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Regular paper

Current and emerging small-scale fisheries and target species in Cabo Verde, with recommendations for pilot actions favouring sustainable development

by

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Abstract. – Fishing activity is a primary sector of great socioeconomic importance for the archipelago of Cabo Verde (eastern-central Atlantic), and has played a relevant role in strengthening food security, reducing poverty, job creation, balance of payments equilibrium and Gross Domestic Product. So, this review was needed to make small-scale fisheries visible in a Developing Island Country with a fast-growing tourist industry. The aims of this study were to make an updated description of small-scale fisheries and their target species, then to point out new or emerging fisheries and propose some pilot actions and challenges to sustainable fisheries development, as a research-based baseline for future regional plans. The difficulties faced today by this sector are: a high degree of unpredictability, seasonality, perishability of the fishery product, risks associated with the activity, and low educational level of most operators. Fishing vessels vary enormously in size and on-board equipment. Biodiversity of resources targeted by these multispecific fisheries involves some 180 species. Due to the large size of Cabo Verde EEZ, its fishing resources are diverse and some reach exploitable biomasses. Tuna fishing in principle is the resource with the greatest potential. Emphasis should be placed on the development of added-value products and the establishment of a quality control system. Possible fisheries development should be planned as a small-scale or artisanal scheme and further cooperation projects will be useful for the country.

Résumé. – Pêche artisanale contemporaine et émergente ; espèces cibles aux îles du Cap-Vert, avec recommandations d'actions pilotes pour le développement durable.

L'activité de pêche est un secteur primaire d'une grande importance socio-économique pour l'archipel du Cap-Vert (Atlantique centre-est) et a joué un rôle majeur dans le renforcement de la sécurité alimentaire, la réduction de la pauvreté, la création d'emplois, l'équilibre de la balance des paiements et l'augmentation de la valeur de la production nationale. Ainsi, ce travail de révision est nécessaire pour rendre visible la pêche artisanale dans ce Pays Insulaire en Développement où l'industrie du tourisme se développe rapidement. Les objectifs de cette étude sont de réaliser une description actualisée des pêcheries artisanales et de leurs espèces cibles ; de signaler certaines pêcheries nouvelles ou émergentes ; d'identifier des actions pilotes et des défis sur le développement durable des pêches, comme base de recherche pour les futurs plans régionaux. Les difficultés rencontrées aujourd'hui par ce secteur sont le degré élevé d'imprévisibilité, la saisonnalité, la périssabilité du produit de la pêche, les risques liés à l'activité et le faible niveau de formation de la plupart des opérateurs. Les bateaux de pêche varient énormément en taille et en équipement de bord. La biodiversité visée par les pêcheries artisanales multispécifiques concerne quelque 180 espèces. Du fait de l'extension importante de la ZEE du Cap-Vert, ses ressources halieutiques sont diverses et certaines d'entre elles possèdent des biomasses exploitables. La pêche au thon est en principe la seule ressource qui a un grand potentiel. L'accent doit être mis sur le développement de produits à valeur ajoutée et la mise en place d'une système de contrôle de la qualité. Le développement éventuel des pêcheries devrait être planifié dans le cadre d'un projet artisanal ou à petite échelle et des projets de coopération seraient utiles au pays.

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INTRODUCTION

Fishing is a primary sector activity of great economic and social importance for the archipelago of Cabo Verde (eastern-central Atlantic) and has a prominent place in the country's strategic economic development plan. This sector has played an important role in strengthening food security, reducing poverty, job creation, balance of payments equilibrium and increase in gross domestic product (GDP) (FAO, 2005, 2015; BO, 2009). Fresh fish is the main animal protein consumed by Cabo Verdeans. In 1998, the country per-capita fish consumption was 19 kg/y. In the following years, this consumption increased to 23 kg/y in 2003 and 26.5 kg/y in 2004 (González *et al*., 2009), a figure that seems to have remained unchanged over the last decade (FAO, 2016).

Fish, crustaceans and molluscs are among the products most exported by Cabo Verde. In 2015, fishery products accounted for 84.5% of the country exports: 44.5% as fresh products and 40% as processed and canned products (INE, 2015). In 2016, the expanding trend of the sector regarding exports continued, despite a slight reduction in value (INE, 2016).

It is estimated that the fishery sector will soon account for 2-3% of GDP, if we take into account the contribution of fishing to other sectors, such as fish processing and commercialization. According to the available information (INE, 2015), the contribution of fish catches to GDP is 1.2%. It should be noted that this is the contribution as far as the primary sector is concerned, that is, the activity until first sale at the port of landing. Therefore, the fishery product has practically no added value. This figure has remained almost unaltered since 2009, when González *et al*. (2009) reported that the primary activity of fishing did not exceed 1.5% of GDP.

The impact on employment and job creation is very clear. In 2016, for example, there were an estimated 7,000 jobs in artisanal, semi-industrial and industrial fishing (DNEM, 2017). Fish processing and canning industries have generated 1,350 jobs (FAO, 2016) and in fish commercialization, the estimated number of jobs was 987 (INDP, 2012). Other indirect jobs are also generated, namely those related to stowage, storage, fish meal production for animal feed, and shipbuilding and repairs. It is estimated that the whole sector employs 5% of the active population (FAO, 2016). This figure has remained at similar levels over the last decade; in 2008 the sector employed near 2.1% of Cabo Verde's total population and 5.2% of the active population (González *et al*., 2009). For women contribution to workforce, see information in section Results and table I.

Artisanal fisheries in Cabo Verde constitute around 64% of the country fishing activity, both in terms of catches and fishermen involved (Government of Cape Verde, 2004). In the last decade, (semi-)industrial fishing has come to dominate landings with an average contribution of the order of 57% and artisanal fishing has reduced its contribution to 43%. This fact is the result of the development of the semi-industrial fleet, but also due to the market factor, since there has been a greater demand for fish since local canners have significantly increased the production capacity for small pelagic fish and tunas. These small-scale fisheries provide important income to a considerable number of families from fishing communities such as São Vicente-Santo Antão (26.6% of the national population) and Santiago (54%). The main resources exploited by artisanal fishing are the large pelagic fish (41% in weight), small pelagic (40%) and demersal fish (13%) and lobsters (0.5%). In 1999 the arti-

Table I. – Number of boats and fisherpersons by islands and for the country, referred to artisanal, (semi-)industrial and the whole fishing sector (including the extractive, fish commercialization, and fish processing and canning industries) estimated for 2016. Sources: INDP (2012), FAO (2016) and DNEM (2017).

Islands	Artisanal fishing		(Semi-)industrial fishing		Fishing sector	
	No. of boats	No. of fishermen	No. of boats	No. of fishermen	No. of boats	No. of fisherpersons
Santo Antão	156	640	6	72	162	712
São Vicente	113	514	45	502	158	1016
São Nicolau	94	267	5	58	99	325
Sal	151	482	7	63	158	545
Boa Vista	140	318	6	25	146	343
Maio	103	229	0	0	103	229
Santiago	571	1863	45	456	616	2319
Fogo	157	514	4	35	161	549
Brava	103	251	1	9	104	260
Extractive activity	1588	5078	119	1220	1707	6298
Fish commercialization (vendors: municipal fish markets and itinerant sale of fresh fish)						987
Fish processing and canning industries						1350
Cabo Verde (2016)						8635

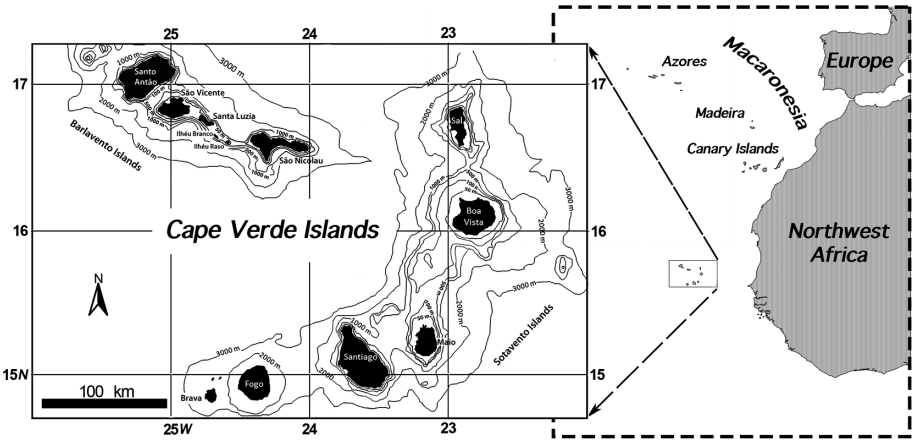

Figure 1. – The Cabo Verde Islands and their geographical location (map adapted from BlueChart Atlantic v9.5, garmin-bluechart-atlantic.software.informer.com).

sanal fleets employed 4,283 fishery workers, 3,899 of them full-time.

