.2. The four principal steps typically employed in the identification and assessment of VMEs: (i) Step 1, the identification of the geomorphological units and VME Elements associated with VMEs, (ii) Step 2, targeted biological and habitat sampling of the geomorphological units and VME Elements, (iii) Step 3, modelling VME Indicator Species distributions and suitable habitat, including an assessment of VME Indicators Species abundance and biomass thresholds, and (iv) Step 4, combining all the information on VME extent, vulnerability and fisheries to define different management options to protect VME from fisheries related significant adverse impacts. For each step different sampling and assessment methods can be utilized with increasing spatial resolution and complexity resulting in increased confidence in identifying and delineating areas of VME. GEBCO = General Bathymetric Chart of the Oceans, MBES = Multibeam Echosounders, AUV = Automated Underwater Vehicle, ROV = Remotely Operated Vehicle, MCA = Multi-Criteria Analysis.

3.4.1 Step 1: Identifying geomorphological features and VME Elements

The physical nature of the seabed environment plays a vital role in determining the structure and function of seabed communities. The importance of such abiotic factors in determining the status of benthic communities is well known, to the extent that the physical characteristics of the seabed environment, including its morphology, can often be used to provide a good estimate of the types of benthic communities likely to be found inhabiting the seabed (Kenny & Southeran 2013). This is especially the case for deep-sea habitats where seamounts and other geomorphological features can significantly alter the local hydrography and physical and chemical oceanographic conditions in such a way as to favour the presence of VMEs (Taranto *et al*. 2023).

High-resolution bathymetric data obtained from multibeam echosounder (MBES) scans, regardless of their origin, can therefore help to meet the spatial information needs for biodiversity assessments. Indeed, the lack of high resolution MBES data used to develop robust Digital Terrain Models (DTMs) is often one of the major constraints limiting the identification of deep-sea geomorphological features and VME Elements. To generate the most extensive and highest resolution seafloor bathymetric map possible, it is often necessary to collaborate with national and international institutions to combine MBES data from at-sea surveys from multiple sources and augment it with lower resolution publicly available bathymetry datasets (e.g., GEBCO and satellite-derived ocean surface elevation data). However, in the absence of high resolution multibeam bathymetric data, relatively low resolution bathymetric data (500 m by 500 m) can be obtained covering most regions from the GEBCO website, which is adequate for the approximate identification of most VME Elements, e.g., seamounts, steep slopes, ridges and canyons (Section 1).

Conclusion: An important limiting factor in the effectiveness of identifying VMEs in the deep sea is the lack of large-scale high resolution (< 100 m) seabed bathymetry from which geomorphological features and VME Elements can be adequately identified and sampled.

Recommendation: Guidance should be developed to ensure consistency when identifying and classifying geomorphological features to VME Elements in such studies, especially in relation to the mapping and assessment of VME habitats.

3.4.2 Step 2: Characterizing or ground truthing potential VME habitats

Evaluating the patterns of biodiversity distributions over wide geographic areas requires large-scale sampling efforts that might span several years. Underwater imaging technology has provided the means to access the deep seabed employing non-invasive technologies that can provide *in situ*, representative and potentially repeatable samples in the form of still and video images but are too rarely used systematically to cover large areas (Fourt *et al*. 2016, Morato *et al*. 2018). In the Canaries and the Azores, video surveys have been consistently used to provide baseline data across large spatial scales. VMEs are best sampled using underwater imagery which enables an accurate and quantitative description of mega-epibenthic community composition and associated habitat characteristics, including damage caused by bottom contact fishing gears (e.g., Hansen *et al*. 2013, Ardron *et al*. 2014). Although deep-sea camera-based systems tend to be complex and expensive pieces of equipment, especially when incorporated in multi-functional Remotely Operated Vehicles (ROV), recent developments in underwater camera technology have resulted in relatively inexpensive and simple camera-based systems which can be deployed from non-specialist support vessels, e.g., the *Azor drift-cam* (Dominguez-Carrió *et al*. 2021) system (see Annex 4). However, in many instances the commonest type of benthic biota sample data available for VME identification purposes is obtained from bycatch records, either from fisheries independent surveys or commercial fishing operations via scientific observer reports (Duran *et al*. 2023).

In the Outermost Regions, there are VMEs and VME Indicator Species that extend into waters that fall within depth ranges for human diving. The Under the Pole DEEPLIFE programme uses specialized diving gear, Trimix Closed Circuit Rebreathers, to collect samples at depths that cannot be reached with traditional scuba diving. Rebreathers recycle divers' exhalations and filter out carbon dioxide to enable them to undertake longer, deeper dives in the mesophotic zone. Placing humans directly in the VME habitats is a unique situation for the Mesophotic Zone and Submarine Cave VME habitats. Divers in DEEPLIFE undertook photographic transects at different depths (40, 60 and 90 m) and collected samples for taxonomic and genetic studies (see Annex 3).

Conclusion: Complementing video surveys with taxonomic studies is fundamental for the development of improved lists of VME indicator taxa, including developing a better understanding of VME Indicator Species life histories and biological traits.

Conclusion: Developing a cost-effective drop down camera system and regional surveys based on such systems can largely improve the knowledge base of VME distribution over a time period of 2-5 years.

3.4.3 Step 3: VME Habitat suitability and species distribution modelling

Spatial species distribution and habitat suitability models use biological and environmental data to predict where key species or communities are likely to be found in areas that have not yet been explored. Additionally, they represent an important tool to investigate regional biodiversity patterns and predict how benthic communities might change under future climatic conditions and different anthropogenic pressures.

Predictive modelling of the distribution of VMEs may be achieved in a variety of ways (Guinan *et al*. 2009, Howell *et al*. 2011, Knudby *et al*. 2013, Rengstorf *et al*. 2013, Ross & Howell 2013, Kenchington *et al*. 2015, NAFO 2016, Taranto *et al*. 2023b). Where the habitat is formed by a single dominant species (as in the case of some deep-sea sponge grounds), modelling the distribution of the species may be informative. In other cases the distribution of the community, or of multiple VME Indicator Species can be jointly modelled or ensembled. However, it has also been observed that techniques which model the distribution of habitat are sensitive to the spatial resolution of the environmental data (e.g., bathymetry) used to parameterize the model (Anderson *et al*. 2016). In such cases where low spatial resolution bathymetric data has been used to predict broad scale VME distribution there tends to be significant overestimation of suitable habitat (Anderson *et al*. 2016). Nevertheless, where a 'habitat' is composed of a distinct assemblage of species (as typified by e.g., a biogenic reef), then the distribution of that assemblage may be modelled with relatively low error (Piechaud *et al*. 2015) and when overlaid with the modelled distribution of key VME Indicator Species accurate habitat distribution maps can be generated at a range of spatial scales (NAFO 2016).

Identification of VME communities based on community composition, and subsequent modeling of those communities has been successful in terms of habitat mapping for MPA characterization in the Canary Islands (Annex 5). Predictive maps of the occurrence of a community of vulnerable species rather than of the occurrence of a single VME Indicator species, align best with the intent of the FAO DSF Guidelines to protect VMEs from the harmful effects of bottom contact fishing gears. Figure 3.3, from Banco de La Concepción in the Canary Islands, shows the number of c-squares affected is very different depending on whether species or communities are modelled, and whether actual occurrences records, or species distribution models, are used to identify areas of VME.

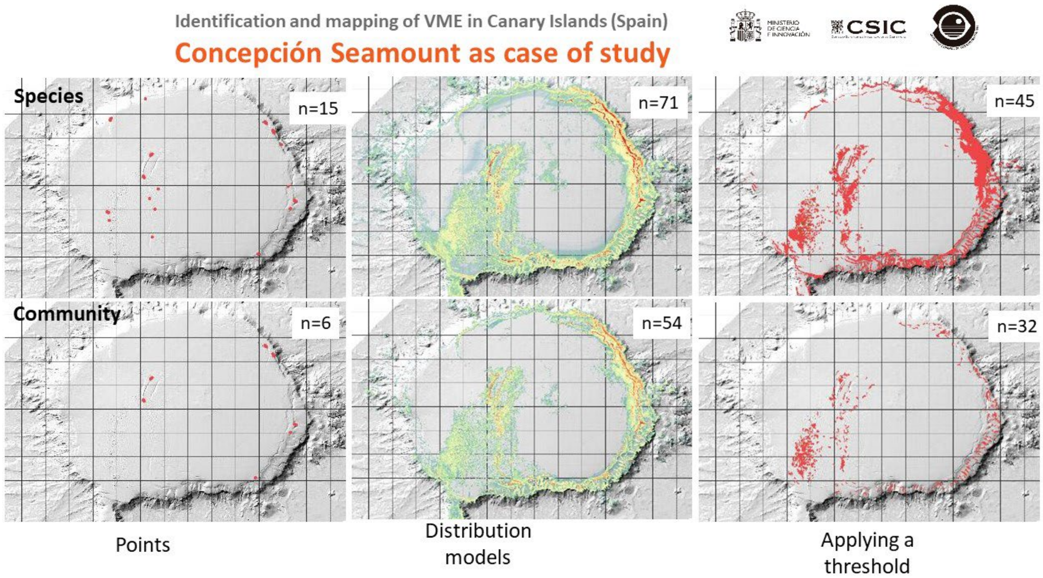

Figure 3.3 Distribution models of a single VME Indicator Species and of VME communities from Banco de La Concepción in the Canary Islands. The number of c-squares affected is much smaller for the distribution of VMEs (see Annex 5).

Recommendation: Models of VME communities should be supported in preference of single species models for decision making.

Recommendation: Building habitat suitability models with robust quantifications of uncertainties is crucial to increase the likelihood of models being useful to inform management.

3.4.4 Step 4: Multi-criteria Analysis to identify areas of likely VME including management options

Multi-criteria analysis is a method of aggregating different sources of data and information based on weighted criteria or attributes to provide a single metric that captures all the relevant information and evidence (Morato *et al*. 2018, Morato *et al*. 2021, ICES 2022b). In the context of identifying VMEs in the northeast Atlantic, ICES recently benchmarked its approach "on the occurrence and protection of VMEs" (ICES 2022b) which combines data derived from; (i) a VME index, which itself combines different sources of information on the vulnerability of VME Indicator Species to mobile bottom contact fishing gears and the abundance of VME indicator species, (ii) the presence of VME Elements, (iii) specific VME Indicator Species records, and (iv) fisheries pressure data as VMS-derived swept area ratios. The data were combined to identify and map areas of likely VME according to four defined scenarios and options (ICES 2022b). However, in this case habitat suitability and species distribution models were not used, although it is noteworthy that ICES is in the process of investigating the use of such models in its VME advisory processes (Workshop on the Use of Predictive Habitat Models in ICES Advice (WKPHM)).

Other information which is particularly important when considering appropriate measures for the protection and sustainability of VMEs is the ecological or 'functional' connectivity between VMEs in the deep-sea. This concept generally refers to processes by which genes, organisms (adults and larvae), nutrients and/or energy, transfer between habitats (both pelagic and benthic) in space and time, connecting populations and communities of marine organisms (Kenchington *et al*. 2019, O'Leary & Roberts 2018, Wang *et al*. 2024). Indeed, habitat connectivity was recently recognized as the 4th most important scientific topic for research amongst a survey of deep-sea scientists (Danovaro *et al*. 2020). The importance of ecological connectivity for the management and persistence of VMEs has been recently addressed by ICES WGDEC (ToR e; WG Report to be published in 2024). The document provides an overview of recent advances in knowledge of the life history, connectivity and reproductive ecology of VME Indicator taxa in the northeast Atlantic, as well as various approaches that can be used to estimate connectivity within ICES regions, based on data availability and quality.

In addition, MARXAN has been widely used as a management decision support tool in marine conservation planning, based on multivariate and multiple criteria analytical methods, especially in relation to the design of networks of marine protected areas and the assessment of trade-offs with other users (Galparsoro & Borja 2021, Martín-García *et al*. 2015). A case study using MARXAN to identify areas most suitable for establishing seamount marine protected areas in the Canary Islands is provided in Annex 6.

4 Approaches for mapping and assessing VME data in the Outermost Regions

The identification of VMEs, indicators of VMEs and VME elements requires a suite of data that regard different aspects of the regions of interest. At a first and more general level, it is essential to have a good characterization of the seafloor and, in particular of its topography. In fact, bathymetry and bathymetric derived information set the stage for the identification of VMEs and, more in general, for the exploration and management of the deep sea. Additional information about local oceanography and biogeochemistry (e.g., derived from fine-resolution numerical models) is also very useful as it provides the environmental setting of different seafloor elements and can be useful in understanding and predicting how deep-sea biodiversity and VMEs change across a region.

Bathymetric and oceanographic data, *per se*, can only provide a general idea about where VMEs are more likely to occur. Only biological data and a proper description of the regional deep-sea fauna can provide essential information to contextualize VME Indicator taxa and habitats within the area of interest, determine VME thresholds and provide an accurate and fine-scale spatial description on the occurrence of VMEs.

Finally, ecological models represent valuable tools for assessing different aspects of VMEs. When the knowledge about regional deep-sea biodiversity is poor, spatial models can complement the scarce biological records producing estimates on where VMEs are more likely to occur based on environmental conditions (e.g., habitat suitability and species distribution models). The confidence of habitat suitability models (HSMs) and species distribution models (SDMs) largely depends on the biological records available and on the quality of the environmental layers. As the knowledge about regional deep-sea biodiversity increases and actual biological data, *per se*, can drive management decisions, ecological models can be used to answer more complex questions such as: What are the main drivers of distribution of VMEs? How do VMEs change across geographic and bathymetric gradients? What are the effects of climate change and anthropogenic pressures on VMEs distribution?

The extent and quality of data available for the identification and mapping VMEs in the Outermost Regions of the EU is highly variable between the regions (see Section 2). However, for all regions, there is basic information available (including responses from the questionnaires; Figure 4.1) which can be used to identify VME Elements and VME Indicator Species at a resolution suitable for mapping purposes.

Given the availability of relevant basic data for all regions, it should be possible to apply an assessment framework and map the data and information related to VME Elements, VME Indicator Species and VMEs, and habitat suitability models, to identify where VMEs occur and *are likely* to occur. A hypothetical example of the types of VME-relevant information and data that can be mapped and how this may look is shown in Figure 4.2.

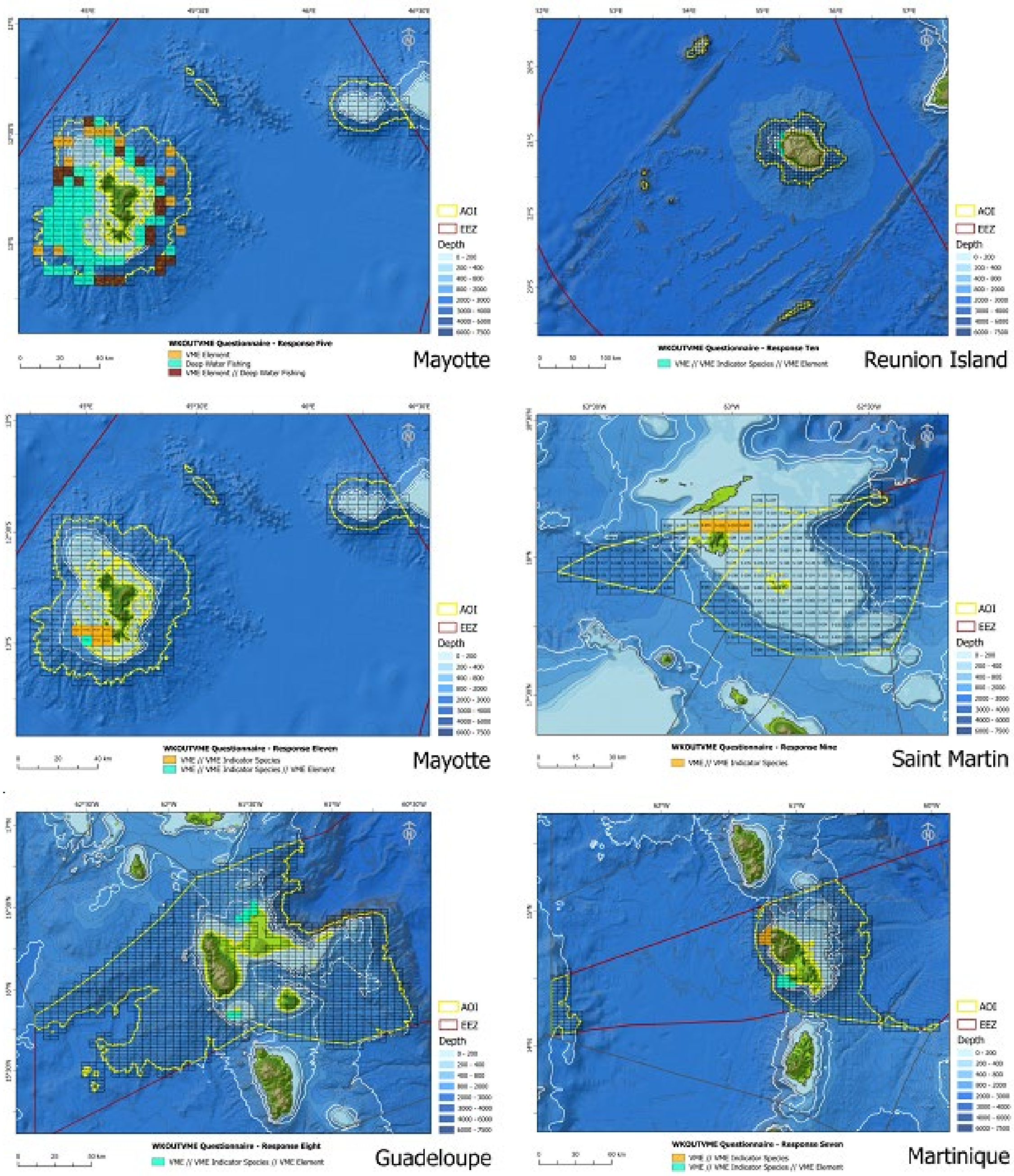

Figure 4.1. Mapped responses from Questionnaires identifying important fishing grounds and areas of potential VME.

The final method of evaluation, e.g., the application of an MCA approach (Step 4 in Section 3.4), will need to be agreed and finalized once all the available data has been mapped during a second follow-up workshop, but in principle it should be possible (as determined by the present workshop) to provide an indication of confidence in the data for VME assessment and mapping, based upon the weight of spatial evidence. This combined with a knowledge of where important fishing activities occur should enable future options to be considered for potential VME protection measures.

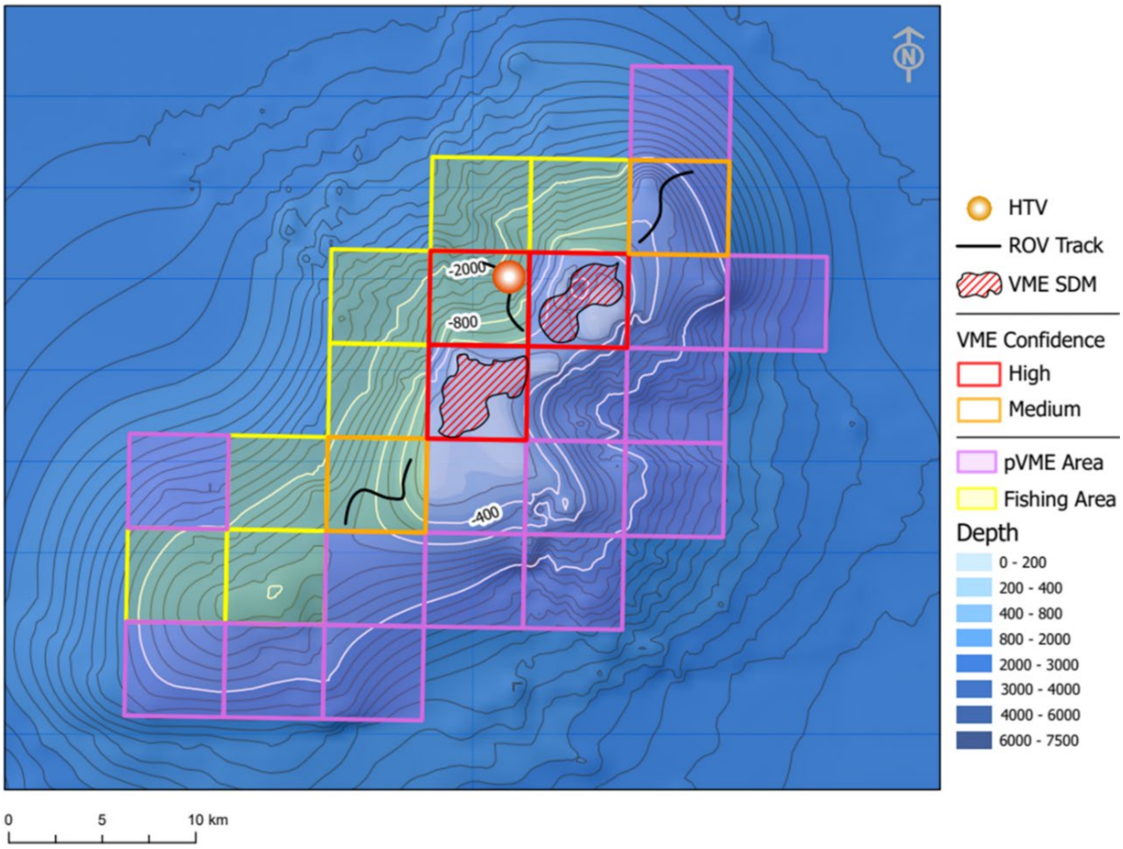

Figure 4.2. Hypothetical example of the types of VME relevant information and data that can be mapped to identify areas of VME and likely VME. HTV – hydrothermal vent, ROV = remotely operated vehicle, SDM – species distribution model, pVME = potential VME.

4.1 Overall evaluation of data availability for the identification of VMEs in the Outermost Regions

An important requirement is understanding the uncertainties and levels of confidence associated with the VME assessment outputs generated for each of the Outermost Regions (Figure 4.3). Such uncertainties relate to the availability and quality of data, which in the present study are defined by a set of criteria which correspond to the different steps (Steps 1-3 in Section 3.4) of the proposed VME assessment framework, as shown in Table 4.1.

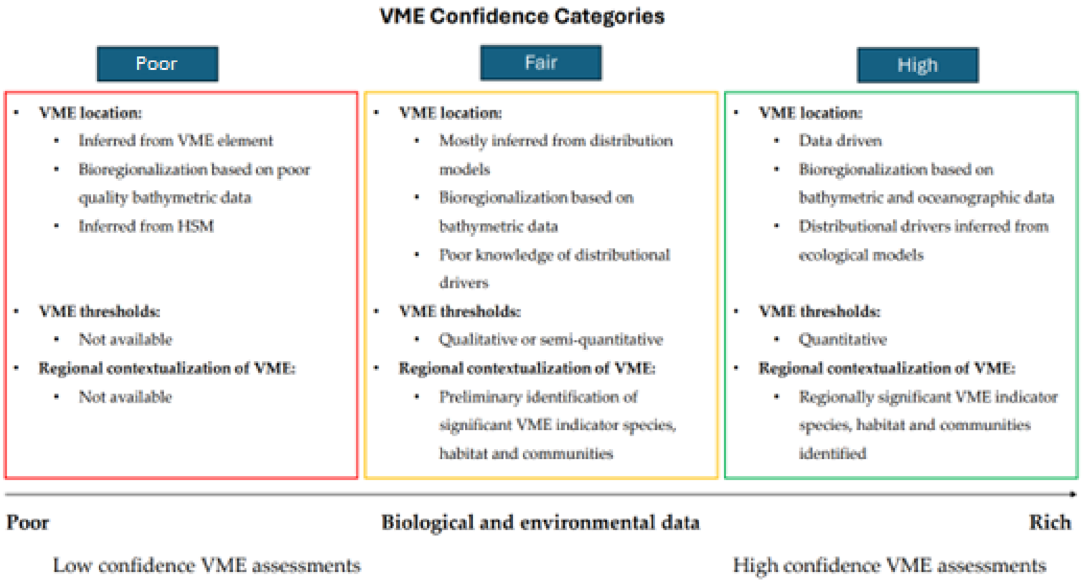

Figure 4.3. Confidence categories in the presence of a VME related to the knowledge base available.

The confidence in whether the available data represents areas where VMEs are known to occur increases with spatial precision and information content. Although VME Elements are considered by the UNGA to be indicators of VME as inferred from the literature, their spatial scale is large relative to the patch size of VMEs. While many RFMOs have protected VMEs from the harmful effects of fishing based on the presence of VME Elements (e.g., NAFO seamount protections), this has been a management decision based on the fact that the VMEs are likely to occur in such areas. With more information from direct observations and modelling, confidence in the geographic circumscription of the VME boundaries increases (Figure 4.3).