Within the UN perspective for Developing Island Countries, this paper aims at an updated description of the recent and current artisanal fisheries and their target species in the waters of Cabo Verde. A second objective is to point out some new or emerging fisheries, as a result of recent research in the region. Finally, we propose some pilot actions and identify challenges to sustainable fisheries development, as a research-based baseline for future regional plans.

MATERIAL AND METHODS

Study area

This work covers all marine small-scale fisheries and their target fish and shellfish species in the Cabo Verde archipelago from intertidal to deep waters. The study area is bounded by the 14°50'N and 17°20'N parallels, and the 22°40'W and 25°30'W meridians (Fig. 1).

This archipelago is situated in the eastern-central Atlantic, with an EZZ of about 734,265 km^2 – the second largest in Africa after South Africa – and 965 km of coastline, the islands lying within the 4,000 m marine contour. The islands are well-separated from the coasts of West Africa by great depths (> 3,000 m), being located 570 km from Senegal. Most of the islands arise from great depths, but the windward island chain, and Boa Vista and Maio are linked by relative shallows (< 200 m) (Bravo de Laguna, 1985; González, 2018; Freitas *et al*., 2019). Their volcanic nature is evident in the absence of wide insular shelves, with the 300-m isobath close to the coast, except around Boa Vista and Maio. Geologically, these islands show an increasing age from west (< 3 my) to east (8-15.8 my) (Ramalho, 2011). Oceanographically, their waters are under the influence of the North Equatorial Counter-Current and the Canary Current, with sea-surface temperature normally higher than 20°C throughout the year (Lázaro *et al*., 2005; González *et al*., 2009). Biogeographically, Cabo Verde form its own ecoregion within the West African Transition province of the Tropical Atlantic realm (Spalding *et al*., 2007) or rather, Cabo Verde should be given the status of a biogeographical sub-province within the West African Transition province (Freitas *et al*., 2019).

Information sources

The present inventory of the small-scale fishing gear used in the Cabo Verde archipelago follows the FAO and related classification and nomenclature for small-scale fisheries, based on the way of capture of the targeted fisheries resources (FAO, 1972; Nédélec, 1975; Nédélec and Prado, 1987), adapted to the peculiarities of this region.

Taxa nomenclature follows FishBase (Froese and Pauly, 2019), Eschmeyer's Catalog of Fishes (Fricke *et al*., 2020), and World Register of Marine Species (WoRMS Editorial Board, 2020).

Data on official fisheries landings, vessels, and fishermen were provided by the former National Fisheries Development Institute (INDP) (since late 2019 renamed as Instituto do Mar, IMar) of the Cabo Verde Government (http://www.indp.cv/).

Data on fish and shellfish from Cabo Verde with commercial interest (proven or potential) were taken or inferred from: a) related bibliography on faunistic and biogeographic studies, such as González *et al*. (2004, 2009, 2010, 2014, 2017), Reiner (2005), Monteiro (2008), Fernández-Gil *et al*. (2013), Wirtz *et al*. (2013), González (2018) and Freitas *et al*. (2019); and b) the authors' experience over 18 years (2003-2020) through nine cooperation/research projects in Cabo Verde (González *et al*., 2004, 2006, 2009, 2012; Pajuelo *et al*., 2010, 2012), which have included periodic fishing campaigns, visits to fishing communities and ports, fish markets, and processing and canning industries throughout the country.

Socioeconomic information was taken from national (BO, 2009, 2018; INDP, 2012; INE, 2015, 2016; Correia, 2017; DNEM, 2017) and supranational (FAO, 2016) official

sources, as well as from related appropriate literature (*e.g.* Menezes *et al.*, 2004; González *et al.*, 2009; Fernandes *et al.*, 2010; González-Lorenzo *et al.*, 2010a, b).

RESULTS

Fishing vessels and fishermen

The number of boats and fisherfolk by islands and for the country, referring to artisanal, (semi-)industrial (= "semi-industrial" and "industrial") and to the whole fishing sector (including the extractive, fish commercialization – mainly both market and itinerant women vendors –, and fish processing and canning industries – also mainly female labour –) (INDP, 2012; FAO, 2016; DNEM, 2017) are estimated for 2016 and presented in table I. More than 8,600 people were employed in the sector in 2016.

The zone within 3 nautical miles (n.m.) is reserved exclusively for national small-scale fishing, consisting of small wooden open-beam vessels (some covered with fibreglass), with reduced autonomy at sea (Fig. 2). They are generally 3.5 to 8 m long and 1.5 to 2.5 m beam, motorized (outboard engine) or not, engine power varying between 5 and 25 hp. This fleet uses handlines for demersal and large pelagic fish, and harvesting methods (by hand, snorkel, scuba-diving, gaffs, and handlines) for the capture of demersal fish, coastal lobsters and molluscs (whelks, clams, goose barnacles, octopus and cuttlefish). In 2017, according to data from the National Directorate of Maritime Economy (DNEM), there were 5,078 fishermen working in 1,588 boats, an average of three per boat, with earnings based on the sharing system (on average 20 to 40 € per week per fisherman) (DNEM, 2017). The income from artisanal fishing is normally divided into one part for the owner of the vessel, one part for the owner of the engine, one for fuel (whatever is spent on fishing) and the last part being divided among fishermen. So just a quarter is left for the fishermen, meaning that incomes are low. This prevents them to accumulate savings, mainly because they have large families (5 to 7 elements), lack of any saving tradition and very little schooling.

In 2005, there were 3,108 fishermen working in 1,036 boats, 74% of which were motorized (González *et al.*, 2009). Therefore, in the last 12 years, the number of artisanal fishermen has increased by 63% and the number of vessels by 53%. The number of artisanal vessels was decreasing in the 90s. With the incentives for fishing, it was possible to increase the motorization rate, introduction of boats with greater autonomy, diversification of fishing devices, creation of private initiatives and organization of fishermen in associations, allocation of credit facilities for the financing of boats/engines, marketing, and construction of infrastructure to support fishing. All of these, combined with the aging of the (semi-)industrial fleet as well as the scarcity of rain (which affects the rural environment) may be more than plausible reasons for the increase in artisanal fishing effort (in terms of fishermen and boats).