From Table 4.1 and Figure 4.3 each of the Outermost Regions was scored with respect to their data availability and confidence by experts attending WKOUTVME. The results of this evaluation are shown in Table 4.2. However, despite the lack of agreed specific evaluation criteria for Step 4, it was possible to score the Azores and the Canary Islands for this category as they have by far the greatest confidence and availability of VME and fisheries data and information compared to the other regions. For all other regions the outcome of the VME assessment at a regional scale will likely have a low level of confidence due to limited data coverage and data quality.

Table 4.1. Criteria used to evaluate different data sources and their availability to assess VMEs, VME Indicator Species and VME Elements according to the framework proposed in the present study. GEBCO is General Bathymetric Chart of the Oceans (GEBCO 2023), EMODnet is European Marine Observation and Data Network (https://emodnet.ec.europa.eu/en/bathymetry), GLODAP is Global Ocean Data Analysis Project (Lauvset *et al*. 2022), WOA is World Ocean Atlas (Reagan *et al*. 2024). These steps predicate Step 4 which is a multi-criteria assessment.

Data Availability	Step 1: Seafloor characterization	Step 2: Biological and habitat characterization	Step 3: Ecological modelling
Poor	*Seafloor topography*. Derived from large bathymetric repositories (e.g., GEBCO, EMODnet, etc.) without confirming the quality of the bathymetric data available for the region. *Oceanographic setting.* Derived from global data sets (e.g., WOA or GLODAP).	*Regional fauna.* No or poor knowledge of the deep-sea fauna associated with the area of interest. No information about local communities. *Surveys.* Occasional sampling. *Data types.* None or little presence data. *Spatial coverage.* None or limited. *VME knowledge.* VME Indicator Species can only be inferred from literature (e.g., ICES list); impossible to contextualize VME indicator taxa and habitats within the area of interest; impossible to determine VME density or biomass thresholds.	*Type.* Presence only habitat distribution models. *Use.* Preliminary inference about spatial distributions of the species of interest; preliminary inference about the spatial drivers of distribution.
Fair	*Seafloor topography*. High-quality multibeam data for part of the area of interest. *Oceanographic setting.* Derived from global data sets (e.g., WOA or GLODAP).	*Regional fauna.* Fair knowledge of the fauna associated with the area of interest with preliminary taxonomic and ecological characterization. Poor information about local communities. *Surveys.* Occasional sampling or systematic surveys covering only a biased portion of the area of interest (e.g., shallow areas). *Data types.* Presence data, preliminary abundance data. *Spatial coverage.* Partial. *VME knowledge.* A preliminary contextualization of VME Indicator Species and habitats within the area of interest is possible; impossible to determine VME thresholds.	*Type.* Presence only species or habitat distribution models. *Use.* Infer spatial distributions of the species of interest; preliminary inference about the spatial drivers of distribution.
High	*Seafloor topography*. High-quality multibeam data for most of the area of interest. *Oceanographic setting.* Derived from global data sets (e.g., WOA or GLODAP).	*Regional fauna.* Good knowledge of the fauna associated with the area of interest with proper taxonomic and ecological characterization. Preliminary description of the most relevant regional communities.	*Type.* Presence only species or habitat distribution models; multi-species or community models.

Data Availability	Step 1: Seafloor characterization	Step 2: Biological and habitat characterization	Step 3: Ecological modelling
		Surveys. Unbiased systematic surveys throughout the area of interest. *Data types.* Occurrence and abundance data and early stage complementary datasets (e.g., functional traits, ecosystem functions, population genetic, etc.) *Spatial coverage.* Exhaustive. *VME knowledge.* A contextualization of VME Indicator Species and habitats within the area of interest is possible; qualitative or semi-quantitative VME thresholds.	*Use.* Infer spatial distributions of the species of interest; inference about the spatial drivers of distribution; preliminary inference about the communities of interest.
Optimal	*Seafloor topography*. High-quality multibeam data for all the area of interest. *Oceanographic setting.* Fine scale oceanographic data at a resolution comparable to multibeam data (e.g., derived from high-resolution regional biogeochemical or hydrodynamics models).	*Regional fauna.* Good knowledge of the fauna associated with the area of interest with proper taxonomic characterization. Exhaustive description of all relevant regional communities. *Surveys.* Unbiased systematic surveys throughout the area of interest. *Data types.* Abundance data and complementary datasets (e.g., functional traits, ecosystem functions, population genetic, etc.) *Spatial coverage.* Exhaustive. *VME knowledge.* A contextualization of VME Indicator Species and habitats within the area of interest is possible; quantitative VME thresholds.	*Type.* Presence only species or habitat distribution models; multi-species or community models; ecosystem and biogeochemical models. *Use.* Infer spatial distributions of the species of interest; inference about the spatial drivers of distribution; inference about the communities of interest; inference about anthropogenic and climate-driven impacts on VMEs.

Table 4.2. Scoring of the data availability for each of the Outermost Regions against the steps of the defined VME assessment framework by WKOUTVME experts.

	VME Data Acquisition/ Surveys		VME Assessment/ Mapping	
Region	**Step 1: Geomorphology**	**Step 2: Biota Characterization**	**Step 3: Habitat/ Species Models**	**Step 4*: Multi-Criteria Assessment**
Réunion	Fair/High?	Poor	Poor	-
Mayotte	Fair?	Poor	Poor	-
Canary Islands	High to 1000m	High to 1000m	High	Fair/High (confidence)
Madeira	?	Poor	Poor	-
Azores	High to 1000m	High/Optimal to 1000m	High	Fair/High (confidence)
Saint Martin	Fair /High?	Poor	Poor	-
Martinique	Fair/High?	Fair <100 - Poor > 100m	Poor	-
Guadeloupe	Fair/High?	Fair <100 - Poor > 100m	Poor	-
French Guiana	Fair	Poor	Poor	-

***The assessment for Step 4 was based on expert opinion in the absence of agreed upon criteria.**

5 Approaches for mapping the fishing footprint in the Outermost Regions

5.1 Availability of spatial information on the deep-sea fisheries

One important lesson learned from this workshop is that fishing activity is difficult to track in many of the Outermost Regions. Attempts to use tools like Global Fishing Watch were unsuccessful for small-scale fisheries because of the lack of AIS/VMS transponder on those vessels of < 12 m. Optical imagery from satellite at day or night was not helpful as well. The lack of reply from fishers to the WKOUTVME questionnaire in most regions has not provided substitute information.

Local fishery experts provided information on deep-water fishing activity including the number of boats, used fishing gears, and depth band for the fishing operations. Those information are summarized in Table 5.1 and highlight two groups of datasets in terms of spatial square of fishing activity: 1x1 km to 5x5 km information which are considered data-rich and above 5x5 km which are data-poor. It's worth noting that spatial information is available for all regions. The diversity of fishing situations provided some useful insights to improve the geolocation of small-scale fisheries, which is a prerequisite to identify the overlap between fishery activity and VMEs.

5.2 High resolution spatial information

High resolution spatial information were locally acquired from VMS data, interviews, observers at sea and GPS loggers. Spatial resolution ranged from 1x1 km to 5x5 km (Table 5.1).

5.2.1 Vessel Monitoring System (VMS)

For the Azores, the bottom-fishing (longline plus handline) effort layer was computed from an analysis of the Vessel Monitoring System (VMS) for vessels licensed for bottom longline or handline fishing gears. The fishing licenses granted to each vessel per year were used to allocate a gear type to all VMS pings. We acknowledge that not all boats have VMS systems installed. However, a quick comparison of the VMS outputs with the fishing effort maps obtained from fishers' inquiries (Diogo *et al*. 2015) revealed similar spatial patterns, but much more spatial detail when using the VMS data. VMS data were also available in French Guiana for the Venezuelan fishery targeting *Lutjanus purpureus* but this fishery does not operate deeper than 400 m.

5.2.2 Interviews

For the Azores, some previous work was carried out through interviews in the context of the EU Data Compilation Framework from 1998 to 2012. The resolution of the statistical square was however of 10 nm x 10 nm which can be considered as low resolution data.

In the Canary Islands, vessels are less than 12 m and polyvalent in terms of gears and targeted species. As VMS/AIS is not present on those vessels, several substitute methods have been applied to get proxies of fishing effort spatial distribution at a higher resolution square (1 km x 1 km) including interviews. During those interviews, the measurement unit is the number of boats visiting anytime each c-square over a year (from mid-2022 to mid-2023). There isn't a fishing intensity measurement.

Recommendation: Interviews have caveats and should not be used as raw data to map the fisheries footprint for management purposes as it not actual spatial fishing intensity data but proxies.

Fishermen point in a map where they fish following their geographical interpretation of where they fish, by memory. This is subjectively influenced by the different degrees of profit, the time lapse between the interview and the last time to visit each zone, the reluctancy to identify certain fishing spots, etc. In Martinique, phone interviews are also conducted to get information on the fishing activity in general. This method is generally considered as good for getting proxy estimates of the total catches but may be biased as fishermen who answer phone calls might not be those who are the most active at sea. In Martinique, some discussion with fishermen through regional contacts has allowed WKOUTVME to get data for 5 x 5 km squares of the area of deep-water crustacean pots. In Mayotte, interviews with longline fishermen and one using hooks allowed the Mayotte Marine Park workers to fill out the WKOUTVME questionnaire and pinpoint fishing location.

5.2.3 Global Positioning System (GPS) logging

Portable GPS trackers were used in the Canary Islands to depict the geographical behaviour of an average fishing day of some fishing gears at some of the fishing grounds. A limited number of fishing days were monitored with portable GPS devices. The main issues were the number of available devices (20-30), the level of confidence between the fishermen and scientific staff and the willingness of the fishers to have a specific fishing day monitored (they are able to turn off-on the device as many times as they want). It is worth noting that in some Outermost Regions, fishing vessels may be used for other marine activities, fishermen might not want to divulge those activity as well as their best fishing areas.

5.2.4 Observers at sea

Onboard observation is generally considered as a good way to collect several sources of information including catches, bycatches, discards, fishing effort, spots, and gear used for each of the fishing spots. All the information in the fisheries description section for the Canary Islands of this report comes from this type of field work. The Azores also has a several years of an ongoing observers at-sea program.

As for the GPS logging, onboard observation is limited by the available resources *in situ*. This activity is considered very expensive to deploy and fishermen may need to have extra safety compliancy which may limit access to observers. Some fishermen may be reluctant to embark with observers on their boats to witness their fishing activity. Therefore, it is important to build up a confidence relationship between the scientific staff and the fishers.

5.3 Low resolution spatial information

When the previous information was not available, the relevant territories were considered to have low-resolution spatial information (higher than 5 km x 5 km and up to 120 km x 120 km). In the context of deep-water activities, those areas were Martinique, Guadeloupe, Saint Martin, and Réunion Island.

Catch and effort data are available from national databases but are generally reported at the scale of large statistical sectors rather than the fishing location (Figure 5.1 – left and middle). The covered area by a statistical sector may engulf very different ecosystems, including VMEs, with a wide range of depths (middle of Figure 5.1) from shallow waters to deep-water ones.

For the deep-sea fish species, as many of them are tied to depth bands, it is possible to narrow the location and fishing effort of the vessels by filtering catches by deep-sea species and appropriate depth band (right of Figure 5.1, red polygon) so a relevant trip can be identified. However, as shown on Figure 5.1, the surface might still be wide and overlap known VMEs when the actual fishing spot (yellow square on the left plot) is actually distinct from the location of the VME. This is a significant problem that cannot be solved just using the official fishing data.

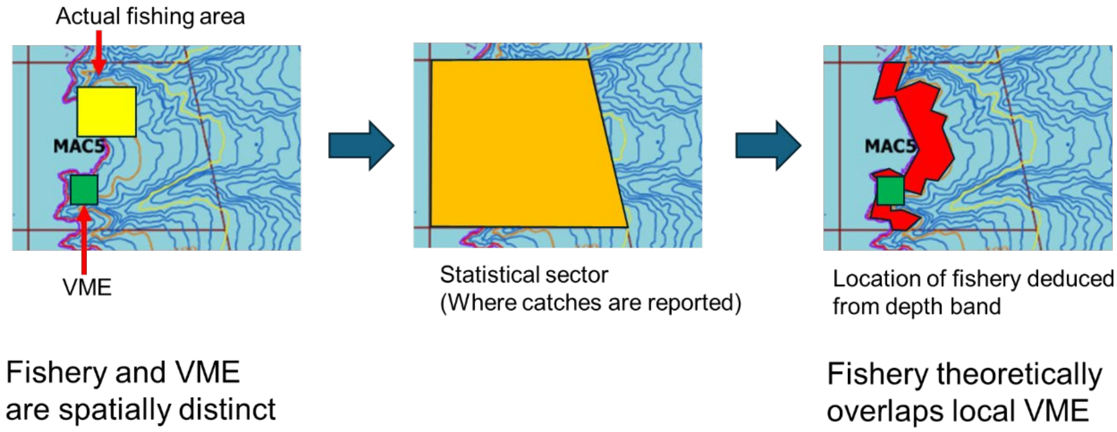

Figure 5.1. The challenge of using low-resolution statistical sector to identify fishery footprint and VME overlap.

Another problem is the capacity for those fleets to change gear and métier and fishing location during a trip. The aggregation process in the official databases prevents from distinguishing all fishing operations. This is where GPS logging or observer at-sea programs could bring the missing information. It is also worth mentioning that those vessels can also quickly change their fishing strategy due to sea condition and there are not really market/price considerations in many cases. The location of each fishing operation is also of importance to deduce the overlap of fishing activity which might generate pressure and impact the VME.

ICES defines pressure as the mechanism through which an activity has an actual or potential effect on any part of the ecosystem, e.g., for demersal trawling activity, one pressure would be abrasion of the seabed. It should be noted that one pressure may be caused by many different activities (e.g., abrasion from fishing, aggregate extraction, dredging) with different extents, frequencies, and impacts, and that one activity may be responsible for multiple pressures (e.g., other non-physical pressures by fishing such as spread of non-indigenous species, mortality/injury to wild species, and inputs of litter). Pressures can cause multiple and progressive biological (e.g., lethal and various sub-lethal changes through damage and stress) and physio-chemical state changes (e.g., sediment homogenization, changes in sediment topography, and compaction) at any level (e.g., communities and habitats). The pressure can lead to some impact/adverse effect that ICES defines as a possible adverse change, influencing or affecting an environmental component, caused by a pressure related to one or more anthropogenic activities.

To characterize Activity, Pressure and Impact, it implies the need to know precisely both the characteristics of the VME and of the fishing activity operating over or around the VME such as the type and characteristics of the used gears, and the fishing effort. It is also important to develop transparent and objective methodologies to assess significant adverse impacts (Impact). The workshop did not have the time to discuss or evaluate this important aspect, but it should be noted that not all fishing or other human activities produce similar impacts.

5.4 Recommendations for assessing the deep-sea fishing footprint

The general guideline is that the spatial and temporal resolution collected should be relevant to the fishing activity. The following is some recommendation to collect fine scale information on non-VMS/AIS vessels.

1. **Spatial resolution and frequency of geolocation data should be relevant to fishing operations.** Appropriate time frame, spatial resolution and frequency of geolocation data are respectively, 8 years of data collected quarterly to account for seasonality at a frequency of 1 hour between ping or geolocation recording. Resolution should be set at the smaller possible scale (1 x 1 km square grid is recommended).
2. **Data on fishing activity should be recorded in provided in such a way that deep-water and shallow fishing operations can be distinguished.** On small vessels, fishing gear and depth of fishing can vary strongly during the same trip and due to the lack of onboard observation, data are often aggregated at the trip and single gear or métier levels. This issue can be solved by having separate recording of each fishing operation and change of gear type.
3. **Information and data from local past projects related to small-scale fisheries should be retrieved** (e.g., experimental fishing) available from grey literature (e.g., institutional reports). That work might be done ahead of time of the next workshop.
4. **Alternate options for getting geolocation data should be considered**
    - Voluntary GPS data logging. This method provides accurate data on fishing trips. However fishermen might be reluctant to accept such equipment onboard. Catch composition will not be available. Fishing operations can be derived from recorded tracks.
    - Interviews of fishermen, preferably *in person*. Information will be less accurate than geolocation data and fishermen might be reluctant to provide sensitive information. That method might also be biased as fishermen available for interviews might not be those the mostly active. Catch composition data might be partly available but provided details from the fishermen will often be limited to the most valuable species or unusual catches/operations. Fishing operations during a trip cannot be distinguished.
    - Observer at-sea programs are considered the best as this option provides both accurate information on fishing operation and catch composition. Fishing operations can be easily distinguished on a single trip.
5. **Development of methodology** on analysing those datasets should be developed such as those carried out by the ICES workgroup on small-scale fisheries geolocation (WGSSFGEO). Some guidelines should be developed to account for the different type of data available.

Table 5.1. Summary of available fishery information in the Outermost Regions.

Region	Source of Data	Period	Average Resolution	Type of Deep-water Gear	Number of Vessels involved in Catches of Deep-water Species	Maximum Fishing Depth (m)	Footnote Comments	Reference
Madeira	Peer-reviewed literature and density plots of fishing activity from DCF and Regional Directorate of Fisheries of Madeira	2015 data	10km radius	Drifting longlines	Vessels >12m (around 48 vessels in 2015)	800-1300		Vallerani *et al*. 2017, Delgado *et al*. 2018
Azores	Interviews for the Data Collection Framework (DCF) (n=6253)	1998–2012	10x10 nm	Bottom longline and handline fishing effort	Average of 169 (142-246)	1000		Diogo *et al*. 2015
	VMS data	2002-2018	5x5 km	Bottom longline and handline fishing effort	74 boats	1000	(A)	confidential (not yet available Morato and Fauconnet, unpublished data)
Canary Islands	Interviews	Mid 2022-Mid 2023	1x1 km	Hooks, Longlines, Fish traps	741 boats (Hooks), 2 big vessels + 20-30 smaller units (Longlines) and around 200 vessels (Fish traps)	1000 (Hooks and longlines), 200 (fish traps)		Spanish framework of Marine Strategy (report not published yet)
	GPS loggers	2023	GPS tracks	Hooks, Longlines, Fish traps	741 boats (Hooks), 2 big vessels + 20-30 smaller units (Longlines) and around 200 vessels (Fish traps)	1000 (Hooks and longlines), 200 (fish traps)		Spanish framework of Marine Strategy (report not published yet)
	Observers at sea	2023	GPS tracks	Hooks, Longlines, Fish traps	741 boats (Hooks), 2 big vessels + 20-30 smaller units (Longlines) and around 200 vessels (Fish traps)	1000 (Hooks and longlines), 200 (fish traps)		Spanish framework of Marine Strategy (report not published yet)
Saint Martin	IFREMER statistical sectors (2 grid cells)	Unknown	min 15x30 km	Longlines	10 boats	Unknown	(B)	IFREMER 2022

Region	Source of Data	Period	Average Resolution	Type of Deep-water Gear	Number of Vessels involved in Catches of Deep-water Species	Maximum Fishing Depth (m)	Footnote Comments	Reference
Guadeloupe	IFREMER statistical sectors (>40 grid cells). Annual vessel census + sampling of effort and landings at harbour	2007-current	min 20x20 km	Gillnets	18 vessels	60-200	(C)	IFREMER 2022
		2007-current	min 20x20 km	Fish traps	36 vessels	60-200	(C)	IFREMER 2022
		2007-current	min 20x20 km	Crustacean traps	4 vessels	400-600	(D)	IFREMER 2022
Martinique	IFREMER statistical sectors (>20 grid cells). Annual vessel census + sampling of effort and landings at harbour	2007-current	min 20x20 km	Longlines	24 boats	60-200	(C)	IFREMER 2022
		2007-current	min 20x20 km	Crustacean deep-water traps	2 boats	400-600	(D)	IFREMER 2022
	Onboard observation on crustacean deep-sea pots	2021-2022	5x5 km	Crustacean deep-water traps	2 boats	400-600	(D)	IFREMER 2022
French Guiana	VMS	2008-current	10' x 10'	Hooks	No French vessels	30-200	(E)	Tagliarolo 2023
	VMS			Handlines	45 boats with licence from Venezuela + 1-3 from Martinique	50-200		IFREMER
Réunion	IFREMER statistical sectors (14 grid cells). Annual vessel census + sampling of effort and landings at harbour	2007-current	25x50 km	Hooks with electric reel	76 boats	600 max but mainly in the 100-300 range	(F)	IFREMER 2022
Mayotte	Observer at sea project	2015-2019,2024	5x5 km	Longlines	3 boats	around 200	(G)	L'Office français de la biodiversité (OFB) provided information and filled out the Questionnaire
	Observer at sea project	2024	5x5 km	Hooks with electric reel	1 boat	350 max		L'Office français de la biodiversité (OFB)

(A): The bottom-fishing (longline plus handline) effort layer was computed from an analysis of the Vessel Monitoring System (VMS) for vessels licensed for bottom longline or handline fishing gears. The fishing licences granted to each vessel per year were used to allocate a gear type to all VMS pings. We acknowledge that not all boats operating in the spatial planning area (beyond 6 nm from island shores) have VMS systems installed. However, a quick comparison of the VMS outputs with the fishing effort maps obtained from fishers' inquiries (Diogo *et al*. 2015) revealed similar spatial patterns, but much more spatial detail when using the VMS data. In total, VMS data was obtained from 74 anonymous vessels over the period 2002-2018 with an average of 12 vessels per year. This number represents about 25% of the bottom longline fleet if considering an average of 52 vessels per year that declared landings using bottom longline.

(B): The fishery is very limited and based on small scale vessels. Unlikely to have substantial deep-water fishing activity.

(C): Vessels are less than 12m.

(D): Vessels are less than 12m. Emerging fishery in the 90s that for now has not increased.

(E): Not a true deep-sea fishery (i.e., deeper than 400 m) and targeting only *Lujanus purpureus.*

(F): Seasonal fishery.

(G): Some smaller vessels operating in shallower waters catch snappers during the summer due to the cooling of surface. There is not really a deep-sea fishery in Mayotte.

6 Reference list

Abecassis, R.C., Afonso, P., Colaço, A., Longnecker, N., Clifton, J., Schmidt, L., and Santos, R.S. 2015. Marine Conservation in the Azores: Evaluating Marine Protected Area Development in a Remote Island Context. Frontiers in Marine Science, 2: 104. doi: 10.3389/fmars.2015.00104

Anderson, O. F., Guinotte, J. M., Rowden, A. A., Clark, M. R., Mormede, S., Davies, A. J., and Bowden, D.A. 2016. Field validation of habitat suitability models for vulnerable marine ecosystems in the South Pacific Ocean: implications for the use of broad-scale models in fisheries management. Ocean and Coastal Management, 120.

Anon. 2015. Proposal for exploratory bottom longlining for toothfish by New Zealand vessels outside the bottom lining footprint during 2016 and 2017: Description of proposed activities and impact assessment. SC-03-DW-01_rev. 57 pp. https://www.sprfmo.int/assets/Meetings/Meetings-2013-plus/SC-Meetings/3rd-SC-Meeting-2015/Papers/b520d6367e/SC-03-DW-01-rev2-New-Zealand-Proposal-to-conduct-exploratory-bottom-longlining.pdf

Ardron, J. A., Clark, M. R., Penney, A. J., Hourigan, T. F., Rowden, A. A., Dunstan, P. K., et al. 2014. A systematic approach towards the identification and protection of vulnerable marine ecosystems. Marine Policy, 49: 146–154. http://dx.doi.org/10.1016/j.marpol.2013.11.017

Artigas, L., F., Vendeville, P., Leopold, M., Guiral, D., and Ternon, J-F. 2003. Marine biodiversity in French Guiana: estuarine, coastal and shelf ecosystems under the influence of Amazonian waters. Gayana, 67(2): 302–326.

Bauchet, R. 2015. Suivi des activités halieutiques dans le Parc Naturel Marin de Mayotte.L'exemple de la pêche professionnelle palangrière et de la pêche traditionnelle au poulpe. Mémoire de Fin d'Etudes Master Sciences Technologie Santé, mention Biodiversité Ecologie Environnement. 82pp.

Bensch, A., Gianni, M., Gréboval, D., Sanders, J.S., and Hjort, A. 2009. Worldwide review of bottom fisheries in the high seas. FAO Fisheries and Aquaculture Technical Paper No. 522, Rev. 1. Rome, FAO, 145pp.