The 12 n.m. zone is reserved exclusively for the national (semi-)industrial fleet (Fig. 3). This fleet targets mainly small pelagic fish, tunas, sharks, and crustaceans, using purse seines, gill nets and/or beach seine nets. The "semi-

Figure 2. – Fishermen at Bay of Mindelo, S. Vicente, with partial view of a beach seine (Credits: I. Gaztañaga, 2018).

industrial" and "industrial" fishing vessels – this is how they are officially categorized in Cabo Verde – are heterogeneous, ranging in length from 8 to 25 m, internal engine power between 25 and 500 hp and tonnage between 2.5 and 121 GRT, with an average crew per vessel of 10. According to DNEM (2017) data, in 2017 there were a total of 119 semi-industrial and industrial fishing vessels, with only one national industrial fishing vessel operating inside and outside the EEZ. This fleet employs 1,201 fishermen. In 2005, there were 840 fishermen operating on 70 vessels (González *et al*., 2009). Therefore, in the last 12 years, the number of fishermen increased by 43% and the number of vessels by 71%. The same explanation given above applies for this remarkable increase.

Beyond 12 n.m. is where foreign fishing boats operate. This industrial fleet targets bigeye tuna, albacore, swordfish and pelagic sharks, with surface longlines and purse seines for large pelagic fish. Foreign vessels may only operate in Cabo Verde EEZ under fishery agreements. Of particular note is the 2007 agreement with the EU, with its subsequent protocols and annexes establishing access conditions for European Union vessels to Cabo Verde fishing resources, for four-year periods (see Carneiro, 2012; Mundt, 2012). Between 2014 and 2018, 71 EU fishing vessels (28 tuna seiners, 13 tuna-bait boats and 30 surface longliners) were authorized to fish within the Cabo Verde EEZ. Examples of EU-Cabo Verde protocols setting out the fishing opportunities, provisions related to fishing zones and the financial contribution can be seen in Carneiro (2012) and European Union (2014). In addition, 6 Senegalese and 9 Japanese fishing vessels operated in 2017.

A new protocol was signed by EU and Cabo Verde to implement the Sustainable Fishing Partnership Agreement (SFPA) on 20th May of 2019. This new protocol covers a 5-year period and provides fishing opportunities for a maximum of 69 Union vessels to fish in Cabo Verde waters, on the basis of the best available scientific advice and following the recommendations of the International Commission for the Conservation of Atlantic Tunas (ICCAT). It contains a yearly EU financial contribution of 750,000 €, including 350,000 € annually earmarked to promote the sustainable management of fisheries in Cabo Verde, notably through measures aiming at reinforcing control and surveillance capacities and supporting local fishing communities (https://ec.europa.eu/fisheries/press/sustainable-fisheries-eu-and-cape-verde-sign-new-protocol_en). Concerning the rules for EU vessels operating in Cabo Verde waters, the main criteria are: number of licenses per type of vessel (seiners and longliners), target species are tuna and allied species, reference tonnage is 8,000 t/y), landings only authorized on São Vicente (for operational and health control reasons in accordance with EU and ICCAT guidelines). We have already seen a positive development of EU boat landings on São Vicente, to supply raw material to Atunlo CV and the canning company Frescomar.

Recent or current fishing techniques and their target species

According to the Executive Plan for the Management of Fishery Resources of Cabo Verde for 2016–2018 (BO, 2018), and to the information gathered and analysed herein, a combination of three characteristics (type of fleet or fisher, fishing equipment used, and fishery resources targeted) allows a number of recent or current small-scale fisheries to be identified. All of them are small-scale fisheries in a widely accepted general context, despite the national classification considering some "semi-industrial" or even "industrial". In the Cabo Verdean fishing context, we have adopted the terminology of *small-scale* fisheries, which include the subsistence, artisanal and domestic (semi-)industrial categories.

Figure 3. – Industrial deep-water lobster vessel (Credits: J.A. González, 2014).

Fishing techniques in the Cabo Verde archipelago vary enormously, from shellfish harvesting (with no particular vessel requirements and involving simple gear) to purse seines (with some amount of on-board technology). From our perspective, these local small-scale fisheries can be classified into three categories (harvesting of coastal shellfish, artisanal fishing, and (semi-)industrial fishing) with several subcategories each, with their related target species, as follows:

Harvesting of coastal shellfish

This first set of fishing techniques are generally used in the framework of subsistence fisheries, with little or no legal regulation and no fishery statistics. In some cases, they involve non-professional people.

Whelk

The gastropod *Persististrombus latus* (Strombidae) is the only whelk species subject to intensive commercial exploitation by hand (apnea), small towed dredge ("rócega"), and mainly by scuba-diving (illegal) in Cabo Verde (Merino *et al*., 2001; González-Lorenzo *et al*., 2010a).

Within this category, this is the most important harvesting activity. In 2009 it involved 25 boats employing nearly 100 fishermen, yielding about 125 metric tons (t) of processed whelk with a first-sale value close to half a million Euros. Their shells are broken at the top of headlands, forming mountains of calcareous remains that are on occasions the object of a more intense crushing process for use as beach filling material and road reinforcement (González-Lorenzo *et al*., 2010a). Despite the fact that most of the catch derives from illegal harvesting, the activity is maintained due to its great potential in terms of employment, constituting an activity of true subsistence in various fishing communities scattered throughout the inhabited islands of the country. Currently, it is intended to implement a programme that includes professional training courses for divers and the use of certified diving cylinders.

Limpet

The gastropods *Patella lugubris* (Patellidae) and *Fissurella* spp. (Fissurellidae) are subject to commercial exploitation by hand (González-Lorenzo *et al*., 2010b).

Cape Verde goose barnacle

The endemic *Pollicipes caboverdensis* (Pollicipedidae) is the only goose barnacle species subject to commercial exploitation by hand in Cabo Verde (Fernandes *et al*., 2010).

Coastal spiny and locust lobsters

The main target species are hand caught: the royal or green spiny lobster *Panulirus regius*, the brown spiny lobster *Panulirus echinatus* (Palinuridae) and the Mediterranean slipper lobster *Scyllarides latus* (Scyllaridae).

Benthic cephalopods

The main target species are the common octopus *Octopus vulgaris* (Octopodidae) and the common cuttlefish *Sepia officinalis* (Sepiidae), caught with gaffs in either intertidal or subtidal zones. Additionally, flying squids (Ommastrephidae) are sporadically caught with handlines.

Clams

The Adanson's tagelus *Tagelus adansonii* (Solecurtidae) is the only native bivalve harvested by hand.

Artisanal fishing

This second set of fishing techniques are generally used in the framework of artisanal fisheries, with legal regulation. Currently, its first subcategory (beach seines) is practically in disuse, probably due to the specialization and higher degree of specific selectivity of the most modern fishing techniques within this group.

Beach seines (Fig. 2)

These traditional fishing techniques are used sporadically for the capture of many varied resources such as: round sardinella (*Sardinella aurita*) and Madeira sardinella (*S. maderensis*), within the clupeids; mackerel scad (*Decapterus macarellus*), round scad (*D. punctatus*), bigeye scad (*Selar crumenophthalmus*), bonito (*Caranx crysos*), black jack (*C. lugubris*), pompano (*Trachinotus ovatus*) and African moonfish (*Selene dorsalis*), within the carangids; grey triggerfish (*Balistes capriscus*) and other triggerfishes, within the balistids; glasseye (*Heteropriacanthus fulgens*), within the priacanthids; West African goatfish (*Pseudupeneus prayensis*) and yellow goatfish (*Mulloidichthys martinicus*), within the mullids; Monrovia doctorfish (*Acanthurus monroviae*), within the acanthurids; Mediterranean parrotfish (*Sparisoma cretense*) and Guinean parrotfish (*Scarus hoefleri*), within the scarids; bulldog dentex (*Virididentex acromegalus*) – both genus and species being endemic to Cabo Verde –, bogue (*Boops boops*), white seabream (*Diplodus lineatus*), banded seabream (*D. fasciatus*) and two-banded seabream (*D. prayensis*) – these three seabreams are endemic to Cabo Verde –, sharpsnout seabream (*D. puntazzo*), striped seabream (*Lithognathus mormyrus*), axillary seabream (*Pagellus acarne*), black seabream (*Spondyliosoma cantharus*) and blackspot picarel (*Spicara melanurus*), within the sparids; African forktail snapper (*Apsilus fuscus*) and golden African snapper (*Lutjanus fulgens*), within the lutjanids; bastard grunt (*Pomadasys incisus*) and Guinea grunt (*Parapristipoma humile*), within the haemulids; flying gurnard (*Dactylopterus volitans*), within the dactylopterids; Guachanche barracuda (*Sphyraena guachancho*), within the sphyraenids;

lesser African threadfin (*Galeoides decadactylus*), within the polynemids; bluefish (*Pomatomus saltatrix*), within the pomatomids; damselfish (*Chromis lubbocki*), within the pomacentrids; and papillose flounder (*Syacium guineensis*), within the paralichthyids.