Bonhommeau S., Jac C., Lebranchu J., and Sabarros P.S. 2023. UE-France - Rapport national destiné au Comité scientifique de la Commission des Thons de l'Océan Indien, 56 pp, CTOI.

Bosch, N.E., Espino, F., Tuya, F., Haroun, R., Bramanti, L., and Otero-Ferrer, F. 2023. Black coral forests enhance taxonomic and functional distinctiveness of mesophotic fishes in an oceanic island: implications for biodiversity conservation. Scientific Reports, 13 : 4963.

Braga-Henriques, A., Buhl-Mortensen, P., Tokat, E., Martins, A., Silva, T., Jakobsen, J., Canning-Clode, J., et al. 2022. Benthic community zonation from mesophotic to deep sea: Description of first deep-water kelp forest and coral gardens in the Madeira archipelago (central NE Atlantic). Frontiers in Marine Science, 9. Doi: 10.3389/fmars.2022.973364.

Braga-Henriques, A., Porteiro, F. M., Ribeiro, P. A., de Matos, V., Sampaio, Í., Ocaña, O., and Santos, R. S. 2013. Diversity, distribution and spatial structure of the cold-water coral fauna of the Azores (NE Atlantic). Biogeosciences, 10: 4009–4036. https://doi.org/10.5194/bg-10-4009-2013

Buhl-Mortensen, L., Vanreusel, A., Gooday, A.J., Levin, L.A., Priede, I.G., Buhl-Mortensen, P., Gheerardyn, H., et al. 2010. Biological structures as a source of habitat heterogeneity and biodiversity on the deep ocean margins. Marine Ecology, 31 (1): 21–50. http://dx.doi.org/10.1111/j.1439-0485.2010.00359.x

Carreiro-Silva, M., Dominguez-Carrió, C., and Morato, T. 2021. DeepWalls: Report on summer 2020 survey with submersible LULA1000. Zenodo. https://doi.org/10.5281/ZENODO.5506765

Carreiro-Silva, M., Ramos, M., and Morato, T. 2019. Greenpeace Pole-to-Pole expedition – Azores 2019. Zenodo. https://doi.org/10.5281/ZENODO.6557865

Carreiro-Silva, M,, Dominguez-Carrió, C,, Morato, T., and Le Bris, N. 2018. "LUSO" Hydrothermal vent field Expedition; 4th August 2018 (RV L'Atalante—IFREMER). Zenodo. https://doi.org/10.5281/ZENODO.6557934

Carreiro-Silva, M., Martins, A., Sampaio, Í., Loureiro, C., Gonçalves, A., Mendes, C., and Morato, T. 2015. Cruise report BIOMETORE 2015 to the Great Meteor Complex seamounts (Atlantis and Irving) onboard the NRP Almirante Gago Coutinho. Zenodo. https://doi.org/10.5281/ZENODO.7433210

Carvalho, N. 2010. Sea to shore: An economic evaluation of the Azorean Commercial Fisheries [PhD thesis]. University of the Azores.

Carvalho, N., Edwards-Jones, G., and Isidro, E. 2011. Defining scale in fisheries: Small versus large-scale fishing operations in the Azores. Fisheries Research, 109(2–3): 360–369. https://doi.org/10.1016/j.fishres.2011.03.006

CBD. 2023a. EBSA Oceanic Islands and Seamounts of the Canary Region. 13pp. https://www.cbd.int/ebsa/

CBD. 2023b. EBSA Madeira – Tore. 16pp. https://www.cbd.int/ebsa/

CBD. 2023c. EBSA Ridge South of the Azores. 31pp. https://www.cbd.int/ebsa/

CBD. 2023d. EBSA North Azores Plateau. 26pp. https://www.cbd.int/ebsa/

CBD. 2023e. EBSA Atlantis-Meteor Seamount Complex. 18pp. https://www.cbd.int/ebsa/.

CBD. 2023f. EBSA Tropic Seamount. 10pp. https://www.cbd.int/ebsa/.

CBD. 2015a. EBSA Northern Mozambique Channel. 5pp. https://www.cbd.int/ebsa/

CBD. 2015b. EBSA Eastern Caribbean. 12pp. https://www.cbd.int/ebsa/

CBD. 2015c. EBSA Amazonian-Orinoco Influence Zone. 8pp. https://www.cbd.int/ebsa/

Christiansen, B., Martin, B., and Hirch, S. 2009. The benthopelagic fish fauna on the sum-mit of Seine Seamount, NE Atlantic: Composition, population structure and diets. Deep-Sea Research Part II: Topical Studies in Oceanography, 56(25): 2705–2712.

Corbari, L., Samadi, S., and Olu, K. 2017. BIOMAGLO cruise, RV Antea. Doi: 10.17600/17004000.

Czechowska, K., Feldens, P., Tuya, F., Cosme de Esteban, M., Espino, F., Haroun, R., Schönke, M., and Otero-Ferrer, F. 2020. Testing side-scan sonar and multibeam echosounder to study black coral gardens: A case study from Macaronesia. Remote Sensing, 12(5): 3244. https://doi.org/10.3390/rs12193244

Danovaro, R., et al. 2020. Ecological variables for developing a global deep-ocean monitoring and conservation strategy. Nature Ecology and Evolution, 4, 181–192.

Davies, A. J., and Guinotte, J. M. 2011. Global habitat suitability for framework-forming cold-water corals. PLoS ONE, 6(4): e18483. Doi 10.1371/journal.pone.0018483

Delgado, J., Amorim, A., Gouveia, L., and Gouveia, N. 2018. An Atlantic journey: The distribution and fishing pattern of the Madeira deep sea fishery. Regional Studies in Marine Science, 23: 107–111. https://doi.org/10.1016/j.rsma.2018.05.001

de Matos, V., Gomes-Pereira, J. N., Tempera, F., Ribeiro, P. A., Braga-Henriques, A., and Porteiro, F. 2014. First record of *Antipathella subpinnata* (Anthozoa, Antipatharia) in the Azores (NE Atlantic), with description of the first monotypic garden for this species. Deep Sea Research Part II: Topical Studies in Oceanography, 99: 113–121. https://doi.org/10.1016/j.dsr2.2013.07.003

Diaz, N., Druault-aubin, V., Frangoudes, K., Guyader, O., Knockaert, C., Roy, Y.L.E. *et al*. 2007. Main Results from the Work Completed by the "Lesser Antilles" Working Group on the Sustainable Development of Moored FADs Fishing and Perspectives. 58th Gulf and Caribbean Fisheries Institute, pp. 226–233. Available at: https://aquadocs.org/handle/1834/28973

Diogo, H., Pereira, J. G., Higgins, R. M., Canha, Â., and Reis, D. 2015. History, effort distribution and landings in an artisanal bottom longline fishery: An empirical study from the North Atlantic Ocean. Marine Policy, 51: 75–85.

Diop, B., Blanchard, F., and Sanz, N. 2018. Mangrove increases resiliency of the French Guiana shrimp fishery facing global warming. Ecological Modelling, 387:27–37. doi: https://doi.org/10.1016/j.ecolmodel.2018.08.014

Dominguez-Carrió, G., and Morato, T. 2021a. Cruise report—64PE479 onboard of R/V Pelagia Terceira Island 2020—Hopper tow-cam video footage. Zenodo. https://doi.org/10.5281/ZENODO.7429503

Dominguez-Carrió, C., Fontes, J., and Morato, T. 2021b. A cost-effective video system for a rapid appraisal of deep-sea benthic habitats: The Azor drift-cam. Methods in Ecology and Evolution, 12(8): 1379–1388.

Dominguez-Carrió, C., Gollner, S., Visser, F., and Morato, T. 2019a. Cruise Report—NICO Cruise Leg 12, Hopper dives on board of R/V Pelagia. Zenodo. https://doi.org/10.5281/ZENODO.3416992

Dominguez-Carrió, C., Gollner, S., and Morato, T. 2019b. RV Pelagia cruise 64PE454: Rainbow hydrothermal vent and southern MAR 2019 - Hopper tow-cam video footage. Zenodo. https://doi.org/10.5281/ZENODO.6593981

Dorta, C., and Martín-Sosa, P. 2022. Fishery essentiality: a short-term decision-making method based on economic viability as a tool to understand and manage data-limited small-scale fisheries. Fisheries Research, 246: 106171. https://doi.org/10.1016/j.fishres.2021.106171

Duncan, R.A. 1990. The volcanic record of the Réunion hotspot in Duncan, R.A., et al., Proceedings of the Ocean Drilling Program, Scientific results, Volume 115: College Station, Texas, Ocean Drilling Program, p. 3–10, Doi:10.2973/odp.proc.sr.115.206.1990.

Dupont, P., Mouquet, P., Roos, D., Sucre, E., and Claverie, T. 2016. Cartographie des habitats des récifs coralliens du banc d'Iris. *In* Roos, D., Dupont, P., Gaboriau, M., Sucre, E., and Claverie, T. 2017. Etude des Peuplements Ichtyologiques et des CommUnautés REcifales à partir d'indicateurs spatiaux et de l'approche fonctionnelle des bancs du Geyser, de la Zélée et de l'Iris (EPICURE). Programme du Xème FED régional « Gestion durable du patrimoine naturel de Mayotte et des îles Eparses. Rapport de contrat no 15/1212185. 239p.

Durán Muñoz, P., Sacau, M., Vidal-Liñán, L., Sarralde, R., Del Rio, J.L., Guijarro, B., Ordinas, F., et al. 2023. Improving environmental sustainability of deep sea fisheries with emphasis on the conservation of Vulnerable Marine Ecosystems (VMEs), Publication Office of the European Union, 2023, doi 10.2926/854134.

Durville, P., Mulochau, T., Alayse, J.-P., Barrere, A., Bigot, L., and Troadec, R. 2009. Deep sea survey of Réunion Island continental slopes using an R.O.V. system- ABYSSEA expedition. Revue d'Ecologie (La Terre et la Vie), 64 : 293-304.

Etnoyer, P., and Warrenchuk, J. 2007. A catshark nursery in a deep gorgonian field in the Missisipi Canyon, Gulf of Mexico. Bulletin of Marine Science, 81: 553–559.

Fauconnet, L., Frangoudes, K., Morato, T., Afonso, P., and Pita, C. 2019b. Small-scale fishers' perception of the implementation of the EU Landing Obligation regulation in the Outermost Region of the Azores. Journal of Environmental Management, 249: 109335. https://doi.org/10.1016/j.jenvman.2019.109335

Fauconnet, L., Pham, C. K., Canha, A., Afonso, P., Diogo, H., Machete, M., Silva, H. M., et al. 2019a. An overview of fisheries discards in the Azores. Fisheries Research, 209: 230–241. https://doi.org/10.1016/j.fishres.2018.10.001

FAO. 2009. International Guidelines for the Management of Deep-sea Fisheries in the High Seas. 73pp. Rome/Roma, FAO. https://www.fao.org/in-action/globefish/publications/details-publication/en/c/346096/

Feldens, P., Held, P., Otero-Ferrer, F., Bramanti, L., Espino, F., and Schneider von Deimling, J. 2023. Can black coral forests be detected using multibeam echosounder "multi-detect" data? Frontiers in Remote Sensing, 4: 988366. https://doi.org/10.3389/frsen.2023.988366

Fontana, T, Cóndor-Luján B., Azevedo, F., Pérez, T., and Klautau, M. 2018. Diversity and distribution patterns of Calcareous sponges (subclass Calcinea) from Martinique. Zootaxa, 4410 (2): 331–369.

Fourt, M., Goujard, A., Perez, T., and Chevaldonne, P. 2017. Guide de la faune profonde de la Mer Méditerranée Explorations des roches et canyons sous-marins des côtes françaises. Muséum National d'Histoire Naturelle de Paris, 213pp.

Galparsoro, I., and Borja, A. 2021. Defining cost-effective solutions in designing marine protected areas using systematic conservation planning. Frontiers in Marine Science, 8. https://doi.org/10.3389/fmars.2021.683271.

Geldmacher, J., Hoernle, K., Klügel, A., Wombacher, F., and Berning, B. 2006. Origin and geochemical evolution of the Madeira-Tore Rise (eastern North Atlantic). Journal of Geophysical Research: Solid Earth (1978–2012), 111(B9).

Gibson, D., and Sumaila, U.R. 2017. Determining the degree of' small-scaleness' using fisheries in British Columbia as an example. Marine Policy, 86: 121–126.

Gomes, H., Kersulec, C., Doyen, L., Blanchard, F., Cisse, A.A., and Sanz, N. 2021. The roles of climate warming and ecological competition in the small-scale coastal fishery in French Guiana. Environmental Modeling & Assessment, 26:655–675. doi: 10.1007/s10666-021-09772-8

Grasshoff, M. 1977. Die Gorgonaria des östlischen Nordatlantik und des Mittelmeeres. III. Die Familie Paramuriceidae (Cnidaria: Anthozoa). Auswerlung der "Atlantischen Kuppenfahrten 1967" von F. S. "Meteor". "Meteor" Forschungergebnisse, D 27, pp. 5–76.

Grenier, M., Ruiz, C., Lage, A., and Pérez, T. 2020. New cave-dwelling Plakina (Plakinidae, Homoscleromorpha, Porifera) from Martinique island (French Antilles). Zootaxa, 4729 (1): 092–104.

Guinan, J., Brown, C., Dolan, M. F., and Grehan, A. J. 2009. Ecological niche modelling of the distribution of cold-water coral habitat using underwater remote sensing data. Ecological Informatics, 4 (2): 83–92.

Guyader, O., Bellanger, M., Reynal, L., Demaneche, S., and Berthou, P. 2013. Fishing strategies, economic performance and management of moored fishing aggregating devices in Guadeloupe. Aquatic Living Resources, 26(1): 97-105. Publisher's official version : https://doi.org/10.1051/alr/20013044, Open Access version : https://archimer.ifremer.fr/doc/00137/24836/

Guyader, O., Frangoudes, K., Timor, J., Reynal,, L., and Dromer, C. 2015. Socio-économie et gouvernance des dispositifs de concentration de poissons ancrés dans les Antilles françaises.

Guyader, O. 2019. Status and evolution of small scale fisheries in ORs . Final conference of the ORFISH project at the European Parliament. 11th of April 2019, Bruxelles.

Hanafi-Portier, M., Samadi, S., Corbari, L., Chan, T-Y., Chen, W-J., Chen, J-N., Lee, M-Y., et al. 2021. When Imagery and Physical Sampling Work Together: Toward an Integrative Methodology of Deep-Sea Image-Based Megafauna Identification. Frontiers in Marine Science, 8. Doi: 10.3389/fmars.2021.749078.

Harmelin, J.-G., Vacelet, J., and Vasseur, P. 1985. Les grottes sous-marines obscures : un milieu extrême et un remarquable biotope refuge. Téthys, 11: 214–229.

Harris, P.T., and Whiteway, T. 2011. Global distribution of large submarine canyons: geomorphic differences between active and passive continental margins. Marine Geology, 285: 69–86. https://doi.org/10.1016/j.margeo.2011.05.008

Harris, P.T., MacMillan-Lawler, M., Rupp, J., and Baker, E.K. 2014. Geomorphology of the oceans. Marine Geology, 352: 4–24. https://doi.org/10.1016/j.margeo.2014.01.011

Herfaut, 2005. Prospection des ressources côtières démersales profondes autour de Mayotte. Résultats et conclusion des campagnes de pêche expérimentales de juillet 2004 à juin 2005. Rapport INENV. 37pp.

Howell, K. L., Holt, R., Endrino, I. P., and Stewart, H. 2011. When the species is also a habitat: comparing the predictively modelled distributions of *Lophelia pertusa* and the reef habitat it forms, Biological Conservation, 144 (11): 2656–2665.

ICES. 2024. ICES Vulnerable Marine Ecosystems. ICES Data Flow Schematics Vol. 9: Ed. 1. 8 pp. http://doi.org/10.17895/ices.pub.25610307

ICES. 2023. Data submission for ICES workshop on VMEs in EU waters of the Outermost Regions (WKOUTVME 2024). Data Calls. Report. https://doi.org/10.17895/ices.pub.24727533.v1

ICES. 2022a. Azores ecoregion – Ecosystem overview. In Report of the ICES Advisory Committee, 2022. ICES Advice 2022 Section 3.1. https://doi.org/10.17895/ices.advice.21725465

ICES. 2022b. Benchmark Workshop on the occurrence and protection of VMEs (vulnerable marine ecosystems) (WKVMEBM). ICES Scientific Reports, 4: 55. 99 pp. http://doi.org/10.17895/ices.pub.20101637

ICES. 2021. Vessel Monitoring System (VMS) and Logbook data in the North East Atlantic (FAO Major Fishing Area 27). ICES Data Flow Schematics Vol. 2: Ed. 1. 10 pp. https://doi.org/10.17895/ices.advice.7670

ICES. 2020. ICES/NAFO Joint Working Group on Deep-water Ecology (WGDEC). ICES Scientific Reports. 2:62. 171 pp. http://doi.org/10.17895/ices.pub.6095

IEO. 2013a. Caracterización del Banco de La Concepción. Informe del Instituto espa-ñol de Oceanografía - Centro Oceanográfico de Canarias. Madrid.

IEO. 2013b. Caracterización del Sur de Fuerteventura. Informe del Instituto Español de Oceanografía-Centro Oceanográfico de Canarias. Proyecto LIFE+ INDEMARES (LIFE07/NAT/E/000732). Madrid.

IFREMER. 2022. Fiches régionales sur la pêche. Website : https://sih.ifremer.fr/Publications/Fiches-regionales

Impact Mer. 2023. Suivi en surface de la zone d'immersion Sargasses et étude du fond marin 2023/2024 - Etude du fond marin de la zone de clapage des sargasses. Rapport de terrain pour la Direction de la mer de Martinique.

Impact Mer. 2022. Etudes environnementales relatives au projet d'extension du port de commerce de Galisbay. Online report https://www.portdemarigot.com/dash/files/Documents/Concertation-etude-environnement/57t98292399544___OSAtIFN1aXZpIGZhdW5lIHByb2ZvbmRlIC0gSW1wYWN0IE1lci-AtIDAxLTA5LTIwMjI=b_64.pdf

Impact Mer. 2021. Expédition scientifique dans la zone économique exclusive de la Martinique, mission An Ba Dlo - Campagne exploratoire. Etude pour PNMM - Parc Naturel Marin de Martinique.

Impact Mer. 2015-2018. Suivi vidéo de la faune profonde, campagnes C1, C2, C3, C4. Rapport pour GPMG - Grand Port Maritime de Guadeloupe.

Iborra Martin, J. 2007. Fisheries in Martinique. Policy department – Structural and Cohesion Policies, Directorate General Internal Policies of the Union – European parliament. Note IPOL/B/PECH/NT/2007_01. 18p.

Incera M, Valbuena L, Falcón J, González EL, González-Porto M, Martín-García L, Martín-Sosa P, and Gago J. 2024. Assessment of seabed litter at Concepción Seamount (Canary island) using a remotely operated towed vehicle. Environmental Pollution, 346 :123654. doi: 10.1016/j.envpol.2024.123654. Epub 2024 Feb 24. PMID: 38402933.

Janssen, A., Chevaldonne, P., and Martinez-Arbizu, P. 2013. The meiobenthic copepod fauna of a marine cave (3PP cave, NW Mediterranean) closely resembles that of deep-sea communities. Marine Ecology Progress Series, 479: 99–113.

Kenchington, E., Wang, Z., Lirette, C., Murillo, F., J., Guijarro, J., Yashayaev, I., and Maldonado, M. 2019. Connectivity modelling of areas closed to protect vulnerable marine ecosystems in the northwest Atlantic. Deep-Sea Research Part I, 143: 85 –103.

Kenchington, E., Murillo, F. J., Lirette, C., Sacau, M., Koen-Alonso, M., Kenny, A. J., Ollerhead, N., et al. 2015. Kernel density surface modelling as a means to identify significant concentrations of vulnerable marine ecosystem indicators. PLoS One, 9 (10): e109365. http://dx.doi.org/10.1371/journal.pone.0109365

Kenny, A., and Sotheran, I. 2013. Characterising the Physical Properties of Seabed Habitats, Fourth edition, Methods for the Study of Marine Benthos, pp. 47–95. http://dx.doi.org/10.1002/9781118542392.ch2

Klautau, M., Lopes, M.V., Tavares, G., and Pérez, T. 2021. Integrative taxonomy of calcareous sponges (Porifera: Calcarea) from Réunion Island, Indian Ocean. Zoological Journal of the Linnean Society, 194: 671–725. https://doi.org/10.1093/zoolinnean/zlab014

Knudby, A., Kenchington, E., and Murillo, F. J. 2013. Modelling the distribution of *Geodia* sponges and sponge grounds in the northwest Atlantic. PLoS One, 8 (12): e82306 http://doi.org/10.1371/journal.pone.0082306

Kostylev, V.E., Todd, B.J., Fader, G.B.J., Courtney, R.C., Cameron, G.D.M., and Pickrill, R.A. 2001. Benthic habitat mapping on the Scotian Shelf based on multibeam bathymetry, surficial geology and sea floor photographs. Marine Ecology Progress Series, 219: 121–137. http://dx.doi.org/10.3354/meps219121.

Lauvset, S.K., Lange, N., Tanhua, T., Bittig, H.C., Olsen, A., Kozyr, A., Álvarez, M. et al. 2022. Global Ocean Data Analysis Project version 2.2023 (GLODAPv2.2023) (NCEI Accession 0283442). NOAA National Centers for Environmental Information.

Leblond, E., Berthou, P., Laurans, M., Woerther, P., and Quemener, L. 2008. The Recopesca project: a new example of participative approach to collect in-situ environmental and fisheries data using fisheries vessels of opportunity. ICES 2008 Annual Science Conference, 22-26 September 2008, HALIFAX, CANADA . https://archimer.ifremer.fr/doc/00059/17000/

Leblond, E., Lazure, P., Laurans, M., Rioual, C., Woerther, P., Quemener, L., and Berthou, P. 2010. The Recopesca Project : a new example of participative approach to collect fisheries and in situ environmental data. Mercator Ocean - Quarterly Newsletter , 37: 40-48 . Open Access version : https://archimer.ifremer.fr/doc/00024/13500/

Legrand, H., Lenfant, P., Sotheran, I., S., Foster-Smith, R., L., Galzin, R., and Maréchal, J-P. 2012. Mapping marine benthic habitats in Martinique (French West Indies). Caribbean Journal of Science, 46(2–3): 267–282. https://doi.org/10.18475/cjos.v46i2.a15

Lopes, M.V., Cóndor-Luján, B., Azevedo, F., Pérez, T., and Klautau, M. 2018. A new genus of calcareous sponge discovered in the Caribbean Sea: *Bidderia* gen. nov. (Porifera, Calcarea, Calcinea). Zootaxa, 4526 (1): 056–070.

Loya, Y., Puglise, K.A., and Bridge, T.L.C. 2019. Mesophotic Coral Ecosystems. Springer, Cham, Switzerland.

Machete, M., Morato, T., and Menezes, G. 2011. Experimental fisheries for black scabbard-fish (Aphanopus carbo) in the Azores, Northeast Atlantic. ICES Journal of Marine Science, 68(2) : 302–308.

Mano, A.L. 2019. Redefinition of the circalittoral zone and its assemblages from Azores insular shelves through video survey. Master dissertation, Instituto Universitario de Ciencias psicologicas e da vida, 81pp.

Marsac, F., Annasawmy, P. Noyon, M., Demarcq, H., Soria, M., Rabearisoa, N., Bach, P., et al. 2020. Seamount effect on circulation and distribution of ocean taxa in the vicinity of La Pérouse, a shallow seamount in the southwestern Indian Ocean. Deep Sea Research Part II: Topical Studies in Oceanography, 176:104806. https://doi.org/10.1016/j.dsr2.2020.104806 .

Martín-García, L., González-Porto, M., Falcón, J.M., De La Torriente, A., Serrano, A., González-Irusta, J.M., Jiménez, S., et al. 2022a. LIFE IP INTEMARES. Informe sobre la caracterización, cartografiado y estado de conservación de los hábitats bentónicos del LIC-ESZZ15001 “Banco de La Concepción” (Demarcación marina canaria).

Martín-García, L., González-Porto, M., Falcón, J.M., De La Torriente, A., Serrano, A., González-Irusta, J.M., et al. 2022b. Informe sobre la caracterización, cartografiado y estado de conserva-ción de los hábitats bentónicos de AMANAY Y EL BANQUETE Montes sub-marinos incluidos en el LIC-ESZZ15002 “Espacio marino del oriente y sur de Lanzarote-Fuerteventura” (Demarcación marina canaria).

Martín-García, L., Prado, E., Falcón, J.M., González Porto, M., Punzón, A., and Martín-Sosa, P. 2022c. Population structure of *Asconema setubalense* Kent, 1870 at Concepción Seamount, Canary Islands (Spain). Methodological approach using non-invasive techniques. Deep Sea Research Part I Oceanographic Research Papers 185, 103775. https://doi.org/10.1016/J.DSR.2022.103775

Martín-García, L., Sangil, C., Brito, A., and Barquín-Diez, J. 2015. Identification of conservation gaps and redesign of island marine protected areas. Biodiversity and Conservation 24, 511–529. https://doi.org/10.1007/s10531-014-0833-0

Martins, J., and Santos, R.S. 1988. Breves considerações sobre a implementação de reservas marinhas nos Açores. In 1as Jornadas Atlânticas de Protecção do Meio Ambiente, eds E Dias, J.P. Carretas, P. Cordeiro (Angra do Heroísmo: Secretaria Regional do Turismo e Ambiente).

Menezes, G. M., Sigler, M. F., Silva, H. M., and Pinho, M. R. 2006. Structure and zonation of demersal fish assemblages off the Azores archipelago (mid-Atlantic). Marine Ecology Progress Series, 324: 241–260.

Menezes, G. M., & Sigler, M. F. 2016. Longlines. *In* Biological Sampling in the Deep Sea, pp. 159–183. Ed. by M. R. Clark, M. Consalvey, and A.A. Rowden. Wiley-Blackwell, Chichester, UK, 451 pp.

Menezes, G.M. 2003. Demersal Fish Assemblages in the Atlantic Archipelagos of the Azores, Madeira, and Cape. [PhD thesis]. University of the Azores.

Menezes, G. 1996. Interacções tecnológicas na pesca demersal dos Açores. ['APCC' thesis (Masters thesis equivalent)]. University of the Azores, Department of Oceanography and Fisheries.

Morales-Nin, B., and Sena-Carvalho, D. 1996. Age and growth of the black scabbard fish (*Aphanopus carbo*) off Madeira. Fisheries Research, 25: 239–251. https://doi.org/10.1016/0165-7836(95)00432-7.

Morato, T., Gonçalves, G., Neves de Sousa, L., Porteiro, F., Ramos, M., Cerqueira, T., Balsa, J., et al. 2023a. OceanX 2023 cruise report: Exploration and mapping of deep-sea biodiversity in the Azores on board the RV OceanXplorer. Zenodo. https://doi.org/10.5281/ZENODO.10810580

Morato, T., Rodrigues, L., Balsa, J., Bruno, I., Carneiro, I., Catarino, D., Collazo, N., et al. 2023b. MapGES 2023 cruise report: Exploration and mapping of deep-sea biodiversity in the Azores on board the RV Arquipélago. Zenodo. https://doi.org/10.5281/ZENODO.10785022

Morato, T., Taranto, G. H., Fauconnet, L., Rodrigues, L., Balsa, J., Areosa, I., Bruno, I., et al. 2023c. MapGES 2023 cruise report: Exploration and mapping of deep-sea biodiversity in the Azores on board the MT Physeter. Zenodo. https://doi.org/10.5281/ZENODO.10787942

Morato, T., Dominguez-Carrió, C., Gomes, S., Rodrigues, L., Gonçalves, G., Carneiro, I., Ramos, M., and Carreiro-Silva, M. 2022a. MapGES 2022 Cruise Report: Exploration and mapping of deep-sea biodiversity in the Azores, summer 2022. Zenodo. https://doi.org/10.5281/ZENODO.7075749

Morato, T., Dominguez-Carrió, C., Rodrigues, L., Murta, J., Cerqueira, T., Ramos, M., Gonçalves, G., et al. 2022b. iMAR 2022: Integrated assessment of the distribution of Vulnerable Marine Ecosystems along the Mid-Atlantic Ridge in the Azores region - Cruise Report. Zenodo. https://doi.org/10.5281/ZENODO.7703127

Morato, T., Dominguez-Carrió, C., Evans, S., Taranto, G. H., Neves de Sousa, L., Mohn, C., and Carreiro-Silva, M. 2021. iMAR: Integrated assessment of the distribution of Vulnerable Marine Ecosystem along the Mid-Atlantic Ridge in the Azores region. Zenodo. https://doi.org/10.5281/ZENODO.6556837

Morato, T., Dominguez-Carrió, C., Gomes, S., Taranto, G. H., Ramos, M., Fauconnet, L., Rodrigues, L., and Carreiro-Silva, M. 2020a. MapGES 2020: Cruise Report: Exploration of Azores deep-sea habitats, summer 2020. Zenodo. https://doi.org/10.5281/ZENODO.5503634

Morato, T., Dominguez-Carrió, C., Gomes, S., Taranto, G. H., Blasco, J., Ramos, M., Fauconnet, L., et al. 2020b. MapGES 2019: Summer 2019 cruise on board of N/I Arquipélago. Zenodo. https://doi.org/10.5281/ZENODO.3727570

Morato, T., Afonso, P., Menezes, G.M., Santos, R.S., and Silva, M.A. 2020c. Editorial: The Azores Marine Ecosystem: An Open Window into North Atlantic Open Ocean and Deep-Sea Environments. Frontiers in Marine Science, 7: 601798. doi: 10.3389/fmars.2020.601798

Morato, T., Carreiro-Silva, M., Dominguez-Carrió, C., Taranto, G. H., Rodrigues, L., Brito, J., and Gomes, S. 2019a. Cruise Report - MapGES / ATLAS Project: August 2018 Cruise on board of R/V Arquipélago. Zenodo. https://doi.org/10.5281/ZENODO.3417021

Morato, T., Carreiro-Silva, M., Taranto, G. H., Dominguez-Carrió, C., Ramos, M., Ríos, N., Fauconnet, L., et al. 2019b. Cruise Report—BLUE AZORES Program Expedition 2018 on board the NRP Gago Coutinho. Zenodo. https://doi.org/10.5281/ZENODO.3416897

Morato, T., and Taranto, G. 2019. Cruise report—64PE456 onboard of R/V Pelagia Terceira Island 2019—Hopper tow-cam video footage. Zenodo. https://doi.org/10.5281/ZENODO.6592500

Morato, T., Pham, C.K., Pinto, C., Golding, N., Ardron, J.A., Durán Muñoz, P., and Neat, F. 2018. A multi criteria assessment method for identifying Vulnerable Marine Ecosystems in the North-East Atlantic. Frontiers in Marine Science, 5: 460. doi: 10.3389/fmars.2018.00460

Morato, T., Kvile, K.Ø., Taranto, G.H., Tempera, F., Narayanaswamy, B.E., Hebbeln, D., Menezes, et al. 2013. Seamount physiography and biology in the north-east Atlantic and Mediterranean Sea. Biogeosciences, 10(5): 3039–3054. https://doi.org/10.5194/bg-10-3039-2013

Morato, T. 2012. Description of environmental issues, fish stocks and fisheries in the EEZs around the Azores and Madeira (63 pp.). https://stecf.jrc.ec.europa.eu/documents/43805/465474/Item+6.2+Report+Morato_Azores_Madeira.pdf

Morato, T., Machete, M., Kitchingman, A., Tempera, F., Lai, S., Menezes, G., Pitcher, T.J., and Santos, R.S. 2008. Abundance and distribution of seamounts in the Azores. Marine Ecology Progress Series, 357: 17-21. https://doi.org/10.3354/meps07268

Mouquet, P., Touria, B., and Michel, R. 2016a. Classification de la nature des fonds (Biologie/Substrats) des plateformes récifales de La Réunion en 2015. Ifremer - Délégation Océan Indien.

Mouquet, P., Touria, B., and Michel, R. 2016b. Indice surfacique de la Vitalité Corallienne Hyperspectrale (VCH) des zones récifales de la côte ouest de l'île de La Réunion (2015). Ifremer - Délégation Océan Indien.

Mouquet, P., and Touria, B. 2014. Bathymétrie issue des images hyperspectrales - côte ouest de La Réunion. Ifremer - Délégation Océan Indien.

Moura, R.L., and *38 others*. 2016. An extensive reef system at the Amazon River mouth. Scientific Advances, 2: e1501252. doi:10.1126/sciadv.1501252

NAFO. 2016. Report of the Scientific Council Meeting and its Standing Committees, 3–16 June 2016 Halifax, Nova Scotia. Serial no. N6587, NAFO Scientific Council Studies Document 16–14, 2016, p. 230.

NAFO. 2015. NAFO Conservation and Enforcement Measures. Article 15.6. https://www.nafo.int/Portals/0/PDFs/fc/2015/fcdoc15-01.pdf

Navarro-Mayoral, S., Gouillieuxc B., Fernandez-Gonzalez, V., Tuya, F., Lecoquierre, N., Bramanti, L., et al. 2024. "Hidden" biodiversity: a new amphipod genus dominates epifauna in association with a mesophotic black coral forest. Coral Reefs. https://doi.org/10.1007/s00338-024-02491-y

Navarro-Barranco, C., Ambroso, S., Gerovasileiou, V., Gómez-Gras, D., Grinyó, J., Montseny, M., and Santín, A. 2023. Conservation of dark habitats. Coastal Habitat Conservation: New Perspectives and Sustainable Development of Biodiversity in the Anthropocene, 6: 147-170. https://doi.org/10.1016/B978-0-323-85613-3.00005-0

NEAFC. 2014. Recommendation 19:2014. Article 2(g) and Annex 5. https://www.fao.org/figis/pdf/fishery/vme/29744/168564/en?title=VME-DB

Nicet, J.B., Mouquet, P., Tollis, S., and Bigot, L. 2016. Cartographie des habitats des récifs coralliens de La Réunion. Elaboration des fiches d'habitats marins et cartographie associée. Préfiguration de la Trame Bleue Marine. Rapport Université / Pareto pour le compte de la DEAL Réunion, 64 pages + annexes.

Obura, D. 2012. The diversity and biogeography of Western Indian Ocean reef-building corals. PLoS One, 7: e45013. Doi: 10.1371/journal.pone.004 5013.

Oehler, J.-F., Lénat, J.-F., and Labazuy, P. 2008. Growth and collapse of the Réunion Island volcanoes: Bulletin of Volcanology, 70: 717– 742. Doi:10.1007/s00445-007-0163-0

O'Leary, B.C., and Roberts, C.M. 2018. Ecological connectivity across ocean depths: Implications for protected area design. Global Ecology and Conservation, 15: e00431. https://doi.org/10.1016/j.gecco.2018.e00431

OSPAR Commission (2017), Status Report on the OSPAR Network of Marine Protected Are-as, Biodiversity and Ecosystem Series, pp. 1–73.

Pérez, T., and Ruiz, C. 2018. Description of the first Caribbean Oscarellidae (Porifera: Homoscleromorpha). Zootaxa, 4369 (4): 501–514.

Pérez, T., Diaz, M.C., Ruiz C., et al. 2017. How a collaborative integrated taxonomic effort has trained new spongiologists and improved knowledge of Martinique Island (French Antilles, Eastern Caribbean Sea) marine biodiversity. PLoS ONE, 12(3) : e0173859.

Pérez, T., Albenga, L., Starmer, J., and Chevaldonne, P. 2016. La biodiversité des grottes sous-marines des Marquises : un patrimoine naturel caché et méconnu. *In* Biodiversité terrestre et marine des îles Marquises, Polynésie française, pp. 287-310. Ed. by R. Galzin, S.-D. Duron, and J.-Y. Meyer. Société Française d'Ichtyologie, Paris.

Pérez, T. 2015. PACOTILLES-2 cruise, RV Antea. http://dx.doi.org/10.17600/15005300

Pham, C. K., Diogo, H., Menezes, G., Porteiro, F., Braga-Henriques, A., Vandeperre, F., and Morato, T. 2014. Deep-water longline fishing has reduced impact on Vulnerable Marine Ecosystems. Scientific Reports, 4: 4837. https://doi.org/10.1038/srep04837

Pham, C. K., Canha, A., Diogo, H., Pereira, J. G., Prieto, R., and Morato, T. 2013. Total marine fishery catch for the Azores (1950-2010). ICES Journal of Marine Science, 70(3): 564–577. https://doi.org/10.1093/icesjms/fst024

Piechaud, N., Downie, A., Stewart, H. A., and Howell, K. L. 2015. The impact of modelling method selection on predicted extent and distribution of deep-sea benthic assemblages. Earth and Environmental Science Transactions of The Royal Society of Edinburgh, 105 (04): 251–261. http://dx.doi.org/10.1017/S1755691015000122

Portaria no. 68/2019. Secretaria Regional do Mar, Ciência e Tecnologia. Jornal Oficial, 109, Quinta-Feira, 26 de Setembro de 2019. 5pp.

Puerta, P., Mosquera-Gimenez, A., Renones, O., Dominguez-Carrio, C., Rueda, J. L., Urra, J., *et al*. 2022. Variability of deep-sea megabenthic assemblages along the western pathway of the Mediterranean outflow water. Deep-Sea Research Part I-Oceanographic Research Papers, 185: 103791. doi 10.1016/j.dsr.2022.103791

Pyle, R.L. and Copus, J.M. 2019. Mesophotic Coral Ecosystems: Introduction and Overview. *In* Mesophotic Coral Ecosystems, Coral Reefs of the World 12, pp. 3–27. Ed. By Y. Loya , K.A. Puglise, and T. C.L. Bridge. Springer, New York. 1003 pp. https://doi.org/10.1007/978-3-319-92735-0_1

Ramos, M., Dominguez-Carrió, C., and Morato, T. 2021. Cruise report for 64PE488 onboard of R/V Pelagia Terceira Island 2021—Towed camera video footage. Zenodo. https://doi.org/10.5281/ZENODO.6592634

Ramos, H., Zanella, A., Gomez, C., Pavon-Salas, N., Guyader, O., Berthou, P., Bilbao Sieyro, A., et al. 2019. ORFISH - Development of innovative, low-impact off-shore fishing practices for small-scale vessels in Outermost Regions - MARE/2015/06. WP2 Raising awareness of the opportunities to develop innovative fishing techniques . Task 2.2: Desktop study to collate existing technical information. Deliverable #9. 153 pp.

Reagan, J. R., Boyer, T. P., García, H. E., Locarnini, R. A., Baranova, O. K., Bouchard, C., Cross, S. L., et al. 2024. World Ocean Atlas 2023. NOAA National Centers for Environmental Information. Dataset: NCEI Accession 0270533.

Rengstorf, A. M., Yesson, C., Brown, C., and Grehan, A. J. 2013. High-resolution habitat suitability modelling can improve conservation of vulnerable marine ecosystems in the deep sea. Journal of Biogeography, 40 (9): 1702–1714. http://dx.doi.org/10.1111/jbi.12123.

Reynal, L., Dromer, C., Eugène, S., Frangoudes, K., Gervain, P., Guyader, O., et al. 2015. Rapport de la réunion finale du projet MAGDELESA. Sur le développement durable de la pêche associée aux DCP ancrés dans les petites Antilles. R.INT.RBE/BIODIVENV 2015-1.

Ribeiro, M. C. 2010. The 'Rainbow': the first national marine protected area proposed under the high seas. The International Journal of Marine and Coastal Law, 25: 183–207.

Ross, R. E., and Howell, K. L. 2013. Use of predictive habitat modelling to assess the distribution and extent of the current protection of 'listed' deep-sea habitats. Diversity and Distributions, 19 (4): 433–445. http://dx.doi.org/10.1111/ddi.12010.

Rowden, A. A., Anderson, O. F., Georgian, S. E., Bowden, D. A., Clark, M. R., Pallentin, P., and Miller, A. 2017. High-resolution habitat suitability models for the conservation and management of Vulnerable Marine Ecosystems on the Louisville Seamount Chain, South Pacific Ocean. Frontiers in Marine Science, 4: 335.

Rowden, A. A., Tabitha, R. R. P., Bowden, D. A., Anderson, O. F., and Clark, M. R. 2020. Determining coral density thresholds for identifying structurally complex Vulnerable Marine Ecosystems in the deep-sea. Frontiers in Marine Science, 7: 95.

Ruiz, C., Ereskovsky, A., and Pérez, T. 2022. New skeleton-less homoscleromorphs (Porifera, Homoscleromorpha) from the Caribbean Sea: exceptions to rules are definitely common in sponge taxonomy. Zootaxa, 5200 (2): 128–148. https://doi.org/10.11646/zootaxa.5200.2.2

Ruiz, C., Muricy, M., Lage, A., Domingos, C., Chenesseaus, S., and Pérez, T. 2017. Descriptions of new sponge species and genus, including aspiculate Plakinidae, overturn the Homoscleromorpha classification. Zoological Journal of the Linnean Society, 179: 707-724.

Sampaio, Í., Freiwald, A., Porteiro, F.M., Menezes, G., and Carreiro-Silva, M. 2019. Census of Octocorallia (Cnidaria: Anthozoa) of the Azores (NE Atlantic) with a nomenclature update. Zootaxa, 4550(4): 451-498.

Sampaio, Í., Braga-Henriques, A., Pham, C., Ocaña, O., de Matos, V., Morato, T., and Porteiro, F. M. 2012. Cold-water corals landed by bottom longline fisheries in the Azores (north-eastern Atlantic). Journal of the Marine Biological Association of the United Kingdom, 92(7): 1547–1555. https://doi.org/10.1017/S0025315412000045

Santos, R. S., Hawkins, S., Monteiro, L. R., Alves, M., and Isidro, E. J. 1995. Marine research, resources and conservation in the Azores. Aquatic Conservation: Marine and Freshwater Ecosystems, 5(4): 311-354.

Santos, R. S., Christiansen, S., Christiansen, B., and Gubbay, S. 2009. Toward the conservation and management of Sedlo Seamount: A case study. Deep Sea Research Part II: Topical Studies in Oceanography, 56(25): 2720-2730.

Savina-Rolland, M., Ulrich, C., et al. 2019. DiscardLess Deliverable 1.4—Changes in fish stocks and sensitive components over the course of the project (DiscardLess Deliver-able D1.4; p. 93 pp.). http://www.discardless.eu/media/results/DiscardLess_Deliverable_-_D1-4_16April2019.pdf

Schlacher, T. A., Williams, A., Althaus, F., and Schlacher-Hoenlinger, M. A. 2010. High-resolution seabed imagery as a tool for biodiversity conservation planning on continental mar-gins: submarine canyon megabenthos and conservation planning. Marine Ecology, 31: 200–221. Doi: 10.1111/j.1439-0485.2009.00286.x

Shepard, F.P. 1963. Submarine Geology. Harper & Row, New York.

SIH. 2022. Quartier maritime Cayenne. 2021. Activité des navires de pêche. Système d'Information Halieutique. IFREMER

Silva, H.M., and Pinho, M.R. 2007. Exploitation, management and conservation: Small-scale fishing on seamounts. *In* Seamounts: Ecology, Fisheries and Conservation Ed. by T.J. Pitcher, T. Morato, J.B. Paul, M.R. Clark, N. Haggan, and R.S. Santos, pp. 333–399). Blackwell, Publishing, U.K. https://www.researchgate.net/profile/Ricardo_Santos7/publication/228333317_Seamounts_Ecology_Fisheries_Conservation/links/0fcfd4ff98db018a96000000.pdf

Tagliarolo, M. 2023. Evaluation 2023 du stock de vivaneau rouge en Guyane française . DPMA - Direction des Pêches Maritimes et de l'Aquaculture, La Défense , Ref. RBE/BIODIVHAL/MT 23-060 , 24pp. https://archimer.ifremer.fr/doc/00873/98470/

Tagliarolo, M., Cope, J., and Blanchard, F. 2021. Stock assessment on fishery-dependent data: Effect of data quality and parametrisation for a red snapper fishery. Fisheries Management and Ecology, 28: 592–603. doi: 10.1111/fme.12508

Taranto, G.H., González-Irusta, J-M., Domínguez-Carrió, C., Pham, C. K., Tempera, F., Ramos, M., Gonçalves, G., Carreiro-Silva, M., and Morato, T. 2023a. Habitat suitability maps for vulnerable and foundation cold-water coral taxa of the Azores (NE Atlantic). PANGAEA, https://doi.org/10.1594/PANGAEA.955223

Taranto, G. H., González-Irusta, J-M., Dominguez-Carrió, C., Pham, C. K., Tempera, F., Ramos, M., et al. 2023b. Spatial distributions, environmental drivers and co-existence patterns of key cold-water corals in the deep sea of the Azores (NE Atlantic). Deep Sea Research Part I: Oceanographic Research Papers, 197: 104028. https://doi.org/10.1016/j.dsr.2023.104028

Tempera, F., Atchoi, E., Amorim, P., Gomes-Pereira, J., and Gonçalves, J. 2013. Atlantic area marine habitats. Adding new Macaronesian habitat types from the Azores to the EUNIS Habitat Classification. In MeshAtlantic Technical Report, 4/2013. IMAR/DOP-UAç, Horta.

Tempera, F., Porteiro, F., Carreiro-Silva, M., Braga-Henriques, A., Giacomello, E., Branco, A., Ferreira, P., et al. 2011. Relatório de Cruzeiro CORALFISH Condor, Voador e Banco Açores 2010 a bordo do NRP Almirante Gago Coutinho. Zenodo. https://doi.org/10.5281/ZENODO.7476546

Thomassin, B. 1977. BENTHEDI I cruise, RV Le Suroît. Doi:10.17600/7700 3111.

Valdés, L., and Déniz-González, I. 2015. Oceanographic and biological features in the Canary Current Large Marine Ecosystem. IOC-UNESCO, Paris. IOC Technical Series, No. 115: 383 pp.

Vallerani, M., Carmen-Paz, M., and Ojamaa, P. 2017. Research for PECH Committee - Fisheries in Madeira. European Parliament's Directorate-General for Internal Policies, Policy Department B. https://www.europarl.europa.eu/RegData/etudes/IDAN/2017/601978/IPOL_IDA(2017)601978_EN.pdf

Vallés. H. 2023. Moored Fish Aggregating Device (MFAD) fisheries in the Caribbean: regional challenges from the practitioners' perspective. Current Opinion in Environmental Sustainability, 61: 101267. https://doi.org/10.1016/j.cosust.2023.101267

Wang, S., Kenchington, E., Murillo, F.J., Lirette, C., Wang, Z., Koen-Alonso M., *et al*. 2024. Quantifying the effects of fragmentation of connectivity networks of deep-sea vulnerable marine ecosystems. Diversity and Distributions, 30 (5): e13824. https://doi.org/10.1111/ddi.13824

Watling, L., and Auster, P.J. 2021. Vulnerable marine ecosystems, communities, and indicator species: Confusing concepts for conservation of seamounts. Frontiers in Marine Science, 8: 622586. https://doi.org/10.3389/fmars.2021.622586

Wei, C-L., Cusson, M., Archambault, P., Belley, R., Kenchington, E., Ramey-Balci, P., et al. 2019. Seafloor biodiversity of Canada's three oceans: Patterns, hotspots and potential drivers. Diversity and Distributions, 26: 226 – 241.

Weiss J., Demaneche S., and Guyader O. 2020. Méthodologie de collecte de données et d'estimation des efforts et débarquements des pêcheries côtières. PDG-RBE-STH-LBH. Rapport SIH-Ifremer 2020. https://archimer.ifremer.fr/doc/00471/58281/

Wickel, J., Jamon, A., Pinault, M., Durville, P., and Chabanet, P. 2014. Composition et structure des peuplements ichtyologiques marins de l'île de Mayotte (sud-ouest de l'océan Indien). Cybium, 38(3): 179–203.

Wilbur, A.R. 2000. Fish habitat characterization and assessment: approach to integrate seafloor features and juvenile organisms data. Proceedings of the Oceans 2000 MTS/ IEEE Conference and Exhibition, Providence, Rhode Island, USA. Volume 3: 1555–1561. doi: http://dx.doi.org/10.1109/OCEANS.2000.882162.

Wilson, M.W., Lawson, J.M., Rivera-Hechem, M.I., Villaseñor-Derbez, J.C., and Gaines, S.D. 2020. Status and trends of moored fish aggregating device (MFAD) fisheries in the Caribbean and Bermuda. Marine Policy, 121: 104148. https://doi.org/10.1016/j.marpol.2020.104148

Woolley, S.N.C., Tittensor, D.P., Dunstan, P. K., Guillera-Arroita, G., Lahoz-Monfort, J. J., Wintle, B.A., et al. 2016. Deep-sea diversity patterns are shaped by energy availability. Nature, 533: 393 – 396.