Small purse seines for small pelagic coastal fishes

These fishing encircling techniques are traditionally used for: mackerel scad (*Decapterus macarellus*), round scad (*D. punctatus*), bigeye scad (*Selar crumenophthalmus*), Cunene horse mackerel (*Trachurus trecae*), bonito (*Caranx crysos*), black jack (*C. lugubris*), pompano (*Trachinotus ovatus*), longfin pompano (*T. goreensis*) and African moonfish (*Selene dorsalis*), within the carangids; round sardinella (*Sardinella aurita*) and Madeira sardinella (*S. maderensis*), within the clupeids; African forktail snapper (*Apsilus fuscus*), within the lutjanids; flying gurnard (*Dactylopterus volitans*), within the dactylopterids; and bogue (*Boops boops*), within the sparids; among others. In recent years, the roughear scad (*Decapterus tabl*) (Carangidae) and the Atlantic chub mackerel (*Scomber colias*) (Scombridae) have appeared in Cabo Verde waters and are being caught with purse seines.

Handlines for coastal demersal fishes

These highly selective techniques are traditionally used for many varied large and medium-sized benthic fishes such us: bluespotted seabream (*Cephalopholis taeniops*) – a resource of great socioeconomic importance in Cabo Verde –, island grouper (*Mycteroperca fusca*), mottled grouper (*Mycteroperca rubra*), Dungat grouper (*Epinephelus goreensis*), dusky grouper (*Epinephelus marginatus*) and blacktail comber (*Serranus atricauda*), within the serranids; moray eels (*Muraena robusta*, *Muraena melanotis*, *Gymnothorax polygonius*, *Gymnothorax vicinus*), within the muraenids; lesser amberjack (*Seriola fasciata*), amberjack (*Seriola rivoliana*), bonito (*Caranx crysos*), black jack (*C. lugubris*), rainbow runner (*Elagatis bipinnulata*), African moonfish (*Selene dorsalis*), longfin pompano (*Trachinotus goreensis*) and pompano (*T. ovatus*), within the carangids; barred hogfish (*Bodianus scrofa*) and blackbar hogfish (*B. speciosus*), within the labrids; Mediterranean parrotfish (*Sparisoma cretense*), West African parrotfish (*S. choati*) and Guinean parrotfish (*Scarus hoefleri*), within the scarids; golden African snapper (*Lutjanus fulgens*), within the lutjanids; bulldog dentex (*Virididentex acromegalus*), southern common seabream (*Pagrus africanus*), axillary seabream (*P. acarne*), black seabream (*Spondyliosoma cantharus*), striped seabream (*Lithognathus mormyrus*), white seabream (*Diplodus lineatus*), banded seabream (*D. fasciatus*), two-banded seabream (*D. prayensis*) and sharpsnout seabream (*D. puntazzo*), within the sparids; grey triggerfish (*Balistes capriscus*) and other triggerfishes, within the balistids; glasseye (*Heteropriacanthus fulgens*) and Atlantic bigeye (*Priacanthus arenatus*), within the priacanthids; pigsnout grunt (*Pomadasys rogerii*), Guinea grunt (*Parapristipoma humile*) and lesser bastard grunt (*Pomadasys incisus*), within the haemulids; Atlantic emperor (*Lethrinus atlanticus*), within the lethrinids; yellow goatfish (*Mulloidichthys martinicus*) and West African goatfish (*Pseudupeneus prayensis*), within the mullids; Monrovia doctorfish (*Acanthurus monroviae*), within the acanthurids; lesser African threadfin (*Galeoides decadactylus*), within the polynemids; bluefish (*Pomatomus saltatrix*), within the pomatomids; John dory (*Zeus faber*), within the zeids; Guachanche barracuda (*Sphyraena guachancho*), within the sphyraenids; blackbar soldierfish (*Myripristis jacobus*) and squirrelfish (*Holocentrus adscensionis*), within the holocentrids; red scorpionfish (*Scorpaena scrofa*), within the scorpaenids; and blackbelly rosefish (*Helicolenus dactylopterus*), within the sebastids. Occasionally, the nurse shark (*Ginglymostoma cirratum*) (Ginglymostomatidae) is also caught.

Handlines for neritic or oceanic epi- and pelagic fishes

These highly selective techniques are traditionally used for: flat needlefish (*Ablennes hians*) and Atlantic needlefish (*Tylosurus acus rafale*), within the belonids; swordfish (*Xiphias gladius*), within the xiphids; Atlantic blue marlin (*Makaira nigricans*), Atlantic white marlin (*Kajikia albida*) and longbill spearfish (*Tetrapturus pfluegeri*), within the istiophorids; and common dolphinfish (*Coryphaena hippurus*), within the coryphaenids, among others.

Longlines for semi-deep demersal fishes

These fishing techniques are sporadically used for: red scorpionfish (*Scorpaena scrofa*), within the scorpaenids; blackbelly rosefish (*Helicolenus dactylopterus*), within the sebastids; moray eels (*Muraena helena*, *Gymnothorax polygonius*, *G. maderensis*), within the muraenids; and European conger (*Conger conger*), within the congrids, among others.

Pole-and-line for tunas and allied species

These highly selective techniques are traditionally used for scombrids such as: bullet and frigate tuna (*Auxis rochei* and *Auxis thazard*) and wahoo (*Acanthocybium solandri*) – these three species are of great socioeconomic importance in Cabo Verde –, skipjack tuna (*Katsuwonus pelamis*) and little tunny (*Euthynnus alletteratus*); and also for true tunas of the genus *Thunnus*, *i.e.* bigeye tuna (*T. obesus*), yellowfin tuna (*T. albacares*), albacore (*T. alalunga*) and bluefin tuna (*T. thynnus*).

Fixet gillnets

This fishing gear is mainly used for blackspot picarel (*Spicara melanurus*) (Sparidae). Other demersal or epibenthic species targeted by the bottom gillnets are: bonito (*Caranx crysos*), within the carangids; bulldog dentex (*Viri-*

Figure 4. – Piers at the Cova de Inglesa Fishing Complex, Mindelo, S. Vicente (Credits: J.A. González, 2019).

didentex acromegalus), white seabream (*Diplodus lineatus*), two-banded seabream (*D. prayensis*), sharpsnout seabream (*D. puntazzo*), striped seabream (*Lithognathus mormyrus*) and black seabream (*Spondyliosoma cantharus*), within the sparids; Mediterranean parrotfish (*Sparisoma cretense*) and West African parrotfish (*S. choati*), within the scarids; red dogfish (*Bodianus scrofa*), within the labrids; African forktail snapper (*Apsilus fuscus*), within the lutjanids; pigsnout grunt (*Pomadasys rogerii*) and lesser bastard grunt (*P. incisus*), within the haemulids; grey triggerfish (*Balistes capriscus*) and other triggerfishes, within the balistids; West African goatfish (*Pseudupeneus prayensis*) and yellow goatfish (*Mulloidichthys martinicus*), within the mullids; Monrovia doctorfish (*Acanthurus monroviae*), within the acanthurids; lesser African threadfin (*Galeoides decadactylus*), within the polynemids; Atlantic emperor (*Lethrinus atlanticus*), within the lethrinids; blackbar soldierfish (*Myripristis jacobus*) and squirrelfish (*Holocentrus adscensionis*), within the holocentrids; Cabo Verde mullet (*Chelon bispinosus*) – endemic to Cabo Verde –, within the mugilids; smooth-hound shark (*Mustelus mustelus*), within the triakids; and tiger shark (*Galeocerdo cuvier*), within the carcharhinids, among others.