Xavier, J., and van Soest, R. 2007. Demosponge fauna of Ormonde and Gettysburg Seamounts (Gorringe Bank, north-east Atlantic): diversity and zoogeographical affinities. Journal of the Marine Biological Association of the United Kingdom, 87(6): 1643–1653. doi:10.1017/S0025315407058584

Yesson, C., Letessier, T.B., Nimmo-Smith, A., Hosegood, P., Brierley, A.S., Hardouin, M., and Proud, R. 2020. List of seamounts in the world oceans - An update. PANGAEA, https://doi.org/10.1594/PANGAEA.921688

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Annex 2: Resolutions

2023/FT/HAPISG17 The **ICES Workshop on the Occurrence of VMEs (Vulnerable Marine Ecosystems) and Fishing Activities in EU waters of the Outermost Regions (WKOUTVME)**, chaired by Ellen Kenchington (Canada) will meet in person with hybrid afternoon (CET) options 15-19 April 2024 at the ICES Headquarters in Copenhagen, Denmark to:

a) Review and report on the knowledge base in each region. Use a participatory approach to review survey and metadata call responses for completeness in mapping/identifying nursery areas, fishing practices, fishing grounds, and locations of VMEs, indicators of VMEs and further VME elements where VMEs are known or likely to occur. Identify further data sources that could be used to complete the knowledge base.

b) Review and report on available methods used in a range of situations and locations to apply FAO guidance for the identification of VMEs. Consider and report on the complementarity of these methods with the current benchmarked approach used by ICES to identify VMEs in the northeast Atlantic.

c) Define and report on analytical frameworks to generate the requested outputs, scenarios and options at a second workshop, and the extent to which these frameworks are applicable in each region given the knowledge base described response to ToR ‘a’ and ‘b’.

WKOUTVME will report to ICES ACOM and SCICOM in May 2024.

Supporting information:

Priority	ICES has received a special request for Advice on the list of areas where VMEs are known to occur or are likely to occur and on the existing deep-sea fishing areas (ref. (EU)2016/2336) in EU waters of the Outermost Regions subject to the deep-sea access regulation (Regulation (EU) 2016/2336). The 9 Outermost Regions of the EU (French Guiana, Guadeloupe, Martinique, Mayotte, Reunion Island and Saint-Martin (France), Azores and Madeira (Portugal), and the Canary Islands (Spain)) have not yet been part of ICES deliveries. ICES has responded to this request by offering step-wise deliverables, with the first phase a scoping technical service (review), in the form of a workshop (WKOUTVME). This workshop will lay out the foundations for a subsequent workshop which will apply the methodology and deliver the coordinates of the list of VME locations, and of the fishing footprint for static gears, mobile-contacting gears and a combined footprint in the EEZs of the Outermost Regions. The workshop fits within the ICES Science Plan – Conservation and Management Science, the goal of which is to develop tools, knowledge, and evidence for conservation and management — to provide more and better options to help managers set and meet objectives.
Scientific justification	The workshop will conduct a technical scoping exercise and review of available knowledge and data for all 9 of the EU Outermost Regions (Azores, Madeira, Canary Islands, Reunion, Mayotte, French Guiana, Martinique, Guadalupe and Saint Martin). Most of these regions are remote/inaccessible with some of the main fisheries dependent on the seamounts. Therefore, the benchmarked approach used by ICES in the Northeast Atlantic to identify vulnerable marine ecosystems (VME) may have to be adapted to the data sources available while still providing scenarios and options. The workshop will propose a

	framework for that analysis, and identify any knowledge gaps that could compromise that work. **Preparation for the workshop** A core planning group has been established to prepare of the workshop. They will meet by correspondence and once in person (January 2024) to: 1. Establish a network of experts that are engaged and have access to data/information/knowledge in all 9 EU Outermost Regions (Azores, Madeira, Canary Islands, Reunion, Mayotte, French Guiana, Martinique, Gudalupe and Saint Martin); 2. Develop a questionnaire for circulating to the list of experts prior to the workshop; 3. Draft a formal data request from ICES; 4. Engage local experts, knowledge holders and other stakeholders from the Caribbean, Oceanic Atlantic and the Indian Ocean to attend the workshop through targeted invitations. **Expected outputs from the workshop** The outcome of this workshop will be an ICES Scientific Report which will address ToR a-c and elaborate on, for each region: (i) the location and nature of the VMEs; (ii) the location and nature of the fish and fisheries (iii) details for the recommended application of the benchmark approach for delineation of VMEs, (iv) knowledge gaps in (i) and (ii) that could influence (iii).
Resource requirements	Most the preparatory work will be developed by web conferences. The core planning group would like to meet in Copenhagen at the ICES HQ in January and space has been provisionally booked. WKOUTVME may also take place at ICES HQ and if so will require use of facilities and support staff for one week: 15-19 April 2024.
Participants	Up to 30 participants
Secretariat facilities	ICES Professional Officers assigned to this workshop.
Financial	No financial implications.
Linkages to advisory committees	ACOM
Linkages to other committees or groups	SCICOM, HAPISG, we anticipate strong interest from WGDEC, WGMHM, and WGSFD.
Linkages to other organizations	DGMARE, NEAFC, NAFO, GFCM, FAO

Annex 3: Sampling methodologies for the Mesophotic Zone undertaken by Under The Pole

UNDER THE POLE • DEEPLIFE • 2021-2030 Programme

Under The Pole is an underwater exploration program which combines innovative expeditions around the world, support for scientific research, and awareness-raising, to promote better knowledge and conservation of the Ocean. Armed with its experience in deep scientific diving and ambitions for improving the scientific knowledge base for more effective conservation, Under the Pole has initiated the research program UNDER THE POLE • DEEPLIFE • 2021-2030, dedicated to the study of marine animal forests down to 200 m. The DEEPLIFE scientific program was designed by French National Centre for Scientific Research (CNRS) researchers and implemented as part of a collaboration between Under The Pole and a scientific consortium of international researchers.

Marine Animal Forests have been recently recognized as Vulnerable Marine Habitats by the International Union for Conservation of Nature (IUCN) requiring urgent management, conservation and restoration actions. The mesophotic zone (30-200m depth) offers optimal conditions for MAF development, but specific diving techniques are needed to approach this zone. DEEPLIFE brings together the scientific expertise of an international consortium and the exploration exper-tise of the Under The Pole team, with a sailboat equipped for underwater exploration and a crew composed of deep-diving professionals.

Methodology used in DEEPLIFE

The objective of the programme is to study the ecological function of Marine Animal Forests. To this aim the following actions are taken:

1. Identification of the key engineer species composing the animal forests;
2. Study of the microclimate generated by forests canopies;
3. Description and quantification of the associated biodiversity.

The following methods were applied following approximately the same protocols during the Canaries and Guadeloupe expeditions with differences due to the different environments. The data for Canary Islands were collected between 13 October and 14 December 2022. The data for Guadeloupe were collected between 23 February and 29 April 2023.

Description of the key engineer species

Benthic assemblages

On each of the 9 study sites, photographic transects at different depths (40, 60 and 90 m) were performed. Depths were chosen based on previous sampling in the framework of the DEEPHOPE and DEEPLIFE expeditions, to compare the biodiversity of rocky sessile species between polar, temperate and tropical environments. At each depth, 20 pictures of a 1x1 m quadrat, randomly placed along a 30 m transect, were taken in high definition with a Nikon D810 camera in a Nauticam housing with a 16 mm lens, 36.3 megapixel and Keldan strobes.

The relative cover of each benthic group will be quantified and identified to the maximum taxonomic resolution possible per quadrat using the software "Photoquad".

Black coral taxonomy

In each site, black corals (Hexacorallia: Antipatharia) were first identified based on the morphological characteristics of the colonies. Each different morphotype was sampled to assess the species diversity. Fragments of ~10 cm in length were collected either on the middle of the colonies for branched species, or the first 10 cm in the apical part for whip-shaped colonies. In addition, each colony was photographed underwater to describe the morphology of the colony as well as the polyp characteristics *in situ*.

Samples were then brought back on the sailboat, before being stored in 96% ethanol for further identification and genetic analysis. Each sample was stored and labelled individually to keep record of their original locality and depth.

In the laboratory, morphological characteristics are described using a stereomicroscope and an ocular micrometer and the following measures:

- Number of polyps per cm;
- Polyp transverse diameter;
- Mutual distance of the polyps.

For branched species; the following characteristics are measured:

- Branch, pinnules and branchlets length;
- Number of branchlets/pinnules per cm;
- Branchlets/pinnules mutual distance;
- Basal diameter of the terminal branchlets/pinnules.

Finally, images of the skeletons are taken by Scanning Electron Microscope to describe the morphological characteristics, which will be used for the final taxonomic identification. To do so, a fragment of around 1 cm in length will be prepared using a bleaching solution in order to remove the soft tissues, with a special care to keep track of the polypar side. After removal of the soft tissues, samples will be put in increasing concentrations of ethanol baths and air dried overnight. They will be then mounted on aluminum stubs before being coated under a JEOL sputter coater using a mix of 40% gold and 60% palladium for three minutes.

Different diameters of the skeleton samples are used to take the following measures:

- Spine shape and ornamentation;
- Polypar and abpolypar (part of the coral without polyps) sizes and mutual distances;
- Number of longitudinal rows of spines.

This work is carried out in the Biology of Marine Organisms and Biomimetics unit of the University of Mons (Belgium) under the supervision of the Natural History Museum and Vivarium of Tournai (Belgium). Morphological comparisons will be made using samples from all the dive sites.

Genetics

A first attempt to sequence the whole genome of *Stichopathes gracilis* has been carried out. Genomic DNA was extracted using the cetyltrimethylammonium bromide (CTAB) method in the Evolutionary Biology and Ecology laboratory of the Free University of Brussels (Belgium) under the supervision of the Natural History Museum and Vivarium of Tournai (Belgium).

Genomic DNA was purified using the Rapid Sequencing Kit of Nanopore© before being loaded on a Flongle Flow Cell (Nanopore©) using a MinION adapter. The Flongle allows to collect around 2.8 Gb of real-time sequencing data.

In parallel, the Internal Transcribed Spacer 1 (ITS1) has been sequenced for several specimens coming from three different species. Genomic DNA has been extracted using a QIAGEN Blood

& Tissue Minikit© and ITS1 amplified using the primers described in Terrana et al. (2021)1 for *Stichopathes maldivensis*. Amplicons were then Sanger Sequenced using the same primers as amplification. Raw data was analysed in Sequencher® and black coral sequences of other species retrieved from GenBank. Sequences were aligned with multiple alignment using fast Fourier transform (MAFFT). Phylogenetic trees were constructed using MrBayes® for bayesian inference, and PhyML for Maximum Likelihood.

These data will be used to examine conspecificity and population connectivity at local and global scales in black coral species.

Black Coral Forest density and size structure

Forest density was measured by video transects taken with an underwater camera oriented downside and kept at 5 m distance from the bottom, along a transect line used as reference for image analyses. Frames extracted for the video will be analyzed by image analysis software (imageJ) and black coral density will be estimated as the percentage cover of the substrate. Size structure of black coral colonies was measured, at the same time by means of a graduated stick (antipathometer®) (Figure 3.1 in main text of the report).

Canopy effect on microclimate

Sedimentation rates and Particulate Organic Matter (POM) were measured through sediment traps deployed at 60 and 80 m inside and outside the black coral forest (BCF) canopy to determine its effect on the biogeochemical environment. Each sediment trap is formed by a three PVC tube, with the precise measures of 16 cm long and 4 cm diameter, secured to a 2.5 kg weight (Figure A3.1). Tubes are open on the top and placed in a vertical position with the open part upward in order to capture the sediment. Traps were positioned close to a high-resolution doppler current profiler. The traps remained for around 8 days underwater. Once on the boat, the content of each trap was filtered under suction onto Whatman GF/F glass fiber filters (0.7 µ x 47 mm) using a vacuum pump. Previously filtered seawater was used to rinse each trap. Sediment samples contained in filters were stored in previously labelled aluminum foil envelopes, frozen and transported to University of Las Palmas de Gran Canaria to quantify sediment content, humidity and percentage of organic matter inside and outside BCF's canopies. Organic content of the deposited sediments will be estimated based on loss on ignition method (Cerpovicz & Lasker 2021).

The sampling of the water column for the analyses of Dissolved Organic Matter (DOM) was performed by SCUBA divers through 60 mL syringes. The standard protocol involves the use of three syringes (replicates) to collect water from inside the canopy and three syringes from outside the canopy. Sampling is replicated in three different locations of the canopy. Once on the boat, samples were treated following the following protocol:

1) Each syringe is filtered on a 0.7 µ GF/F combusted filter applied directly on the syringe;
2) Filtered water from each syringe is divided in two glass vials, one of which will be used for Dissolved Organic matter (DOC) content analysis and the other for Fluorescent Dissolved Organic matter (FDOC) content analysis;
3) HCl is added to the vials dedicated to DOC content;
4) Vials are preserved at 4 ºC pending for analyses in laboratory.

High-Resolution acoustic doppler profiler (aquadopp) was deployed to measure the current profile outside and inside BCF canopies of different densities and structures. The aquadopp obtained profiles of the direction and velocity of the current along 3 m with 3 cm resolution. The current profiler was placed at different canopy densities of the three black coral species: i) *A. wollastoni*, ii) *A. furcata* and iii) *S. gracilis*. Measurement cycles of at least 24 h were performed to account for the current variability linked to the tidal cycle. Instrument was set up to take one 15 min long measure every 30 min, for a total of 48 measurements for each deployment.

Measurements were also performed on bare sand, in absence of black corals to have a control profile to be compared with the profiles obtained at different BCF densities. Forest density was measured by video transects as described above.

To estimate the effect of BCF on seawater temperature and light, a set of underwater data loggers were deployed inside and outside the BCF to measure light irradiance and temperature. Two devices recording temperatures (ºC) and light intensity (Lux) (Hobo data-logger Pendant Temp-Light, Onset Computer Corporation, USA) were attached with cable ties, one anchored to the seabed inside the *Antipathella wollastoni* forest through 2 kg diving weight and a second datalogger attached to a float (cork) placed just above the forest (ca. 2.5 m) and also tied to the same seabed weight. Devices logged measurements every 10 minutes during at least 24 h at different depths.

Associated fauna

To study the epifauna associated with black corals, the research focused on two depths, corresponding to the distribution range of coral species on each island. At each depth, 10 colonies between 40 and 180 cm height (measured from the colony base to the upper tip of the colony) were randomly selected and collected by divers. Samples of associated epifauna were collected on the coral branches of each colony by an epifauna collector (underwater suction pipe) applied for 20 seconds.

Collected epifauna samples were brought to the laboratory in sealed containers filled with seawater. Then, each sample was carefully rinsed and sorted to separate epifauna from marine debris and coral mucus. Each organism was then sorted in 95% ethanol and identified to the lowest taxonomic level. Identifications were implemented by using a stereoscopic microscope (Leica, EZ4W, Wetzlar, Germany).

In some of the sites characterized by high biodiversity, the soundscape was recorded over 48 hours by means of a hydrophone (RTSYS SYLENCE-LP underwater acoustic recorder). This approach allows to obtain data on BCF frequentation by vertebrates and invertebrates species in absence of human observers and during the night. A hydrophone was positioned in sites with highly dense forests as well as in a site characterized by the absence of forest. The instrument was set up to take continuous recording for at least 48 hours. Results will be used to evaluate the acoustic biodiversity associated to BCF and estimate the associated biodiversity.

Data availability and contacts

Considering the co-direction of the DEEPLIFE program by Under The Pole and the two scientific directors, and the fact that a whole scientific consortium is involved in the program, Under The Pole does not own the data collected. Table A3.1 details which researcher should be contacted for each type of data in the two expeditions (Canarias and Guadeloupe). Please remember that the scientific directors and the scientific coordinators should always be in copy of emails. Finally, the Under The Pole Consortium shall always be cited when the data are used.

Table A3.1. Contact details for the researchers who should be contacted for each type of data for the two expeditions (Canarias and Guadeloupe) under DEEPLIFE.

Type of data	Name	Email
Black Coral Forest (BCF)		
Forest demography	Lorenzo Bramanti	lorenzo.bramanti@obs-banyuls.fr
Benthic assemblages (Photoquadrats)	Laetitia Hédouin	laetitia.hedouin@criobe.pf
Black Coral taxonomy and genetics (Canarias)	Lucas Terrana Francisco (Fran) Otero Ferrer	lucas.terrana@tournai.be francisco.otero@ulpgc.es
Connectivity	Lucas Terrana Francisco Otero Ferrer	lucas.terrana@tournai.be francisco.otero@ulpgc.es
Sponge diversity	Camille Clerissi	camille.clerissi@ephe.sorbonne.fr
Environment		
Temperature and light sensors	Laetitia Hédouin	laetitia.hedouin@criobe.pf
Current	Katell Guizien	katell.guizien@obs-banyuls.fr
Sedimentation rate and particulate organic matter	Francisco Otero Ferrer	francisco.otero@ulpgc.es
Dissolved organic matter	Cristina Romero-Castillo	crisrc@icm.csic.es
BCF Associated biodiversity		
Acoustic	Lucia Di Iorio	lucia.diiorio@univ-perp.fr
Fish survey (Guadeloupe)	Luiz Rocha	lrocha@calacademy.org
Epifauna	Sandra Navarro Mayoral Francisco Otero Ferrer	sandraanm16@gmail.com francisco.otero@ulpgc.es
Bacteria in water column	Lorenzo Bramanti	lorenzo.bramanti@obs-banyuls.fr
Fish and vulnerability maps	Joachim Claudet and Juliette Jacquemont	joachim.claudet@gmail.com juliette.jacquemont.fr@gmail.com

Person to put in copy of any email:

Scientific direction: Lorenzo Bramanti (lorenzo.bramanti@obs-banyuls.fr) and Laetitia Hédouin (laetitia.hedouin@criobe.pf)

Under The Pole scientific coordination: Myrina Boulais (myrina@underthepole.com) and Marie Maillot (Marie@underthepole.com).

References

Cerpovicz, A., and Lasker, H. 2021. Canopy effects of octocoral communities on sedimentation: modern baffles on the shallow-water reefs of St. John, USVI. Coral Reefs, 40: 10.1007/s00338-021-02053-6.

Terrana, L., Flot, J. F., and Eeckhaut, I. 2021. ITS1 variation among *Stichopathes* cf. *maldivensis* (Hexacorallia: Antipatharia) whip black corals unveils conspecificity and population connectivity at local and global scales across the Indo-Pacific. Coral Reefs, 40: 521-533.

Figure A3.1. A diver points to the position of the sediment traps placed under the Black Coral Forest (BCF) canopy. These data will be used to examine the ecosystem function of the BCFs and to identify drivers of biodiversity.

Annex 4: Methodologies adopted for the characterization of deep-sea habitats in the Azores

Contributors[20]: Telmo Morato, Carlos Dominguez-Carrió, Gerald H. Taranto, Luís Rodrigues, Laurence Fauconnet & Marina Carreiro-Silva

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Recognizing (i) the EU regulation (EU 2016/2336) that recommends Member States to use the best available scientific and technical information to identify where vulnerable marine ecosystems (VMEs) are known to occur or are likely to occur and (ii) recognizing the need to assess the footprint of fishing activities posing a significant risk of a negative impact on VMEs, the OKEANOS (University of the Azores) Deep-sea Research Group (ADSR) established a well-structured workflow to inform area-specific management plans for a sustainable use of deep-sea natural resources. The methodologies presented here were provided by the ADSR members attending WKOUTVME as roadmap for other countries in the Outermost Regions and elsewhere for acquiring information to support conservation and management decisions on VMEs and other deep-sea habitats.

To help achieve such goal, the ADSR championed the development of the Azor drift-cam, a cost-effective video platform designed to conduct rapid appraisals of deep-sea benthic habitats and to democratize deep-sea exploration. Over the last 5 years, ADSR mapped the deep-sea benthic megafauna of the Azores region, to 1000 m depth (the maximum depth where human activities currently occur), in an unprecedent way. Using the Azor drift-cam it was possible to visit systematically geomorphological features and island slopes (950 dives on more than 140 features) throughout the Azores EEZ. This information was complemented by highly technological surveys (including the RV OceanXplorer with two submersibles and one ROV) that collected additional data (e.g., biological specimens, etc.) at specific locations. These surveys covered more than 800 km of seafloor and are expected to generate over 100,000 new occurrences records of deep-sea benthic megafauna taxa. Thanks to the development of the Azor drift-cam, international and regional collaborations, and funds made available by the EU and Regional Government of the Azores, ADSR have now placed Portugal as one of the top 5 regions in the world in terms of information regarding composition and spatial distribution of deep-sea benthic communities. Such research efforts have led to significant discoveries, including several new octocoral gardens, dense aggregations of black coral species, many undescribed sponge aggregations and even a new hydrothermal vent site. ADSR found that the Azores region is a biodiversity hotspot with many seamounts and island slopes harbouring structurally complex assemblages, which include diverse cold-water coral gardens, sponge grounds and a wide variety of associated fish species, clearly fitting the FAO VME criteria. ADSR explored all the geomorphological features shallower than 1000m and is now finalizing the data collection and starting the data analyses. The results are expected to be available through peer reviewed scientific publications by 2025-2027. These analyses will include qualitative and quantitative methodologies to inform where VMEs are known or likely to occur.

ADSR is also developing methodologies to help define what is a significant risk of a negative impact on VMEs and the MSFD Descriptor 6 Seafloor Integrity, namely the assessment of D6C5

[20] Details of work on Deep-sea Mining and Climate Change are available from the authors.

“The extent of the negative effects of anthropogenic pressures on the condition of the habitat type”. The recent collection of seafloor imagery made it possible to assess that a large part of structuring benthic communities observed within bottom fishing grounds in the Azores are still in good environmental condition and have a high natural and ecological value. These in-situ observations corroborate the conclusion of previous studies that suggest that well-regulated deep-sea fishing based on hook and line gear (preferably hand line), in the absence of more destructive fishing practices such as bottom trawling (banned in the Azores since 2005), could contribute to the sustainable exploration of the deep sea. Finally, the knowledge we acquired on the location of the different regional benthic communities increased our capacity to develop area-specific management plans (e.g., Systematic Conservation Plans) which are crucial to inform a sustainable use of deep-sea natural resources and promote a long-term conservation of marine biodiversity for present and future generations.

Objectives: Here, we present a brief description of the workflow adopted by the ADSR to identify VMEs, to evaluate significant negative impacts on VMEs, and to enable systematic conservation planning frameworks for achieving well-defined conservation and management goals in the deep-sea of the Azores Exclusive Economic Zone (EEZ) down to 1000 m depth; which is the maximum depth where human activities currently occur in this region.

1. **Collection of high-resolution (multibeam) bathymetry**

To improve the assessment of the spatial distribution of biodiversity in the deep sea and to understand the distributional drivers of species and communities, to identify sampling areas and to plan new surveys at sea, it is necessary to work with the best bathymetric information available (Figure A4.1). High-resolution bathymetric data resulting from multibeam scans should help meet the basic requirements of any spatial biodiversity assessments. The lack of data for the development of robust Digital Terrain Models (DTMs) is generally one of the major constraints associated with deep-sea exploration. Therefore, collaborations with national and international institutions are crucial to obtain high quality bathymetric data that can be used to improve publicly available DTMs (e.g. EMODnet), which are built combining measured and inferred bathymetric data of different quality. Over the last years, the ADSR has partnered with the Government of the Azores, the Portuguese Hydrographic Institute and with other international organizations (e.g., NIOZ, IFREMER) to produce multibeam maps for most of the deep seabed within the Azores sub-area of the Portuguese EEZ down to 1500 m. The work to be done during the next years relates to continue improving the spatial coverage of high-resolution multibeam bathymetry, specifically in those areas currently targeted as a priority (in the Azores, for instance, priority areas include seamounts and ridges on the northern side of the Mid-Atlantic Ridge, north of Kurchatov, Mar da Prata Seamount and Albert of Monaco Ridge).

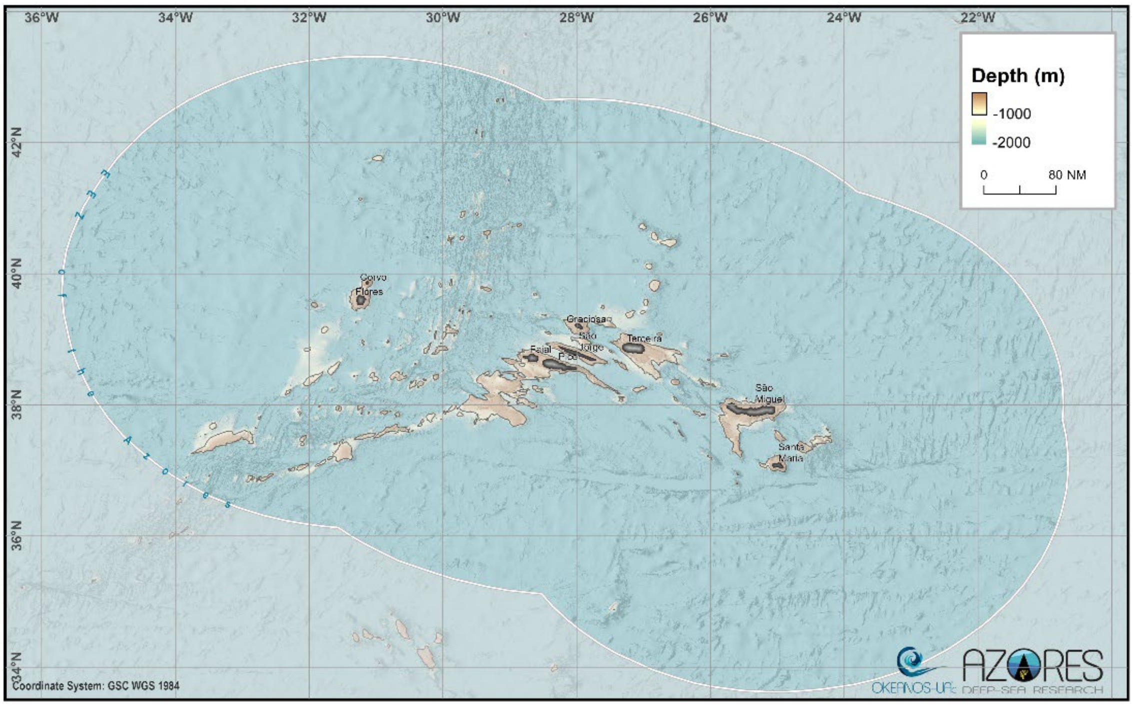

Figure A4.1. Map of the deep seabed of the Azores sub-area of the Portuguese EEZ down to 1000 m depth.

Recommendation: since collecting bathymetry data is time-consuming and costly, multibeam surveys should prioritize areas of high interest for management and conservation.

2. **Compilation and production of environmental raster layers**

Having a good set of environmental layers is of key importance to understand patterns in the distribution of benthic biodiversity, including VME Indicator taxa (Figure A4.2). It is hence fundamental to collect environmental data regarding the characteristics of the surrounding seawater to produce spatial layers of good quality and at suitable resolutions for the identification of the main drivers that explain the observed species distributions Moreover, these layers are fundamental for producing good quality habitat suitability models. Several environmental parameters are generally used in studies of benthic ecology, and those include (among others) sea bottom temperature, oxygen concentration, salinity, pH, flux of organic carbon to the seabed or bottom current velocity and direction. Over the past years, the ADSR group has worked towards compiling all environmental layers available for the Azores EEZ at the best resolution possible. At present, we have compiled information for a set of 24 spatial layers at resolutions of several kilometres, including seabed temperature, alkalinity and salinity, Aragonite and Calcite saturation, bottom Nitrate, Phosphate and Oxygen concentrations and bottom current intensity. At present, the ADSR group is working with physical oceanographers to improve the quality of regional environmental data (1 km spatial resolution) and to produce local high-resolution hydrodynamics models (100 m spatial resolution) to better understand the correlation of species distributions with oceanographic forces at a fine scale.

Recommendation: Complementing multibeam bathymetry surveys with oceanographic surveys and with the development of high-resolution oceanographic models will reduce the uncertainties associated with, for example, habitat suitability models and projection of climate change impacts on VME indicator taxa.

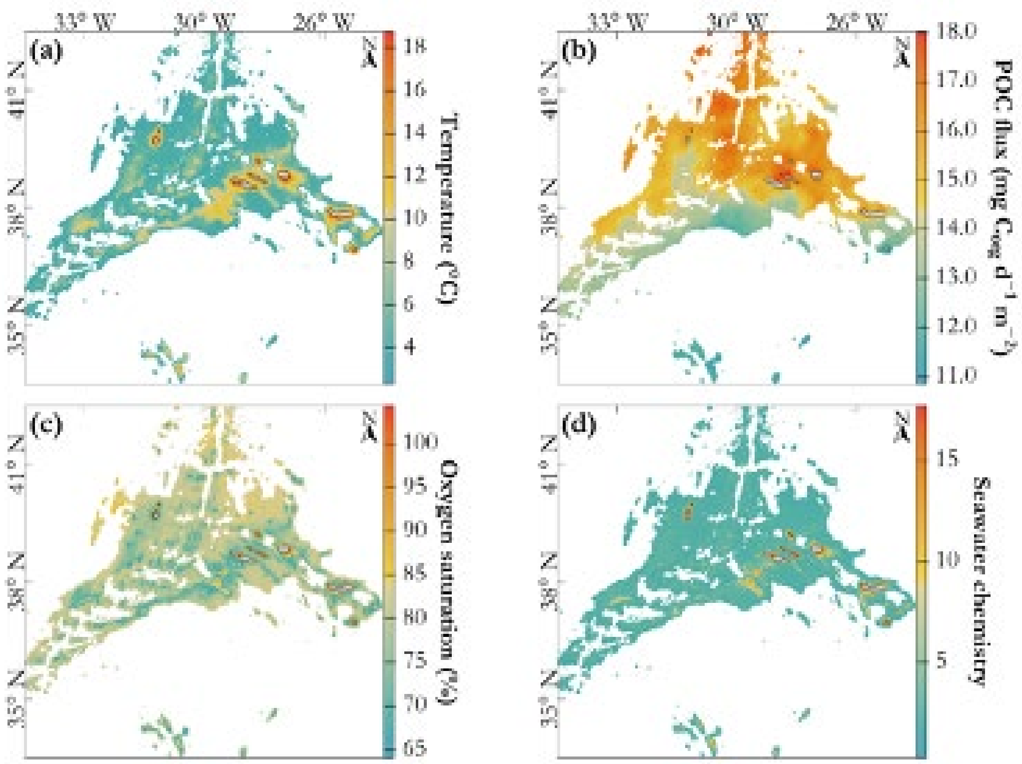

Figure A4.2. Maps of different oceanographic variables on the deep seabed of the Azores sub-area of the Portuguese EEZ. From Taranto *et al*. (2023).

3. Identification of Geomorphological Units (GMUs) and seabed habitats

Bathymetry and bathymetric derived information set the stage for deep-sea exploration and management (Figure A4.3). In the context of the Azores, this information is used to provide a first level characterization of the seafloor. Based on high-resolution multibeam bathymetry, geomorphological analysis is performed to classify discrete geomorphological features (GMUs) that rise from the seafloor (e.g., seamounts, ridges, island slopes, etc.) with a newly developed semi-automated processes using ArcGIS tools and the R package scapesClassification. Individually, GMUs provide a useful bounding box where to synthetize biological and management information and a tool for monitoring and survey planning. As a whole, GMUs provide a general framework useful for communicating scientific information (thus, inform management) and set the stage for studying geographic and bathymetric gradients in species and community distributions within the study area. Additionally, we used the new scapesClassification tool to classify the seafloor heterogeneity (i.e., steep slopes, crests, valleys, etc.) and to identify a diversity of habitats that could be useful to interpret the observed fauna. The ADSR group has identified so far 140 geomorphological units or sampling areas using this approach, which extend down to 1000 m depth. These areas informed the compilation of existing data, identification of gaps in the available information, collection of new data, and policy recommendations. The delimitation of the geomorphological units found in areas with a poor bathymetry coverage will be improved in the next years following the acquisition of new multibeam data of high-resolution.

Recommendation: When identified at a scale meaningful for management and research purposes and when the defined units are easily recognized by all relevant stakeholders (e.g., researchers, fishermen and policymakers), geomorphological management units represent a valuable framework for addressing research and management questions.

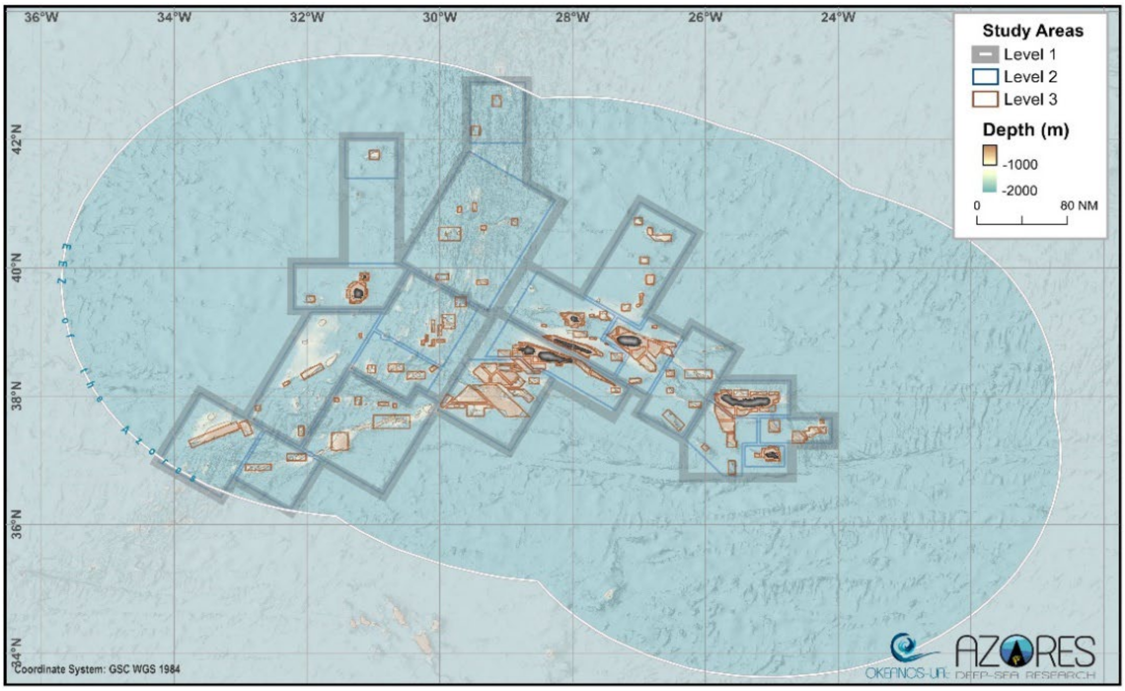

Figure A4.3. Location of the 140 sampling areas identified using the best available bathymetry data that will serve to inform the compilation of existing information, the identification of knowledge gaps, the collection of new data, and the policy recommendations.

4. **Methods to characterize benthic diversity**

   a. **Collection of underwater images**

Evaluating patterns of biodiversity distributions over wide geographic extents requires large-scale sampling efforts that might span over several years. Underwater imaging technology has provided the means to access the deep seabed employing non-invasive technologies that can provide in-situ, representative and potentially repeatable samples in the form of still and video images. Since the access to state-of-the art technologies is not only very expensive, but requires a complex set up with large oceanographic vessels and specialized crews, the ADSR group developed the Azor drift-cam, a cost-effective video system (€15K) that allows visual surveys of deep-sea benthic habitats down to 1,000 m depth and that can be operated from small local boats (Figure A4.4). The system is made with off-the-shelf components, using small action cameras, powerful LED lights, a parallel laser system for image scaling and a temperature/depth sensor. It is designed to reflect the reality of the Azores, which means being cost-effective, cover as much ground as possible in each deployment, perform well over rough terrains and escape abandoned or lost fishing lines when entangled. Over the last 5 years, using the Azor drift-cam, ADSR mapped the deep-sea benthic megafauna of the Azores region, to 1000 m depth, in an unprecedent way (950 dives on more than 140 features; Figure A4.5). This information was complemented with highly technological surveys (including the RV OceanXplorer with two submersibles and one ROV) essential to collect complementary information (e.g., physical specimens, seafloor samples, etc.) at specific locations. These surveys covered more than 800 km of seafloor and are expected to generate 100,000 new occurrences records of cold water-corals and other deep-sea benthic species. In the following years, ADSR will continue to collect imaging data of the deep seabed of the Azores to complement existing data in areas where additional data are required. Some of these areas include seamounts along the Mid-Atlantic Ridge, Mar da Prata seamount, or the seamount chain southeast of Pico Island.

<u>Recommendation</u>: Set a well-defined SMART target for deep-sea explorations (Specific, measurable, achievable, realistic and time-bonded) and move to cost-effective deep-sea exploration it is the only manner to expand the spatial coverage of deep-sea data.

Figure A4.4. Members of the ADSR group deploying the Azor drift-cam from the side of the N/I Arquipélago to explore deep-sea areas shallower than 1000 m depth in the Azores.

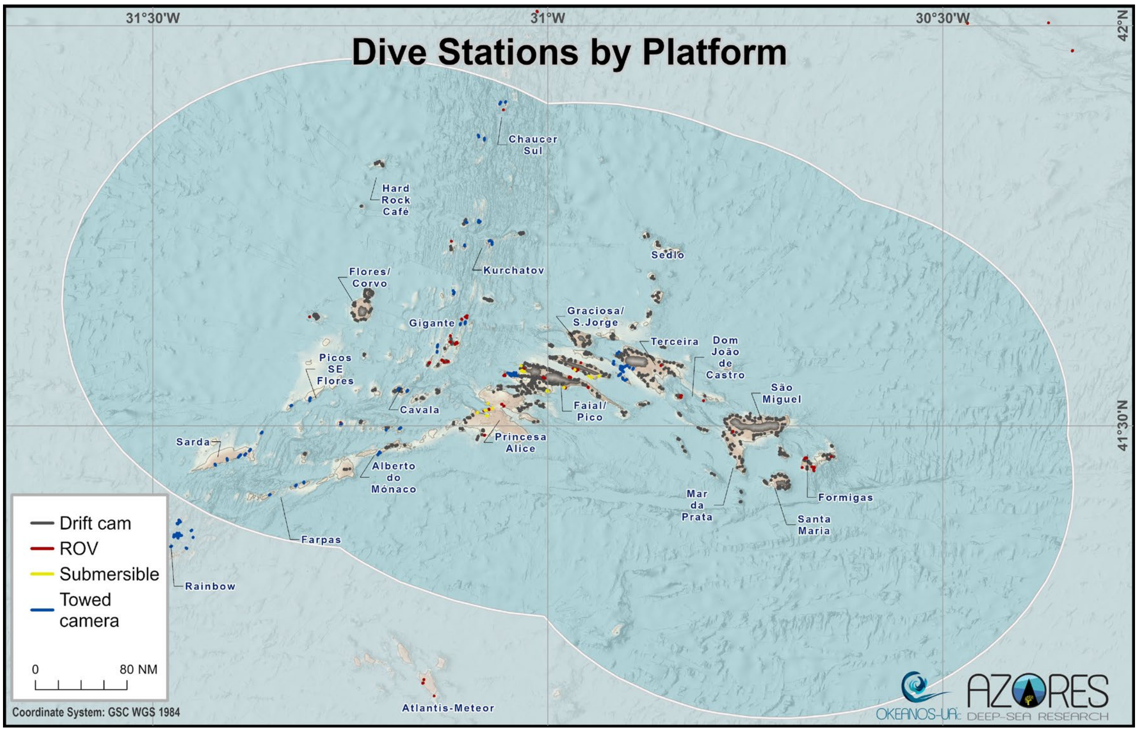

Figure A4.5. Location of the video surveys carried out in the Azores by the ADSR group in areas shallower than 1000 m depth.

b. Physical specimens from fishing bycatch

Collaborations with the local fishing fleet to report and collect by-catch produced during their fishing operations are important for mapping the distribution of biodiversity and VME indicator taxa, especially when some of the specimens collected are VME indicator taxa (e.g., aggregating habitat-forming cold-water corals and sponges), as in the case of the Azores (Figure A4.6). The ADSR group has been collaborating with local fishermen to collect deep sea invertebrate fauna accidentally captured during fishing activities. These records and their specimens obtained opportunistically have been stored and catalogued in the Marine Biological Reference Collection of the University of the Azores (COLETA) since 1990's. Currently COLETA contains 6,796 records of deep sea corals, sponges, and other deep-sea benthic megafauna organisms, which have been collected by sampling programs in fishing ports of the Azores, fisheries observers' programs, scientific longline surveys, experimental bottom trawl surveys and scientific cruises within the scope of national and international projects using ROVs. During the next years, ADSR will continue collaborating with local fishermen organizations to compile, classify and store the invertebrate by-catch produced by the fleet aiming to continue improving the quantity and quality of the information stored at the reference collection of COLETA.

Recommendation: Establishing collaborations with local fishers allows for the collections of biological samples of great importance to clarify species identification, genetics studies, laboratory experiments and impact assessments. Of equal importance is the establishment of regional reference collections, essential to identify and catalogue regional biodiversity and to contextualize VMEs and VME thresholds.

Figure A4.6. Examples of cold-water coral species commonly collected as by-catch in the Azores by the local fishing fleet and stored at the reference collection COLETA.

c. Environmental DNA

The collection of seawater samples can also be a robust alternative to perform biodiversity assessments through the analysis of environmental DNA sequences (eDNA) found suspended in the water column (Figure A4.7). Water samples are filtered using specific filters and peristaltic pumps and can be then analysed using both DNA metabarcoding (multiple markers) and quantitative PCR (qPCR) with species-specific primers for the detection of targeted species. The ADSR group has been collecting water samples for eDNA analyses since 2021, generally coupling water collection with underwater video surveys, to disentangle differences between the diversity observed in the images and that depicted from the eDNA sequences. This line of research will continue to be developed with the aim of generating a library of sequences for the Azores deep sea that will be of use in deepen our understanding of biodiversity and distributional patterns throughout the Azores EEZ.

Recommendation: Establishing eDNA sampling programs may be a cost-effective way to assess deep-sea biodiversity and inform, for example, where video surveys dedicated to the identification of VMEs should occur. These kinds of programs are only valid when there is a good knowledge base about regional biodiversity.

Figure A4.7. Collection and processing of water samples to extract eDNA for biodiversity assessments during one of the cruises led by ADSR.

5. **Identification of benthic species**

Identification of deep-sea species is primarily made through the study of voucher specimens collected during field missions using an integrative taxonomic approach that combines (i) classic methods based on morphological characters and (ii) the analysis of DNA sequences. Over the past years, the ADSR group has examined several specimens of cold-water corals across 18 taxa generating 94 new DNA barcoding consensus sequences, attributing names to 7 morphotypes and identifying 4 putative new species. The taxonomic examination of Porifera specimens brought to the identification of 36 species new to the region and, possibly, to the identification of 4 putative new species and one genus. This taxonomic work should be coupled with the processing of the underwater images collected to develop an area-specific image catalogue of deep-sea fauna, which should assist during image annotations. The catalogue should be created following the guidelines provided under the SMarTar-ID project (https://smartar-id.app), which provides a framework to classify organisms into Operational Taxonomic Units (OTUs), i.e. the creation of specific and unique reference numbers for each taxa. The ADSR group has a species catalogue that currently contains images and information for a total of 410 OTUs. In the next years, the ADSR will continue this effort to identify and catalogue the diversity of benthic fauna of the Azores deep sea, which will lead to an overall improvement of our understanding of the regional biodiversity at a finer taxonomic resolution.

Recommendation: Complementing video surveys with taxonomic studies using voucher specimens is the only way to build improved lists of VME indicator taxa, deepen our knowledge of the actual living organisms inhabiting a region and evaluate life histories and biological traits.

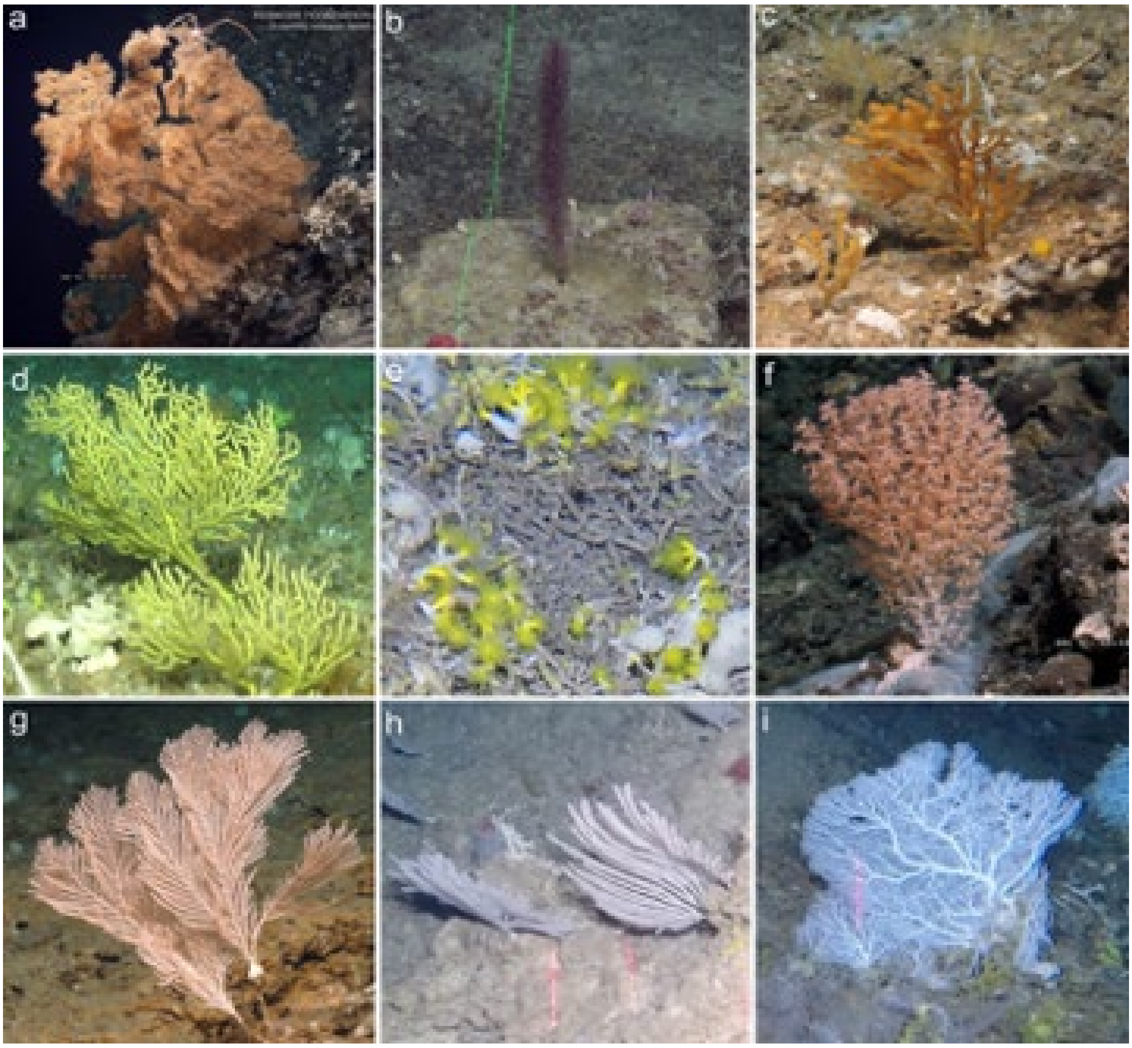

Figure A4.8. Examples of cold-water coral species, most of which are considered VME indicator species, included in the catalogue of deep-sea species of the Azores. (a) *Leiopathes expansa*. (b) *Parantipathes hirondelle*. (c) *Acanthogorgia hirsuta*. (d) *Dentomuricea aff. meteor* (e) *Eguchipsammia cf. cornucopia*; (f) *Acanella arbuscula*. (g) *Callogorgia verticillata*. (h) *Narella bellissima*. (i) *Errina dabney*. Credits: (a,f) Fundação Rebikoff-Nieggler; (b,c,d,g) Luso ROV, Fundação Oceano Azul; (e,h,i) Azor drift-cam, Okeanos-UAç.

6. Identification of benthic communities

Biological communities (or biocenosis), defined as characteristic associations of populations of species that occur together in space, are identified from underwater images as groups of species whose composition and structure is maintained stable across large areas. The catalogue of deep-sea benthic communities developed by the ADSR group currently contains images and information for a total of 39 biological communities down to 1000 m depth, most of which correspond to coral gardens (23) and aggregations of sponges (9) (Figure A4.9). In the next years, the ADSR group will continue to improve the identification, cataloguing and characterization of the biological communities present in the deep sea of the Azores sustained on the continued work on image annotation, taxonomic characterization and analysis the team is developing.

Recommendation: identification and classification of benthic communities is a crucial step towards the identification of vulnerable marine communities.