Fishing harpoons

These highly selective fishing techniques are traditionally used for some moray eels like stout moray (*M. robusta*), honeycomb moray (*M. melanotis*), purplemouth moray (*G. vicinus*) and polygon moray (*G. polygonius*).

Semi-industrial and industrial fishing

This third set of fishing techniques are officially considered as belonging to the (semi-)industrial fisheries, being subject to stricter legal regulation and monitoring.

Purse seine for mackerel scad and others

These medium-sized encircling nets are mainly used for the mackerel scad (*Decapterus macarellus*) – this carangid is a resource of great social, economic and cultural importance in Cabo Verde. Accompanying species are: round sardinella (*Sardinella aurita*) and Madeira sardinella (*S. maderensis*), within the clupeids; round scad (*Decapterus punctatus*), bigeye scad (*Selar crumenophthalmus*), bonito (*Caranx crysos*), black jack (*C. lugubris*), pompano (*Trachinotus ovatus*), longfin pompano (*T. goreensis*) and African moonfish (*Selene dorsalis*), within the carangids; skipjack tuna (*Katsuwonus pelamis*) and little tunny (*Euthynnus alletteratus*), within the scombrids; African forktail snapper (*Apsilus fuscus*), within the lutjanids; and blackspot picarel (*Spicara melanurus*), within the sparids.

Specialised bottom traps for Cape Verde spiny lobster

The Cape Verde spiny lobster *Palinurus charlestoni* – endemic to Cabo Verde – is the only deep-water palinurid being subject to commercial exploitation in the region.

Landings and current regulatory measures

Landing operations from artisanal fishing usually take place in ports (Fig. 4) in or near fishing communities. During the 2011 general census, 97 fishing landing points were identified in the country, which are usually located within fishing communities (INDP, 2012). Most of these points are natural beaches and a minority are infrastructures ranging from a simple ramp to a fishing pier. In the archipelago there are about 25 ramps operating with artisanal fishing boats, which facilitate the entry and exit of vessels within the communities, and about 6 small fishing wharfs. It can be said that there are no mandatory landing places in artisanal fishing, that is, artisanal fishermen can land wherever they want within their island, as the law does not allow sailing more than 3 n.m. from the coast.

A large proportion of the landings – especially the (semi-)industrial fishing – is carried out mainly on the piers at the Cova de Inglesa Fishing Complex (CPCI) (São Vicente) (Fig. 4), Praia Fishing Complex (PFC) (Santiago), Port of Palmeira (Sal), and Tarrafal multifunctional centre (São Nicolau), although they may sporadically occur on the island of Santo Antão (Fig. 1). In these cases, berth is required.

The CPCI is the result of cooperation between the Governments of Cabo Verde and Japan and has been in operation since 2001. It has a health license, which allows it to provide export services for whole and/or fresh gutted fish and live lobsters for the EU market and frozen fish for other markets, namely the USA. It has a fish suction system, directly from the ship's hold to the interior of the fish processing area. It includes a fishing pier with a length of 115 m, with a maximum draught of 5 m and a 100 m long breakwater, fish processing facilities, a freezing tunnel with an 8 t/8 h capacity, cold storage (150 t at –25ºC) and ice production (60 t/24 h) to supply most of the (semi-)industrial and artisanal vessels in the North Region. It also supplies drinking water and fuel to fishing vessels. CPCI is most used by (semi-)industrial fishing vessels, but there may be occasional unloading of artisanal boats.

The PFC provides the services of berthing for discharges, berthing for ice (15 t/24 h), water and fuel supplies, use of its proper space for repairing nets and assembly of fishing devices and minor repairs, use of storage cabins for fishing machines, and is also a point of first-sale of fish. It still offers freezing and cold-storage service. It has a freezing tunnel (6 t/6 h), a brine tank (2 t/9 h); three cold-rooms at 0ºC (179 t in total), three cold-rooms at –25ºC (230 t in total). Built in 1991 as a donation from the Japanese government, Praia fishing pier is used by both (semi-)industrial fishing vessels and artisanal boats.

Palmeira is the third Cabo Verdean port in terms of commercial activity of transporting goods and passengers, fishing activities and maritime-tourist industries and also recreational boating. Inaugurated in 1986, the port underwent expansion and remodelling works in two phases, the first in 2010 and the second in 2015. The port has a 34 m long pier, intended for artisanal fishing vessels. It has storage lockers for fishing materials and two structures containerized with a seawater ice machine (200 t/24 h). In the past, it was considered an important point for landing pink lobster for export (capacity 15 t). Rented to Portuguese companies in the 90s, it is now deactivated, but contains ponds for lobster, space for processing fish, an ice machine and two cold-rooms. In 2016 it was acquired by Frescomar, the nursery no longer existed and it was modernized with freezing chambers (300 t), a freezing tunnel and fish treatment rooms. Currently the owner company rents freezer rooms to other private companies.

Lastly, the fishing infrastructure at Tarrafal, built in 1992 with funding from the Italian Government, is considered a multifunctional centre. It incorporates: an ice machine (600 kg/24 h), three cold rooms (20 m^3 at 0ºC; 40 m^3 at 0ºC, and 20 m^3 at negative temperature), an area for fish conserves activity, engine repair, space for the sale of fishing materials, two container structures with an ice machine (2 t/24 h), a landing pier, a social centre with different spaces for meetings and entertainment. It is managed by a group of local operators.

Following the landing operations, fish pass through a chain of intermediaries, each transaction adding cost value, until reaching the final consumer (Fig. 5). The complexity is more concentrated on fishery products for canning and export, taking into account the periods of storage before processing, preservation and export, as well as sanitary requirements in both the internal and foreign markets (Correia, 2017). Fish for final consumption are sold mostly fresh, whether ice-chilled or not and purchased by households in markets or consumed in restaurants. Only a small part of the fish is marketed dry, salted or in brine. In recent years, frozen fish has also been sold by some commercial companies on the islands of São Vicente and Santiago (Correia, 2017).

With the commencement in 2015 of the Mindelo Cold Platform (Fig. 4) (currently under management by the Atunlo CV company) there was an increase and improvement in transhipment, landing and other services related to fishing products. In general, the best fishing infrastructures (in terms of ports, cold storage and processing) are located on the islands of São Vicente, Santiago and Sal. Fish is mostly sold on the local market (Fig. 5), but a certain amount is exported, mostly lobsters and fresh fish (tunas and demersal fish).

In 2003, the Fisheries Resource Management Plan reported an important fishery potential for tuna species, migratory, skipjack tuna and yellowfin tuna basically being the most caught in the country's waters. Other oceanic pelagic fish of some importance in terms of landings, are the wahoo, little tunny, and bigeye, bullet and frigate tuna (Monteiro, 2008; Fernández-Gil *et al*., 2013). Up to now, tunids are the only

Figure 5. – Fish market at Mindelo, S. Vicente (Credits: J.A. González, 2019).

group of fishes that can be traded under the fisheries agreements.

Within the group of small coastal pelagic fish, the most frequently caught species belong to the family Carangidae, including mackerel scad and other scads and blackspot picarel, although other species of carangids with relative commercial value, like jacks and amberjacks are also landed (Monteiro, 2008; Fernández-Gil *et al*., 2013). The main management measures adopted since 2016 for this group establish a closed season for the bigeye scad from June 15 to July 14 and for the mackerel scad from July 15 to September 14, and assign the fishing to Cabo Verde nationals only.