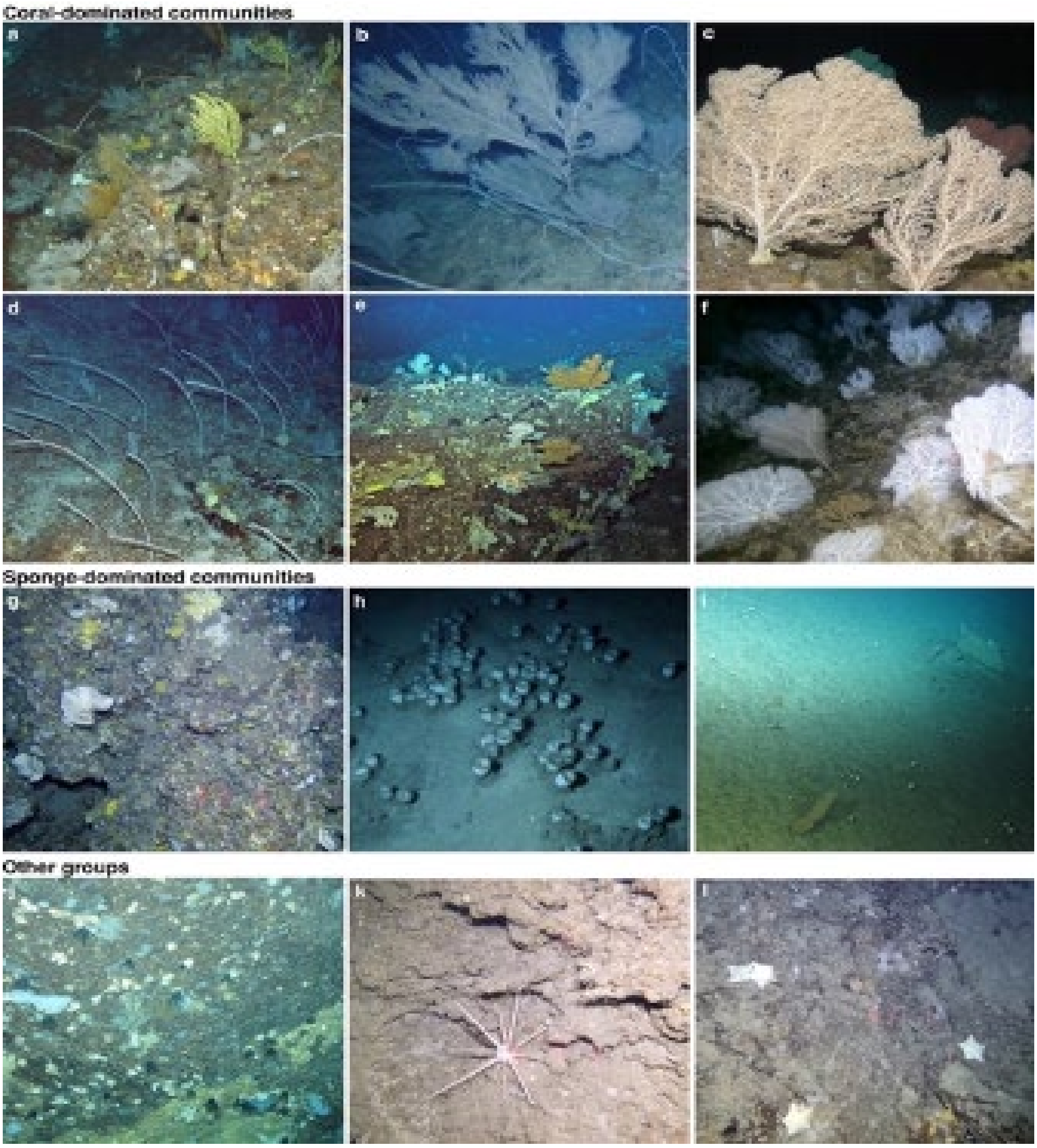

Figure A4.9. Some examples of benthic communities identified in the Azores deep sea. (a) Octocoral-dominated community with *Viminella flagellum*, *Acanthogorgia* sp. and *Dentomuricea* aff. *meteor*. (b) Large colonies of *Callogorgia verticillata* and *Viminella flagellum*. (c) Aggregation of the hydrocoral *Errina dabneyi*. (d) Large *Paragorgia johnsoni* on seamount slopes. (e) Aggregation of the Primnoid *Narella versluysi* with a few other corals and glass sponges. (f) Rocky outcrops with cold-water corals, including scleractinians, octocorals, black corals and bamboo corals. (g) Porifera on large rocky outcrops. (h) Aggregation of *Pheronema carpenteri*. (i) Aggregation of *Stylocordyla pellita*. (j) Ancient community with cf. *Cyathidium foresti*. (k) Outcropping rocks with *Cidaris cidaris*. (l). Sea stars of the family Goniasteridae. Credits: ROV Luso / EMEPC / 2018 Oceano Azul Expedition, organised by Oceano Azul Foundation & partners; (b,f,g,k,l) Azor drift-cam, IMAR/Okenaos-UAç; (d,e,j) MedWaves, ATLAS project: (h) Hopper tow-cam system, NIOZ.

7. Image annotation

Images of the deep seabed collected during the scientific cruises are analyzed following a standardized methodology to obtain four levels of data from each dive: substrate composition, diversity and structure of benthic megafauna, composition of demersal fishes and abundance of marine litter. The type of substrate is visually evaluated along the whole length of each video transect, annotating the sections where each substrate is dominant. The selected substrate types are based on bottom composition and sediment grain size and correspond to categories recurrently used in ecological studies of the deep sea, ranging from mud to outcropping rocks. The assessment of the biological diversity is accomplished through the annotation of the benthic megafauna observed in the images, defined as those sessile (or low mobility) invertebrate species of a size greater than 3 cm that can be identified from underwater images. Each (morpho)species observed is classified based on the OTU number given in step 5. Registration of all fish species observed in the underwater dives to generate a database of demersal fauna at a fine spatial scale. Registration of all human-derived items observed in the underwater dives to generate a database of marine litter at a fine spatial scale. The ADSR group is already at an advanced stage regarding the annotation of its underwater surveys (e.g., Figure A4.10).

Recommendation: Define smart annotation protocols at spatial scales suitable to answer specific research and management questions will enable the production of relevant data at reasonable, achievable, and realistic time frames.

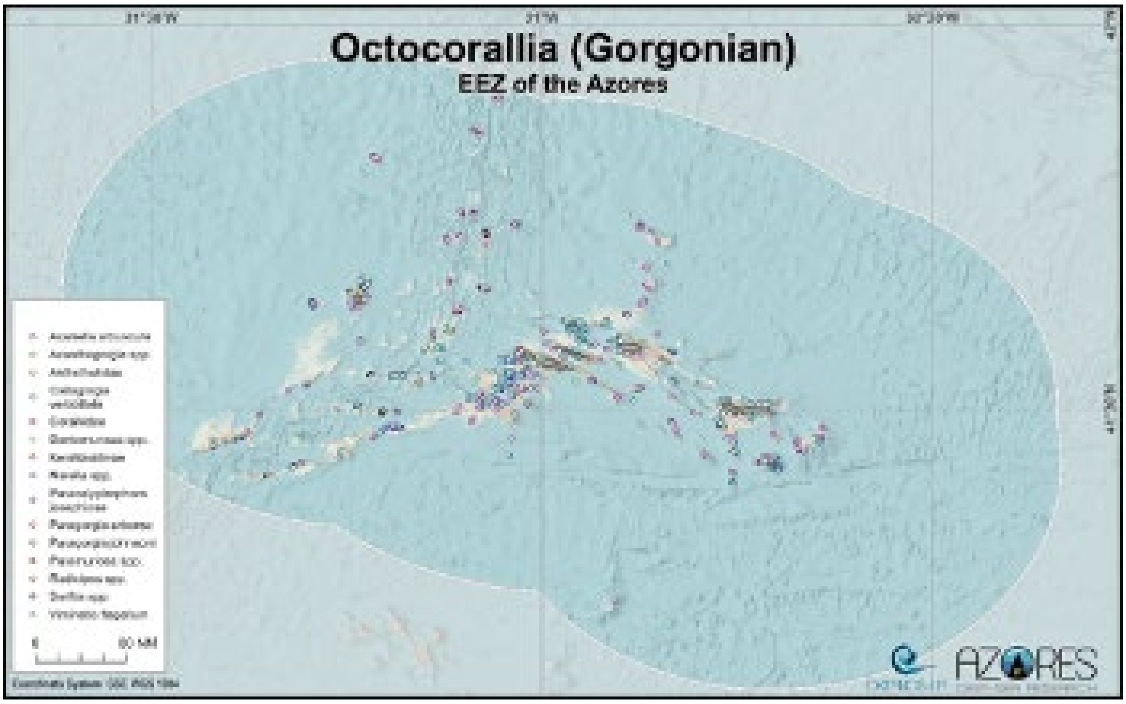

Figure A4.10. Map showing the geographical distribution of several Octocorallia taxa inside the Azores EEZ derived from the annotation of underwater images by the ADSR group.

8. **Spatial models**

Spatial models are used to complement biological and environmental data and inform where key species or communities are predicted to found in areas that have not yet been explored (Figure A4.11). Additionally, they represent an important tool to investigate regional biodiversity patterns and predict how benthic communities might change under future climatic conditions and different anthropogenic pressures. ADSR group has developed spatial predictive models at regional scale (Azores EEZ) with an approximate resolution of 1 km and at local scale with about 100 m resolution. At a regional scale, ADSR developed (i) key cold-water coral species (Taranto *et al*. 2023), (ii) commercial fish species (Parra *et al*. 2017), (iii) deep-sea sharks and rays (Das *et al*. 2022) and abandoned or lost fishing gears (Duncan *et al*. 2023). The future work will include the development of distribution models at regional scale of i) substrate composition, (ii) validation of existing and updating the models developed by Taranto *et al*. (2023) with new biological information, (iii) new models using data for other key species, including sponges and other representative taxa, and (iv) bioregionalization models, such as species archetype models.

Recommendation: Building habitat suitability models with robust quantifications of uncertainties is crucial to increase the likelihood of models being useful to inform management.

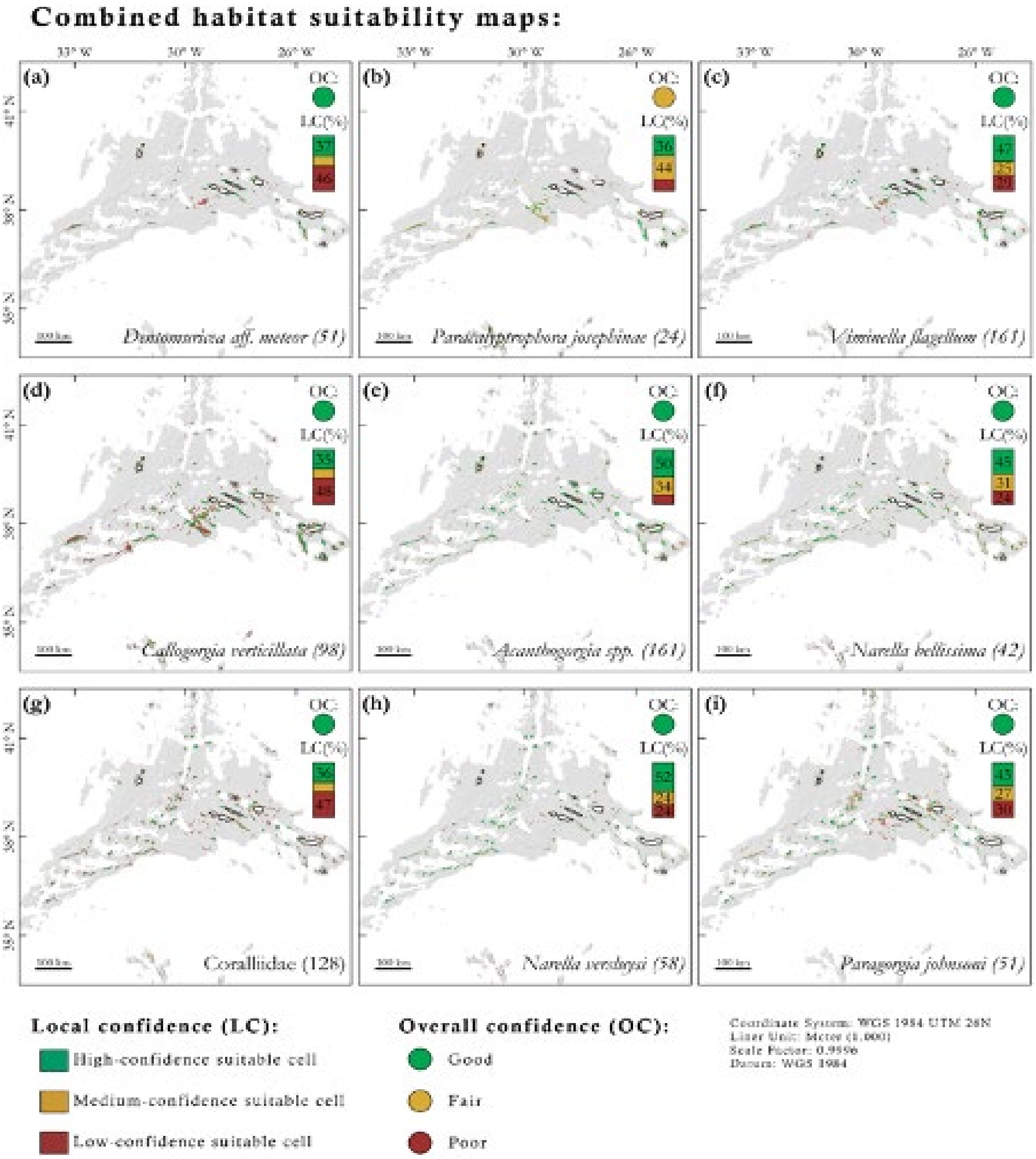

Figure A4.11. Combined habitat suitability maps for several octocoral taxa for the Azores EEZ. Cells were classified as high, medium or low confidence based on the lowest score among the AUC and True Skill statistics of the GAM and Maxent models. From Taranto *et al*. (2023).

9. **VME assessment**

Due to the scarce knowledge that exists regarding the diversity and distribution of benthic species along large areas of the deep sea, the concept of VME Indicator Species has been widely used to signal the occurrence of VMEs. However, the sole presence of an indicator species should not be considered sufficient to classify individual geomorphological features as VMEs, and assessments at different levels should be developed.

a) Direct assessment:

i. <u>Species level</u>

The identification of VME Indicator Species is made through an assessment against the criteria for defining what constitutes a VME (Rarity, Functionality, Fragility, Life-history and Structural complexity; FAO 2009) based on a qualitative scoring following the guidelines established in Morato *et al*. (2018). The ADSR group is assessing the OTUs included in its species catalogue against the FAO criteria using a well-defined expert driven qualitative assessment and have produced a regional list of VME indicators. Some of these VME indicator species have been assessed during the during the WGDEC meeting in 2020 (ICES 2020), while others were recently added by the ADSR based on recent field missions.

ii. Community level

A comprehensive understanding of how benthic species associate in the deep sea to form stable communities is of paramount importance to effectively infer the presence of VMEs. The intrinsic characteristics of the benthic communities identified should be assessed to determine whether they display vulnerability towards human activities, leading to the listing of those that should be regarded as VMCommunities (*sensu* Watling & Auster 2021) following the five criteria for defining what constitutes a VME (FAO 2009). The ADSR group is assessing all the benthic communities identified in the underwater video images against the FAO criteria using expert judgement and have produced a regional list of VMC.

iii. Habitat level

Hydrothermal vent fields are recognized as important VMEs. In the Azores there are six known vent fields located along the MAR, namely 1) Menez-Gwen including Bubbylon, 2) Lucky Strike including Ewan, 3) Menez Hom, 4) Saldanha, and 5) Luso, as well as 6) the Rainbow vent field in the claimed Extended Continental Shelf. Dom João de Castro is a shallow-water hydrothermal vent associated with the hyper-slow spreading Terceira Rift. The ADSR has included the known hydrothermal vents in the list of bone fide VMEs.

iv. Geomorphological unit level

The information on deep-sea biodiversity regarding VME Indicators and biological communities obtained from the underwater images is compiled for each geomorphological unit to generate a detailed characterization of each GMU, which should then be assessed against the criteria that defines a VME (FAO 2009). The consideration of a GMU as an Essential Fish Habitat should also be relevant towards the assessment against the FAO criteria. The ADSR group is producing a preliminary qualitative assessment of the 140 geomorphological units against each of the five FAO criteria for defining what constitutes a VME using expert judgement. The methodology used for the assessment was based on a qualitative scoring and took into consideration the VME Indicator taxa most suitable to address the FAO criteria, and their occurrence and abundance in the different sampling areas.

10. **Evaluation of spatial patterns of human activities:**

a. **Deep-sea fishing effort**

The effort of the deep-sea fishing fleet (bottom longline and handline) is computed from an analysis of the Vessel Monitoring System (VMS). In the case of the Azores, VMS data are relative to vessels licensed for bottom longline and handline fishing gears as bottom trawling is banned from the region. Heuristic methods are used to define the fishing vessels state (fishing, steaming, resting) at any given time using specific rules for speed, course, leg, angle, and distance to harbour. The maps of fishing effort are then used to evaluate the potential pressure and impacts of the fleet in each of the GMUs identified in step 2 (Figure A4.12). Preliminary results have been validated with a quasi-Bayesian approach but will be updated as soon as more recent VMS data (2018-2023) is received.

Recommendation: Development of methodology to analyse fishing effort data should incorporate regional specificities of the local fishing fleet type, gear, and operations.

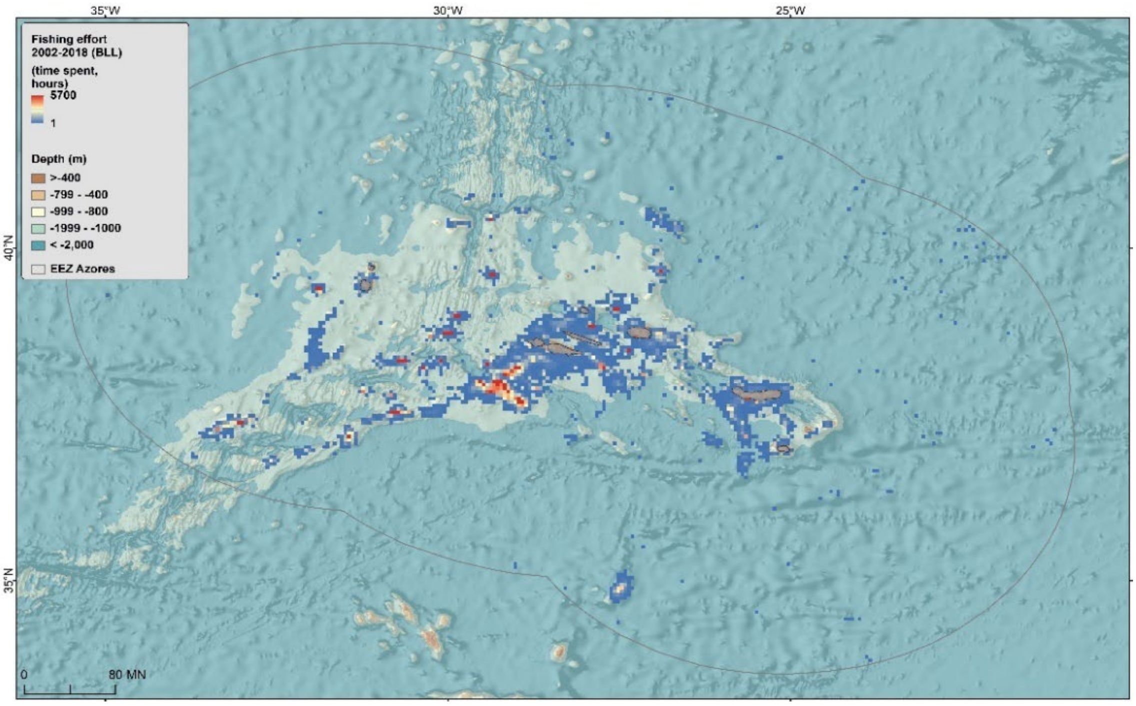

Figure A4.12. Bottom longline fishing in the EEZ of the Azores expressed as a logarithmic index of effort within the fishing footprint at the 5 km resolution, based on the analyses of VMS data.

11. **Evaluation of human pressures**

Work developed by Pham *et al*. (2014) found that deep-sea bottom longline fishing has reduced impact on vulnerable marine ecosystems when compared to bottom trawling. They found reduced bycatch of cold-water corals and limited additional damage to benthic communities, especially compared with bottom trawls. To provide insights on the level of longline damage not accounted as bycatch, the physical conditions of benthic communities on a fishing ground were also assessed by Pham *et al*. (2014). From the colonies observed close to lost fishing lines, 63% were found intact, 15% with minor damage, 20% with major structural damage but with potential for survival, and only 3% of the cold-water corals were found in a critical status with no survival potential.

12. **Evaluation of significant adverse impacts**

While it is important to use the full set of criteria in the FAO DSF Guidelines to identify where vulnerable marine ecosystems occur or are likely to occur, it is also important to develop transparent and objective methodologies to assessing significant adverse impacts. It should be noted that not all fishing or other human activities produce similar impacts. Under the MSFD, the most relevant descriptor to assess the environmental status of deep-sea regions under increasing anthropogenic pressures is D6 (Seafloor integrity), which aims to guarantee that the seabed is found "at a level that ensures that the structure and functions of the ecosystems are safeguarded and that benthic ecosystems are not adversely affected" by human activities. Due to the lack of sensitive indicators and standardized methodologies to evaluate the status of deep-sea benthic ecosystems, the ADSR developed a new methodology that characterizes the health status of CWCs from underwater video images of the seafloor. This methodology provides objective measures to perform environmental assessments that allow for evaluations of D6 (Seafloor integrity) in the deep-sea habitats to respond to the demands of the MSFD.

13. **Systematic Conservation Planning**

Systematic approaches to locating and designing Marine Protected Areas, based on the best available data and specific management and conservation goals, can inform choices about areas to protect. In most parts of the world the deep sea faces severe limitations in data availability, often jeopardizing the application of such methodologies. The ADSR group has presented a data-driven framework to guide the application of systematic conservation planning in the deep-sea, using the Azores Exclusive Economic Zone (EEZ) as a case study. The framework encompassed nine steps: 1) identify a set of management and conservation goals and objectives, 2) define the spatial planning area to be considered; 3) compile the best available data and identify the main knowledge gaps, 4) implement an important areas approach which included VMEs, 5) complement with a Prioritization approach and 6) with a representativity and connectivity approach, 7) conduct a performance assessment of the planning scenarios, 8) forecast the ecosystem level outcomes, and 9) repeat the process until multiple options are evaluated and agreed. The systematic conservation planning framework can support scientists, managers, and stakeholders to develop a transparent and data driven strategy in support of area-based management and to advance the conservation and sustainable use of the deep sea.

14. **Ecosystem forecasts**

The overall benefits of marine protected areas encompass enhanced biodiversity, species abundance, fish size and fecundity that are expected to be exported to adjacent waters via ecological spillover effects. Besides the widely recognized positive effects of fisheries closures, it has been argued that such the implementation alone may not be sufficient to achieve all the management goals and objectives. It is, therefore, of paramount importance to evaluate or project the economic and ecosystem effects of the implementation of area-based management tools such as MPAs. The ADSR group has used spatial ecosystem models (Ecospace, Ecopath with Ecosim) to forecast ecosystem and fisheries effects in response to multiple management scenarios, resulting from the implementation of the different systematic conservation planning scenarios. Changes on biomass, catch and food-web indicators, among others, can be used as metrics to evaluate different responses to management strategies and respective scenarios. The performance of multiple scenarios can be addressed under several management strategies that considered alternative levels of fisheries closures and fishing effort.

References

Carreiro-Silva, M., Martins, I., Riou, V., *et al.* 2022. Mechanical and toxicological effects of deep-sea mining sediment plumes on a habitat-forming cold-water octocoral. Frontiers in Marine Science, 9: 915650. doi: 10.3389/fmars.2022.915650

Carreiro-Silva, M., Cerqueira, T., Godinho, A., Caetano, M., Santos, R.S., and Bettencourt, R. 2014. Molecular mechanisms underlying the physiological response of the cold-water coral *Desmophyllum dianthus* to ocean acidification. Coral Reefs, 33: 465-476. Doi: 10.1007/s00338-014-1129-2

Das, D., González-Irusta, J.M., Morato, T., Fauconnet, L., Catarino, D., Afonso, P., Viegas, C., Rodrigues, L., Menezes, G.M., Rosa, A., Pinho, M.R.R., Silva, H.M.D., and Giacomello, E. 2022. Distribution models of deep-sea elasmobranchs in the Azores, Mid-Atlantic Ridge, to inform spatial planning. Deep-Sea Res. Pt I, 182: 103707. doi:10.1016/j.dsr.2022.103707

Duncan, E.M., Vieira, N., González-Irusta, J.M., Dominguez-Carrió, C., Morato, T., Carreiro-Silva, M., Jakobsen, J., Jakobsen, K., Porteiro, F.M., Schläpfer, N., Herrera, L., Ramos, M., Rodríguez, Y., Pereira, J.M., Fauconnet, L., Rodrigues, L., Parra, H., and Pham, C.K. 2023.

Predicting the distribution and abundance of abandoned, lost or discarded fishing gear (ALDFG) in the deep sea of the Azores (North Atlantic). Science of the Total Environment, 900: 166579.

Morato, T., Pham, C.K., Pinto, C., Golding, N., Ardron, J.A., Durán Muñoz, P., and Neat, F. 2018. A Multi Criteria Assessment Method for Identifying Vulnerable Marine Ecosystems in the North-East Atlantic. Frontiers in Marine Science, 5: 110. doi:10.3389/fmars.2018.00460

Morato, T., Juliano, M., Pham, C.K., Carreiro-Silva, M., Martins, I. and Colaço A. 2022. Modelling the dispersion of Seafloor Massive Sulphide mining plumes in the Mid Atlantic Ridge around the Azores. Frontiers in Marine Science, 9: 910940. doi: 10.3389/fmars.2022.910940

Morato, T., González-Irusta, J.-M., Dominguez-Carrió, C. *et al*. 2020c. Climate-induced changes in the suitable habitat of cold-water corals and commercially important deep-sea fishes in the North Atlantic. Global Change Biology, 26: 2181–2202. http://dx.doi.org/10.1111/gcb.14996

Parra, H.E., Pham, C.K., Menezes, G.M., Rosa, A., Tempera, F., and Morato, T. 2017. Predictive modeling of deep-sea fish distribution in the Azores. Deep-Sea Research Part II, 145: 49–60. doi:10.1016/j.dsr2.2016.01.004

Pham, C. K., Diogo, H., Menezes, G., Porteiro, F., Braga-Henriques, A., Vandeperre, F., and Morato, T. 2014. Deep-water longline fishing has reduced impact on Vulnerable Marine Ecosystems. Scientific Reports, 4: 4837. https://doi.org/10.1038/srep04837

Taranto, G.H., González-Irusta, J.M., Dominguez-Carrió, C., Pham, C.K., Tempera, F., Ramos, M., Gonçalves, G., Carreiro-Silva, M., and Morato, T. 2023. Spatial distributions, environmental drivers and co-existence patterns of key cold-water corals in the deep sea of the Azores (NE Atlantic). Deep-Sea Research Part I, 197: 104028. doi:10.1016/j.dsr.2023.104028

Annex 5: Methodology for the production of habitat distribution models in the Canary Islands

Sampling process and datasets

Within the LIFE INDEMARES (2009-2014), LIFE INTEMARES (2018-2022), and EEMM (2019-2024) projects, several surveys were conducted in different geomorphical regions (seamounts, banks and slopes) aboard the R/V *Ángeles Alvariño*. Different types of sampling methods were used: direct sampling (rock dredges, beam trawls) and video transects with the TASIFE towed camera. This vehicle, which can operate up to a depth of 2000 m, is a perpendicular-mounted High-Definition camera (Nikon D800 AF Nikkor 20mm/f2.8D) equipped with two light sources (LED DSPL Sphere SLS-5000), and two parallel green SeaLaser 100s (532 nm), with a distance of 10 cm between them for scaling and measuring images. On board the TASIFE, an acoustic underwater positioning and navigation system (HiPAP 500) provided the location, velocity and heading of the vehicle. The Zenithal perspective was used to obtain calibrated high resolution and fine quality images of the seafloor.

Samples obtained with rock dredges were excluded from the modelling analysis. This direct sampling is useful for reliable taxonomic identification of certain specimens, however, the dredge captures many cryptic species and few large or structuring species and, therefore, incorporating this data can generate errors to identify and characterize the main communities. Sampling with beam trawls is conducted to characterize biodiversity of soft bottoms.

We consider each video transect or beam trawl as samples that cover an average distance of 200 m. We check that each transect is consistent, representing a similar substrate and range of depth, and any inconsistent sections of the transects were eliminated. Since there was a considerable difference in data abundance between different surveys, due to a progressive improvement in data collection, the analysis of the biological component and subsequently modelling was based on the presence-absence of species.

Only samples from hard substrates with sessile species larger than 2 cm were used, following the steps taken in other regions, e.g., De la Torriente *et al*. (2018).

Identification of benthic communities

Previous to the modelling process, a multivariate analysis of the species records in the database was carried out to obtain a robust analysis of the identification of the different communities and habitats. Data collected in the different areas of the Canary Region were carried out with the same methodology, so it is possible to analyze it together, making it possible to assess if there are common clusters of species between the different study areas.

The Jaccard Similarity Index was applied on the presence-absences matrix of species in the first step of the analyses, for the identification of the main communities or biological aggregations. Subsequently, a CLUSTER analysis was performed together with a SIMPROF (permutation test under the null hypothesis that localities can be grouped according to their species or taxa composition; Clarke & Gorley 2015). As a prerequisite, a significance level of $p < 0.05$ was estimated to define the biological groups. To determine the most representative species of each cluster, the SIMPER (Similarity Percentage) analysis was used, which calculates the percentage of contribution of each species to intra-group similarity and inter-group dissimilarity (Clarke & Gorley 2015). For checking whether these new groups maintained significant dissimilarity between them, a one-way ANOSIM analysis with 999 permutations (Clarke 1993) was also calculated. The statistical package PRIMER v.6 & PERMANOVA + ß4 was used for these analyses (Clarke & Gorley 2015; Primer-E Ltd. 2006).

Environmental variables

Bathymetric data was gathered during the surveys using a Simrad EM710 multibeam echo sounder (70–100 kHz; Kongsberg Maritime, Kongsberg, Norway) onboard and processed using CARIS HIPS and SIPS software to produce bathymetric and backscatter grid models with the most resolution possible (between 3-20 m) depending on the area.

The environmental variables used for modelling were depth, slope, northness and eastness (indices derived from the aspect), reflectivity, roughness, terrain ruggedness index (TRI), broad-scale benthic position index (BPI; with a search radius of 100 and 300 cells) and fine-scale BPI (with a search radius of 1 and 15 cells; Martínez-Carreño *et al*. 2020). The roughness and TRI were calculated "terrain" function of the "raster" library of R (Hijmans 2021), according to the description given by Wilson *et al*. 2007): roughness is the difference between the maximum and minimum values of the 8 surrounding cells while TRI is the absolute mean of the differences between the values of the cell and the 8 surrounding cells. All these variables considered for the model were in asci raster format and had an initial resolution of 15 m, but since the sampling units represent transects of 100-200 m in length, the variables were re-sampled at 200 m, which in turn facilitated the time of modelling calculation.

Before the modelling, correlation between geomorphologic variables were checked with Spearman Correlation and the Variance Inflation Factor (VIF) to eliminate highly correlated predictors and to avoid collinearity.

Distribution modelling of the main benthic communities

The algorithm Random Forest (RF; Breiman 2001) was used to calculate the distribution models of the main benthic communities from the presences and true-absences of each community identify in the multivariant analysis and the variables descripted before.

The resulting models were evaluated with the area under the ROC curve (AUC) (Fielding & Bell 1997) with bootstrapping (Efron & Tibshirani 1993) by resampling 100 times. This evaluation procedure is used to maintain as many points as possible for the construction of the models and to avoid separating the models between training and evaluation data. The mean True Skill Statistic (TSS) was used as a threshold to convert the model to binary raster (Allouche *et al*. 2006) of zones. To facilitate the interpretation and manipulation of the distribution models, all of them were exported to vector format and unified in a single polygonal layer.

The methodology applied in this section and also about the identification of benthic communities may be changed with the improvement of the quality of the initial database, about their location, type of data (including abundance) and identification of the species.

References

Allouche, O., Tsoar, A., and Kadmon, R. 2006. Assessing the accuracy of species distribution models: prevalence, kappa and the true skill statistic (TSS). Journal of Applied Ecology, 43: 1223–1232. https://doi.org/10.1111/j.1365-2664.2006.01214.x

Breiman, L. 2001. Random forests. Machine Learning, 45: 5–32. https://doi.org/10.1023/A:1010933404324

Clarke, K.R. 1993. Non-parametric multivariate analyses of changes in community structure. Australian Journal of Ecology, 18: 117–143. https://doi.org/10.1111/J.1442-9993.1993.TB00438.X

Clarke, K.R., and Gorley, R.N. 2015. PRIMER v7: User Manual/Tutorial Plymouth Routines In Multivariate Ecological Research.

De la Torriente, A., Serrano, A., Fernández-Salas, L.M., García, M., and Aguilar, R. 2018. Identifying epibenthic habitats on the Seco de los Olivos Seamount: Species assemblages and environmental characteristics. Deep Sea Research Part 1. Oceanographic Research Papers, 135: 9–22. https://doi.org/10.1016/j.dsr.2018.03.015

Efron, B., and Tibshirani, R.J. 1993. An Introduction to the Bootstrap. London.

Fielding, A.H., and Bell, J.F. 1997. A review of methods for the assessment of prediction errors in conservation presence / absence models. Environmenal Conservation, 24: 38–49. https://doi.org/10.1017/S0376892997000088

Hijmans, R.J. 2021. raster: Geographic Data Analysis and Modeling. R package version 3.4-10.

Martínez-Carreño, N., Vázquez, J.T., López-Rodríguez, C., Arrese, B., Sánchez-Guillamón, O., López-González, N., Gómez-Ballesteros, M., and Martín-Sosa, P. 2020. Life IP INTEMARES. Informe de distribución espacial de características geomorfológicas y sedimentarias del LIC Banco de la Concepción. Subacción A2.1: Mejora del conocimiento en zonas ya declaradas.

Wilson, M.F.J., Connell, B.O., Guinan, J.C., and Grehan, A.J. 2007. Multiscale Terrain Analysis of Multibeam Bathymetry Data for Habitat Mapping on the Continental Slope. Earth, 3–35. https://doi.org/10.1080/01490410701295962

Annex 6: Marxan tool for conservation planning

Te he use of spatial data, Geographic Information Systems (GIS) and specific applications such as Marxan, supply new opportunities for zoning and management of marine environment. This specific tool provides an objective and systematic methodology which facilitates the analysis of large datasets and allows integration of information to achieve a set of conservation goals whilst attempting to minimize the total cost and impact on socio-economic activities (McDonnell *et al*. 2002). Conservation goals articulate priorities for the protection and restoration of the marine ecosystem, whereas socio-economic goals seek to protect and enhance the social and economic interests of the region and the people living in it (Ardron *et al*. 2010). In the process of selecting areas for marine protection, it is necessary to establish some general principles. In broad terms, there are four categories of aims in systematic conservation planning: representativity, efficiency, design and adequacy (Airamé *et al*. 2003, Foley *et al*. 2010). These general principles refer to the biological and ecological justifications for putting protection in place, but also consider social and economic activities that take place in the case of study, since both aspects are important in the planning stages. Table A6.1 contains a list of some examples of criteria considered with respect to the four general principles.

For the application of Marxan function, first, it is necessary to divide the study area into grids or planning units where all information available about biodiversity, ecology and human activities is transferred. In general, planning unit size and shape is informed by the scale of planning decisions (i.e., global, regional, national, or local), the resolution of datasets being used and also the objective of the planning exercise (Ardron *et al*. 2010).

Subsequently, the conservation features must be defined: those biological, geological or ecological characteristics that pretended to be conserved in the different scenarios. Finally, the human activities that take place in the study area are included as socioeconomic cost, with the objective that the zoning outputs or proposals prioritize the conservation of areas with lower conflict with the socio-economic criteria, if the conservation objectives are achieved. Other step is the definition of the conservation targets (percentage of the conservation features that must be represented in the final solutions) and the calibration of the parameters BLM (Boundary Length Modifier parameter) and species penalty factor (SPF). This calibration is necessary to ensure robust analysis and that the set of solutions Marxan produces are close to the "lowest cost" or optimum (Ardron *et al*. 2010). BLM is the ratio of the solution or scenario to its perimeter and determines the degree of clumping of the planning units: a higher the value, a more compact planning units selection. This is important in management of MPAs to ensure the connectivity and management between protected areas. SPF is a user-defined penalty cost incurred for every feature that fails to meet its target. For each alternative solution, Marxan calculates whether the target for each conservation feature is met or not. If a target is unmet, then the penalty cost is applied. Making the SPF user-defined allows different weightings to be given to different feature targets (Watts *et al*. 2017).

Marxan was applied in a study in the Canary Islands to present different alternative for protection of the marine environment of La Palma, in the northwest of the archipelago, and fill the conservation gaps detected in this island for the protection of benthic habitats (Martín-García *et al*. 2015). IEO has also applied this tool in the Amanay and Banquete banks (Martín-García *et al*. 2023), in the southeast of Fuerteventura, to provide a zonation proposal for the management of this area consider as a Site of Conservation Interest by the Habitat Directive.

Table A6.1. Examples of general principles and specific criteria that are consider in Marxan analysis for designing conservation areas (adapted from Martín-García *et al*. 2015).

General Principles	Specific Criteria	Description	Possible Variables
Representativity	Representative species, habitats and ecosystems	Protection of representative, endangered, protected or unique species, communities and habitats of the region.	Presence, biomass or abundance of habitats, communities and species.
	Conservation of areas with high ecological value	Conservation of sites with healthy ecosystem functioning.	Conservation status index.
Design	Compactness	Degree of spatial clustering of planning units in a reserve solution. This is calculated as total boundary length relative to total area of a reserve network.	Separation distance, boundary cost.
	Connectivity	The continuity of the area. It can be structural (determined by the landscape or environment), or functional, (determined by the dispersal ability of the species).	Boundary length and shape, cost
	Replication or redundancy	Multiple features protected in separate sites to lessen the risk of losing these features due to a site specific event, and to ensure the natural variation of the feature.	Separation distance
Adequacy	Adequacy and viability	Reserve network large enough to allow sufficient biodiversity, structure and function, but an appropriate a size for efficient and viable management and protection.	Size, shape, separation distance, boundary length
	Complementarity	The selection of various conservation areas with different characteristics, which together meet the overall objectives.	Location
	Irreplaceability	The number of times, out of the total number of feasible solutions, that the same specific planning unit is selected for protection because it meets the conservation targets.	

In this last case of Fuerteventura a grid size of 0.25 km^2 was used, according to a compromise between the resolution of the biological and environmental data and the socio-economic activities. We also considered as conservation features the habitats of the Habitat Directive presented in the area, the habitat suitability for the main benthic communities as well as the presences (as data points) of species not modelled due to the lack of sufficient records but are important because of their uniqueness, fragility or structural complexity values.

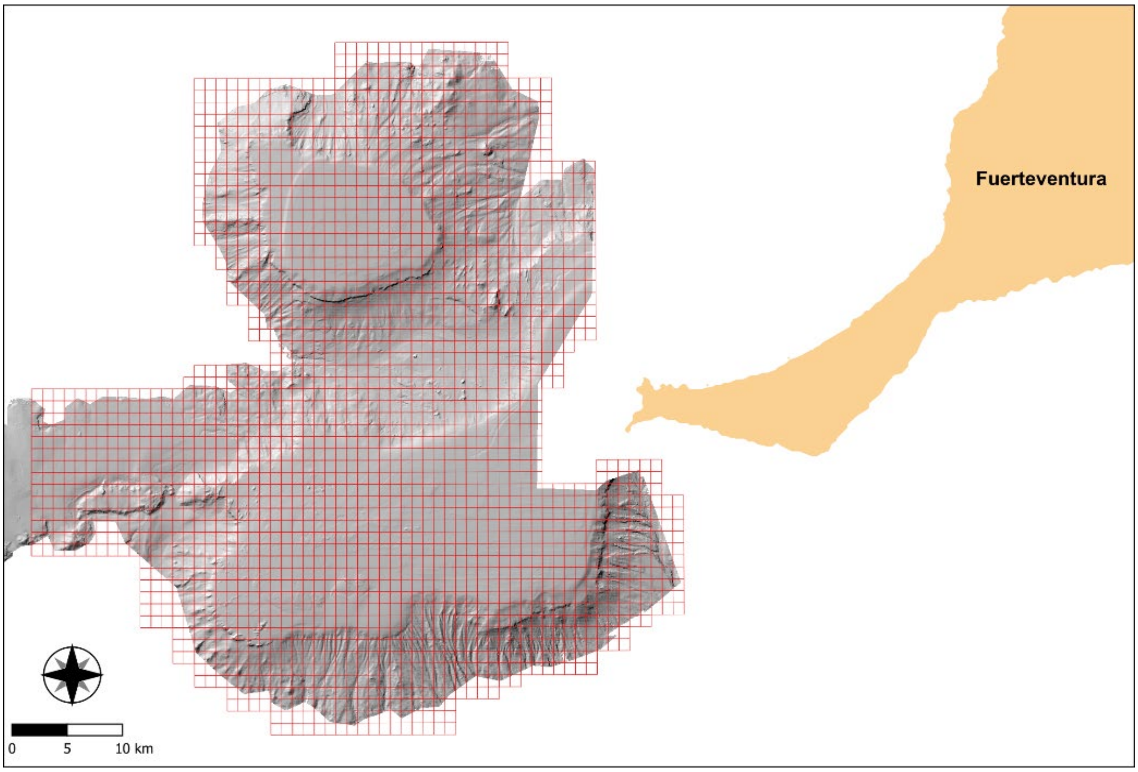

Figure A6.1. Amanay and Banquete Banks and the planning units, the regular spatial cells in which the study area is divided with a resolution of 500 m.

In these banks, the most important human activity is fishing by far. This cost was represented by the distribution of the fishing intensity, data collected in the framework of INDEMARES project (IEO 2013) and also the data on the profit obtained from the sale of the catches were obtained from the application of the fishing Essentiality Index (Dorta & Martín-Sosa 2022; Section 2.3 of this report). On the other hand, we established three levels of targets: 50, 70 and 90% for all the conservation features (communities and species). For each level of conservation, the scenario was calculated with the cost of the artisanal fishing intensity and after the pre-calibration process, the BLM was setting and we keep the same value of SPF for all the conservation features.

As a result, we obtained different scenarios for the three levels of conservation targets. The number of cells to be protected increases with the level of the conservation targets but there are son regions that always are selected: Amanay Bank and the shelf of Banquete (Figure A6.1). Different solutions are consistent in the protection of the conservation values but also distribute the selection according to regions with lower levels of conflict (Figure A6.2). These scenarios help us to design a final proposal for the regional government with the aim to balance the conservation of vulnerable communities and the human activities where management measures are needed.

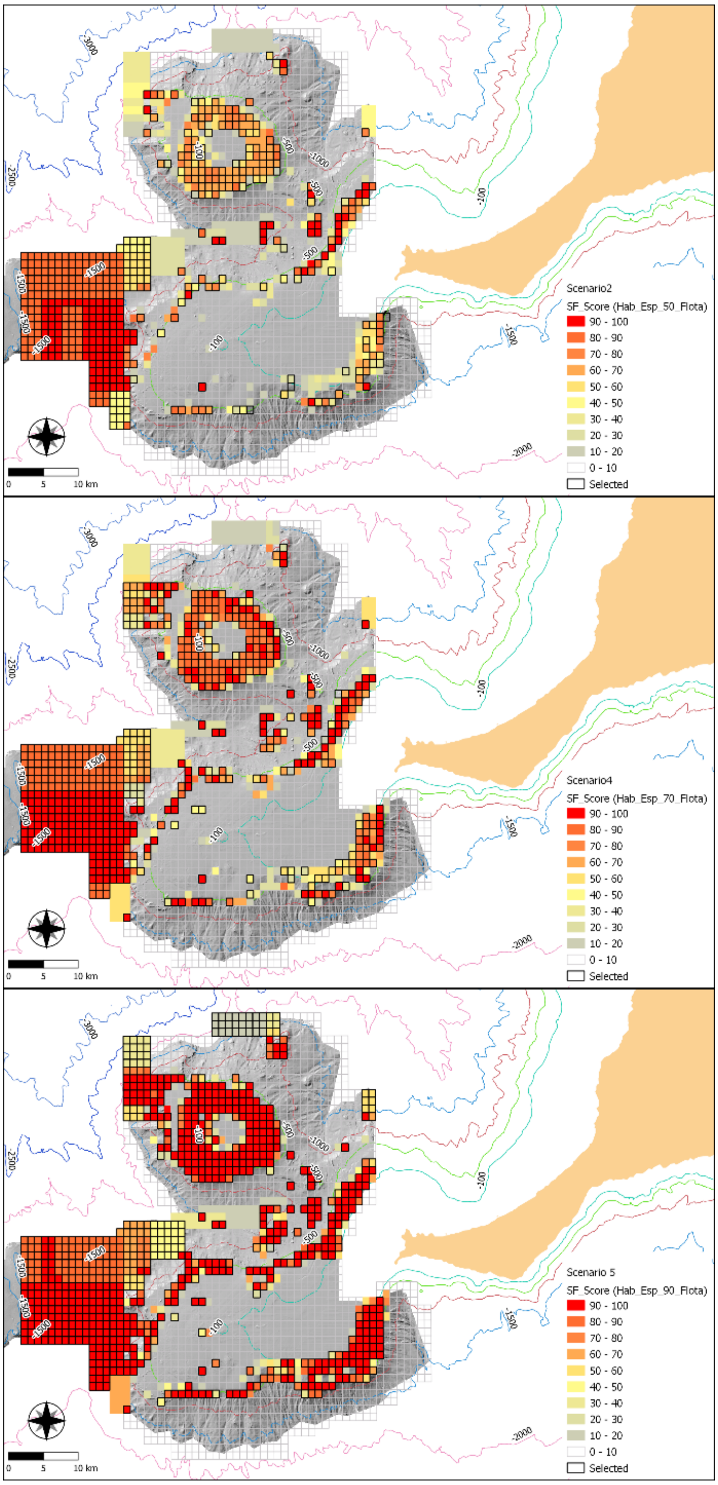

Figure A6.2. Outputs or scenarios with the selection frequency of planning units, according to the conservation goals, cost and established calibration values.

References

Airamé, S., Dugan, J.E., Lafferty, K.D., Leslie, H., Mcardle, D.A., and Warner, R.R. 2003. Applying ecological criteria to marine reserve design: A case study from the California Channel Islands. S170 Ecological Applications, 13: 170–184.

Ardron, J.A., Possingham, H.P., and Klein, C.J. 2010. Marxan Good Practices Handbook.

Dorta, C., and Martín-Sosa, P. 2022. Fishery essentiality: A short-term decision-making method based on economic viability as a tool to understand and manage data-limited small-scale fisheries. Fisheries Research, 246: 106171. https://doi.org/10.1016/J.FISHRES.2021.106171

Foley, M.M., Halpern, B.S., Micheli, F., et al. 2010. Guiding ecological principles for marine spatial planning. Marine Policy, 34: 955–966. https://doi.org/10.1016/j.marpol.2010.02.001

IEO. 2013. Caracterización del Sur de Fuerteventura. Informe del Instituto Español de Oceanografía-Centro Oceanográfico de Canarias. Proyecto LIFE+ INDEMARES (LIFE07/NAT/E/000732). Madrid.

Martín-García, L., Martín-Sosa, P., González-Méndez, E., González-Porto, M., Falcón, J.M., and Dionis., N. 2023. Informe de resultados para la zonificación AMANAY Y EL BANQUETE Montes submarinos incluidos en el LIC-ESZZ15002 “Espacio marino del oriente y sur de Lanzarote-Fuerteventura” (Demarcación marina canaria).

Martín-García, L., Sangil, C., Brito, A., and Barquín-Diez, J. 2015. Identification of conservation gaps and redesign of island marine protected areas. Biodiversity and Conservation, 24: 511–529. https://doi.org/10.1007/s10531-014-0833-0

McDonnell, M.D., Possingham, H.P., Ball, I.R., and Cousins, E.A. 2002. Mathematical methods for spatially cohesive reserve design. Environmental Modeling & Assessment, 7: 107–114. https://doi.org/10.1023/A:1015649716111

Watts, M.E., Stewart, R.R., Martin, T.G., Klein, C.J., Carwardine, J., and Possingham, H.P. 2017. Systematic Conservation Planning with Marxan. Learning Landscape Ecology, 211–227. https://doi.org/10.1007/978-1-4939-6374-4_13