The demersal ichthyofauna exploited in Cabo Verde can be subdivided into two large groups: rocky bottom and sandy bottom resources. In the first group, the demersal rock fishes include serranids (bluespotted seabream, blacktail comber, groupers), moray eels, snappers, Atlantic emperor, black seabream, bulldog dentex, Monrovia doctor fish, hogfishes and parrotfishes. The group of demersal sand fishes includes seabreams, lesser African threadfin, goatfishes, glasseyes and grunts. Triggersfishes are caught on sandy or coral bottoms (Monteiro, 2008; González *et al*., 2009; Fernández-Gil *et al*., 2013).

Regarding crustaceans, the most outstanding are the Cape Verde spiny lobster and the coastal spiny lobsters (González *et al*., 2009; Fernández-Gil *et al*., 2013). The Cabo Verde spiny (or pink) lobster fishery is reserved for the national fleet and, as mentioned, is caught with selective bottom traps by industrial fishing vessels. This is a highly valuable species on the internal and external market, being traditionally exported alive to the EU. However its catch shows signs of overexploitation, leading since 2016 to a limitation of the fishing effort from four to a maximum of three vessels, a closed period from July 1 to November 30, a minimum catch size of 11 cm carapace length and TAC (total allowable catch) of 12 t per year per vessel. The maximum number of boats operating for pink lobster was 8 in 1986–1987 (5 artisanal boats based on Sal (3) and São Vicente (2), and 3 semi-industrial vessels based on São Vicente). Although still actively caught, only one vessel has operated in recent years.

Catching coastal spiny lobsters is permitted with snorkel diving, but most divers illegally use diving cylinders, despite this practice is prohibited under fishing regulations. For this resource a closed period from May 1 to October 30 was established, as well as a minimum size capture of 9 cm carapace length and prohibition of capture of egg-bearing females.

Other fishery resources such as the endemic barnacle, whelk, limpets and benthic cephalopods (octopus and cuttlefish) are widely harvested, but their biological parameters and potential are still unknown. They are not currently subject to legal regulation and there are no catch statistics.

The annual fisheries landings (in t) over the period 2007-2017 in Cabo Verde are given in table II. Average values and percentages of relative composition were estimated as follows: 4,335 t (43%) yielded by the artisanal fisheries, 6,139 t (57%) by "industrial" fisheries, and 10,474 t as the mean value of total landings over the studied period. Resource group composition of total landings (in t) over the same period 2007-2017 is shown in table III. Tunas and small pelagic

Table II. – Annual fisheries landings (in t) over the period 2007-2017 in Cabo Verde archipelago. Source: former National Fisheries Development Institute (INDP).

Year	Artisanal landings (t)	Relative composition (%)	Industrial landings (t)	Relative composition (%)	Total landings (t)
2007	4599	51	4456	49	9055
2008	4018	49	4110	51	8128
2009	4552	51	4329	49	8881
2010	4552	48	4839	52	9391
2011	4617	50	4693	50	9310
2012	4310	42	5955	58	10265
2013	4374	36	7715	64	12089
2014	4418	31	9839	69	14256
2015	4574	30	10794	70	15368
2016	4156	44	5339	56	9494
2017	3512	39	5463	61	8975
Average value	4335	–	6139	–	10474
Average %	–	43	–	57	100

Table III. – Composition of the total fisheries landings (in t) over the period 2007-2017 in Cabo Verde by resource groups. Source: former National Fisheries Development Institute (INDP).

Resource group	Landings (t)	%
Tunas and other oceanic pelagic fish	4392	41.5
Small pelagic fish species	3972	37.5
Demersal fish species	1426	13.5
Crustaceans and Molluscs	41	0.4
Miscellaneous	720	6.8
Sharks	40	0.4
Totals	10591	100

fish species clearly predominated. Demersal fish, sharks, crustaceans and molluscs constituted a relatively low fraction of the total landings. In the previous decade 1998-2007, average total landings were about 9,300 t – i.e. about 1,200 t less than in the subsequent decade –, also with a predominance of tunas and small pelagic fish species (González *et al*., 2009).

Regulatory measures are decided and established by the ministry with powers over fishing, in accordance with scientific-technical reports and recommendations issued by the INDP/IMar. They also consider the standpoint of shipowners and fishery workers associations on technical biological and socioeconomic aspects, which is normally discussed and approved by the National Fisheries Council. Fisherfolk participating in subsistence and artisanal fisheries rarely respect regulatory measures. Concerning conflict, the artisanal fleets have reported some interference of semi-industrial vessels in areas too close to the coast, fishing for small pelagics as live bait for tuna fishing. To avoid this, the latter fleet is not allowed to operate within 3 n.m., and it was established that bait catches in the inhabited bays should be by artisanal operators and sold to industrial vessels. In uninhabited areas and bays, auxiliary boats from (semi-)industrial vessels are allowed to operate within 3 n.m., exclusively to capture live bait.

The National Inspection Agency (fisheries inspectors) inspect and control activities at sea jointly with the Coast Guard and the Maritime Police. Landing operations are supervised by inspectors and the Maritime Police.

Emerging artisanal fisheries

Rodrigues and Villasante (2016) recently assessed how tourism and the local market are driving small-scale fisheries around the island of São Vicente. Identifying these socioeconomic drivers is a fundamental step to understand the resultant impacts and pressures on fishery resources, and the behaviour of seafood trade actors, and this is especially relevant to developing island countries for fisheries management purposes. That study showed how these drivers shape preferences for certain fish species and how they affect the distribution of income among actors involved in the seafood trade. In addition, according to the authors' observations Asian operators are exerting increasing pressure on various types of fishery resources, especially sea-cucumbers and sea-urchins.

As partially mentioned above, the Cabo Verde Archipelago is crucially dependent on the unstable and intermittent inward flow of some basic elements like fuel, food, and international aid (*e.g*. Dancette, 2019). A part of this aid is in the form of social and economic cooperation programmes. Since 2000, an important package of cooperation projects has been included in the so-called Interreg MAC (Madeira-Açores-Canarias) programmes, given that the Republic of Cabo Verde adopted the agreement to form part of the Macaronesia cooperation area endowed with ERDF funds awarded to Spain and Portugal through their outermost regions, the Canary Islands, Madeira, and Azores. As a result, Cabo Verde has been an indirect recipient of European development funds. In a coordinated and consensual way, the research groups of the MAC cooperation space propose cooperation-research projects (including those of a marine-maritime and fishing nature), in accordance with the objectives set by successive multiannual programmes. These are approved or not by mixed committees with representation from the regions and countries involved. These projects have been progressively focused on applied research, for example aimed at improving the competitiveness and internationalization of SMEs. Another issue, outside the scope of this study, would be the existence (and operation) of an overall framework regarding fishing sciences on this archipelago. In

this regard, a prospective survey with bottom longlines was carried out in the Cabo Verde archipelago in 2000 by the R/V "Arquipélago". The main objective was to determine the species composition and relative abundance of demersal fish resources living in the waters of Cabo Verde. It covered the entire archipelago and prospected depths from a few metres to 1,200 m (Menezes *et al*., 2004). During this campaign, apparently no new or potential fish resources were discovered. Recently (2018), within the MARISCOMAC project, a bottom longline for fish was tested in Santo Antão's waters between 130 and 220 m of depth, as a technology and know-how transfer experience to the artisanal fleet. The target species were the scorpaenids, namely the red scorpionfish (*Scorpaena scrofa*) and the offshore rockfish (*Pontinus kuhlii*). Several moray eels and European conger, fish with commercial value in the country, were also caught as bycatch (Macremar and Mariscomac, 2018).

In the framework of the HYDROCARPO project, the seabed around the islands of Boa Vista and Santiago were systematically surveyed twice (by the R/V "Taliarte" in 2003 and by the R/V "Pixape II" in 2005), in search of new alternative or complementary fishery resources. Metallic (benthic) bottom traps were used between 150 and 1,000 m of depth. According to the frequency and abundance of the catches, a number of potential fishery resources were identified: striped soldier shrimp (*Plesionika edwardsii*) between 150 and 300 m of depth, black conger (*Coloconger cadenati*), between 400 and 650 m, and deep-sea red crab (*Chaceon affinis*) between 550 and 1,000 m. Two other deep-sea species of commercial value were also caught to some extent, the deep-sea smooth nylon shrimps *Heterocarpus grimaldii* and *H. laevigatus* (González *et al*., 2004, 2009). An experimental fishing license for deep-sea red crab was granted in 2014-2015. As a precautionary measure, this fishery is reserved for the national (semi-)industrial fleet capable of operating with benthic traps deeper than 500 m depth, with a maximum effort not exceeding 10,000 traps per month.

In 2005, during the second prospection campaign of the HYDROCARPO project, semi-floating shrimp traps were tested for the first time in Cabo Verde in the waters of Boa Vista, yielding interesting results regarding the selective capture of the striped soldier shrimp (*Plesionika edwardsii*) (González *et al*., 2006, 2009).

On board the R/V "Prof. Ignacio Lozano", in the framework of the PROACTIVA action in 2010 (Pajuelo *et al*., 2010) and, especially, in the MARPROF-CV project between 2011 and 2012, each island's stock of striped soldier shrimp was surveyed. Its biology was studied (González *et al*., 2016; Triay-Portella *et al*., 2017a) and its maximum sustainable yield MSY (exploitable biomass) estimated (around 200 t per year between 90 and 220 m depth) (González *et al*., 2012; García-Martín *et al*., 2014). In addition, the bycatch of this emerging fishery was recently studied from an ecosystem approach (Pajuelo *et al*., 2018). Furthermore, in the framework of the PROACTIVA2 action in 2012, a workshop was conducted for the manufacture of semi-floating shrimp traps, and the first test with this fishing system was carried out aboard a Cabo Verdean vessel (Pajuelo *et al*., 2012). The striped soldier shrimp is still a virgin resource in the waters of Cabo Verde. The assessment of this resource was made prior to its exploitation, an unprecedented action in the management of the world's fishery resources, and the fishery was initially reserved for artisanal (and perhaps semi-industrial) vessels with national flag and capacity to operate with multiple semi-floating shrimp traps.

Echinoderms such as sea-cucumbers are caught by means of scuba-diving in Cabo Verde, but their harvesting potential is still unknown and no study on these resources has yet been done. The species sought are: *Holothuria surinamensis*, *H. lentiginosa*, *H. sanctori* and *Isostichopus badionotus*. They have been currently exploited around the islands of São Vicente, São Nicolau and Santiago, processed more or less locally and finally exported to markets in East Asia and Senegal. Based on an experimental licence, sea-cucumbers at depths between 16 and 35 m are being exploited on the former two islands, using boats with certified divers. They are then treated in suitable land facilities on São Vicente, prior to export to Asian markets.

In 2017, in the framework of the MACAROFOOD project, selective traps for coastal lobsters were made locally and used experimentally in Santo Antão waters, between 15 and 42 m in depth. This was a technology and know-how transfer experiment to the artisanal fleet. The target species were royal spiny lobster, brown lobster, and greater locust lobster (Sopromar and Macarofood, 2017a, b). In addition, a vessel based in Mindelo has been fishing with these traps thanks to an experimental licence of 18 months.

DISCUSSION

Small-scale fisheries in the Cabo Verde Islands are not only a "subsistence" activity, but a series of fishing/commercial activities capable of generating significant economic revenue. This becomes more important in a context considered by the UN as a Developing Island Country.

The FAO early pointed out some basic management concepts for small-scale fisheries, and in particular their economic and social aspects (Panayotou, 1983). In contrast to large-scale fisheries, artisanal fishing requires considerable manpower and the participation of vessel owners who use little capital and equipment and few modern techniques. In this context, it should be noted that a fishery is made up of fisherfolk, the fleet and the fish stocks (Panayotou, 1983).

In Cabo Verde's small-scale fisheries, fishing vessels vary enormously in terms of size, and their amount of technology

and sophistication ranges from undecked boats with very little equipment to deepwater lobster-trappers and purse-seiners with on-board fish-detection systems and a power block head. This latter is deck equipment hydraulically powered, used for the handling of fishing net.

The difficulties faced (still today) by the fishing sector often stem from a high degree of unpredictability, seasonality, and perishability of the fishery product, risks associated with the activity, as well as the low level of education of most operators. These challenges are limiting factors for investment, although early on, successive governments considered this sector of great strategic importance for the country's social and economic development. An example illustrating the growing vulnerability of Cabo Verdean small-scale fishing communities has recently been published by Dancette (2019). Our critical analysis of this kind of 'blue economy' is in accordance with this article, which describes declining fish stocks and other environmental factors like climate change and regional tropicalization, along with unstable inward flow of some elements such as fuel, food, and international aid. Moreover, governance, economic and institutional/political factors limit investment leading to uncertainty and vulnerability – see also Barnett and Campbell (2010), Guillotreau *et al*. (2012) and Belhabib *et al*. (2016).

Being a young country, it still does not have specific legislation for all aspects of the fishing sector, such as new technologies, aquaculture, new resource species, state-of-the-art extractive methods. Such a lack delays administrative authorizations for these innovations, as it has to legislate in response to licence requests. The main problem regarding fresh fish and live lobsters is current touristic air transport, which is limited in cargo capacity and without reservations for the insured cargo. This has produced numerous cargos being stuck at the airport, with the enormous nuisance of having to return the product to the original facility, unpack and store it again, and large losses due to mortality in the case of lobsters. The upcoming disappearance of "industrial" deep-sea lobster fishery is largely due to the impossibility of exporting live catches by air to the markets of Portugal and France (Paris was the main market for this gourmet product). Artisanal fishery encounters similar limitations to opening a market for coastal lobsters in the Canary Islands. Passenger aircraft holds are for tourist suitcases!

Fisheries biodiversity directly or indirectly targeted by multispecific artisanal fisheries in Cabo Verde waters encompasses many species, a characteristic of a volcanic archipelago nestled in a tropical region. Statistics and research show that its fishing resources are diverse (a consequence of the large size of Cabo Verde's EEZ) and some show exploitable biomasses. From the specialized literature quoted in the methodology section, it can be inferred that the waters of the archipelago contain some 180 native marine species in terms of common or frequent fish and shellfish with commercial interest. This set of fishery products includes approximately 135 benthic organisms, of which 35 species are shellfish (basically crustaceans, molluscs and echinoderms), 8 rays/sharks and 92 bony fishes. Coastal pelagic species consist of 20 bony fishes. Finally, oceanic pelagic fishes of commercial interest are represented by about 25 species, of which 3 are sharks and 22 are bony fishes. Thus, these resources – especially demersal – are sensitive to high levels of effort and have relatively low recovery capacity once overexploited.

It is important that resources, and especially pelagic fish landings, be monitored regularly and management actions taken to ensure that pelagic stocks are not depleted further, as advised by Krakstad *et al*. (2011). Reflecting on the situation of fishery monitoring in the past and nowadays, in the authors' opinion there has been a rather weak coordination between universities and fisheries research/management centres in Cabo Verde. Recent institutional changes (the widely known INDP has become the *Instituto do Mar* IMar, while the *Universidade de Cabo Verde* in São Vicente is now the *Universidade Técnica do Atlântico*) will require greater institutional consensus, more specialized personnel and an improvement in financial conditions. This will in turn favour the monitoring of fisheries and the establishment, for example, of reliable and useful statistics for the purpose of sustainable fishing management. Monitoring has been traditionally conducted by the INDP, now by the IMar.

Considering that the volumes of exploitable fishery resources in Cabo Verde were estimated at 32,500-44,000 t/y (Bravo de Laguna, 1985; Almeida *et al*., 2003), of which 25,000-30,000 t/y were large pelagic species (Government of Cape Verde, 2004), Cabo Verde's fishery resources could be considered to be underexploited. However, more than half of this potential corresponds to tunas and allied species (notably the skipjack tuna, yellowfin tuna and bullet/frigate tunas), so in principle tuna fishing has the greatest potential for development. The demand for bullet and frigate tuna by domestic canning companies has boosted industrial fishery catches, while for small pelagic fish (mainly carangids) the trend is the reverse. For other resources, the possibilities for expansion of fisheries are limited, especially for demersal species (lobsters, mid- and deep-water benthic fishes and molluscs), which apparently are being exploited near or already beyond the sustainable limits of most of the archipelago's fishing grounds.

Parallel to the resources traditionally fished, there are little or non-exploited species (such as mid- and deep-water bony fishes, pandalid shrimps and maybe large brachyuran crabs) that could be alternative or complementary resources that would allow fishing rotation (*e.g*. González *et al*., 2009). As reported in the 2009 Fisheries Resource Management Plan (BO, 2009), to take advantage of these resources should be seen as a necessity and priority for the sustainable development of the islands fishery sector, in terms of: a) managing

through protection and sustainable exploitation measures; b) fostering a human resources qualification policy; and c) promoting investment policies in infrastructure, equipment and materials with environmental labelling. In our opinion, there is a need to increase the currently scarce professional training of fishermen, in particular through courses on fishing techniques, tidal behaviour and professional ethics. Moreover, the new EU-Cabo Verde protocol to implement the SFPA has to be based on the best available scientific advice and following the recommendations of the ICCAT. Consequently, the large amount of scientific and technological information generated in the last 20 years has to be collected, validated and applied to the objectives of sustainable management and improving the living conditions of people in the fishing sector.

This strategy aims to ease the pressure on resources traditionally exploited through diversification of fisheries and sustainable exploitation of marine resources. As part of a strategy or action plan for sustainable development, some opportunities and challenges have to be addressed in the value chain of local fisheries, in order to reinforce the competitiveness of local small and medium-sized enterprises (SMEs) and their representative organizations. However, aside from these positive perspectives for the socioeconomic issues in the country, biodiversity impacts have to be considered from an ecosystem approach. Therefore, any potential direct or indirect impacts on species diversity should be assessed prior to authorizing increased fishing effort or exploiting new resources. These precautions are especially relevant to coastal shellfish or deep-water benthic species, such as lobsters, sea-cucumbers and sea-urchins, striped soldier shrimp and allied pandalids, large deep-water crabs and deep-water black conger. In the case of the striped soldier shrimp (*Plesionika edwardsii*), changes in catch and bycatch composition and in species diversity of a potential semi-floating shrimp-trap fishery in Cabo Verde and in other eastern Atlantic island ecosystems with different degrees of human alteration have been recently published (Pajuelo *et al*., 2018).

Among the opportunities is to exploit tuna and allied species in the Cabo Verde EEZ, using gear other than pole-and-line – such as purse seines, surface longlines or trolling – and to develop the capture of high-value commercial species, *i.e*. yellowfin tuna, swordfish, bigeye tuna, wahoo or even common dolphinfish. In order to make this fishery feasible, emphasis should be placed on added-value products (*e.g*. frozen, vacuum packaged loins and steaks) and the establishment of a quality control system.

Another possibility lies in sandy-bottom demersal fish resources, which are little exploited on the platform around Boa Vista-João Valente Bank-Maio. These have already been modestly prospected with bottom trawls. Alternative gear such as bottom gillnets and traps (both selective and nonselective) should be properly studied, designed and tested, without forgetting the negative environmental impacts of bottom trawling for commercial purposes (*e.g*. González *et al*., 2009).

In order to reduce fishing pressure on demersal fish stocks at maximum depths of 150/200 m, alternative gear such as bottom longlines (for fish) and various types of traps (for crustaceans) can be used, operating at greater depths. Some exploration campaigns carried out in the previous decade of the 2000s revealed resources with commercial interest and possibilities to develop directed fisheries, but their biomass and sustainability must first be assessed.

As a result of the prospection campaigns described in the previous section, three experimental-commercial actions based on adequately trained and equipped local crews should be implemented. First, according to Macremar and Mariscomac (2018), scorpionfishes – mainly *Pontinus kuhlii* –, moray eels and several associated benthic fish species would be profitable catches, by means of bottom longlines at around 100–300 m depth. Second, according to González *et al*. (2010, 2012), García-Martín *et al*. (2014) and Pajuelo *et al*. (2018), fishing operations with selective traps should target the striped soldier shrimp (*Plesionika edwardsii*), other associated pandalids and at least the morid *Physiculus cyanostrophus* at 90-250 m depth. Lastly, according to González *et al*. (2004, 2006, 2009), similar fishing operations with bottom traps could explore the presence of profitable biomasses of bony fish (*Coloconger cadenati*), brachyuran crab (*Chaceon affinis*) and pandalid shrimp (*Heterocarpus* spp.) resources at 400-1000 m depth. Deep-sea red crab is vulnerable to heavy fishing pressure, and can easily be overexploited due to its biological characteristics, such as slow growth, late maturation and discontinuous distribution (Biscoito *et al*., 2015; Triay-Portella *et al*., 2017b).

Regarding echinoderm resources, a scientific and technical monitoring project is necessary to assess current harvesting activities targeting sea-cucumbers. This project should include morphological characterization and genetic identification of the exploited species, stock assessment, and proposals for measures to ensure their sustainable exploitation.

In parallel, for all the fisheries, a programme to collect information on biological (basic parameters) and technical data (fishing gear characteristics) is required, as a baseline for future regulatory, control and monitoring measures (fishing effort, meshes, quotas, minimum landing size, closed seasons or zones, etc.), following the widely-recommended best biological data available and ecossystem approaches.

It is important to bear in mind that this volcanic archipelago has a significant presence of rather abrupt seabeds, and limited potential fishing grounds – only 5,394 km^2 in the whole archipelago down to the 200-m isobath (Bravo de Laguna, 1985). Therefore, our field experience in the region indicates that possible fishery developments should

be planned in a small-scale or artisanal way. In this regard, cooperation projects including training actions, fishing and market research, as well as valorization and promotion of novel seafood products, would be highly suitable and useful for the country. This means that future projects should be more addressed to teaching and training actions, pilot studies on fishing prospection and new markets, including export experience and experiments, and definition and trial production of innovative added-value seafoods (for instance, vacuum-packaged wahoo loins).

Finally, an opportunity for the diversification of fisheries products could be aquaculture with native marine species of economic interest. With this perspective, among others, the experience of countries such as Spain, Brazil and/or Portugal can be used in culturing large species of serranids, sparids (*e.g.* bulldog dentex) or large carangids (amberjacks). In the two aquaculture trials with non-indigenous species in the country to date (red tilapia *Oreochromis* spp., and Pacific white shrimp *Penaeus vannamei*), the technical projects approved to obtain the licence included an Environmental Impact Assessment. They were assisted by the INDP and produced within the existing legal framework and regulations (FAO-INDP, 2010, 2013). However, to minimize possible environmental disturbances, it would be highly desirable to prioritize the prospective studies and use of integrated culture methods and native species with demonstrated potential in the country and/or existing foreign markets.

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