



## The coastal ichthyofauna of the Cape Verde Islands: a summary and remarks on endemism

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### ABSTRACT

The zoogeographic composition of the coastal ichthyofauna of the Cape Verde archipelago shows a predominance of Guinean species, followed by tropical-subtropical (amphi-Atlantic) fishes and several endemic species. Recent taxonomic revisions, new species descriptions, new fish records in the area and recent ecological surveys of intra-specific fish interaction as well as emergent research on seamounts in national waters warrant an up-to-date review of research on the ichthyofauna of Cape Verde. An updated percentage of endemic coastal reef fish of 10.2% attest significant speciation in Cape Verde waters. Almost half of the total cryptobenthic fish species richness in Cape Verde comprises endemic species, some of them newly discovered. Examples of endemism are discussed, notably white seabream *Diplodus sargus lineatus*, bulldog dentex *Dentex (Virididentex) acromegalus*, blackfish drummer *Girella stuebeli*, Lubbock's chromis *Chromis lubbocki*, Cape Verde damselfish *Similiparma hermani* and Guinean parrotfish *Scarus hoefleri*. Cape Verde diverges considerably from the other Macaronesian island groups in terms of its ichthyofauna and its uniqueness warrants special attention by governmental agencies and conservation organizations.

### RESUMO

A composição zoogeográfica da ictiofauna litoral do arquipélago de Cabo Verde apresenta uma predominância de espécies Guineanas, seguidas de peixes tropicais-subtropicais (anfi-Atlânticas), e várias espécies costeiras endémicas. Recentes revisões taxonómicas, descrição de novas espécies, novas ocorrências de espécies na zona e novos estudos ecológicos focando interações intraespecíficas de peixes assim como a investigação emergente dos montes submarinos nas águas de Cabo Verde justificam uma revisão do estado da arte da investigação na ictiofauna cabo-verdiana. Uma percentagem actualizada de peixes costeiros endémicos de ambiente recifal em 10,2% atesta uma especiação significativa em águas de Cabo Verde. Quase metade da riqueza total de espécies de peixes criptobentónicos em Cabo Verde é composta por espécies endémicas, alguns dos quais recém-descobertos. Exemplos de endemismos são discutidos, focando: sargo-branco *Diplodus sargus lineatus*, benteia *Dentex (Virididentex) acromegalus*, morro *Girella stuebeli*, burrinho *Chromis lubbocki*, pá-mané-de-rabo-branco *Similiparma hermani* e bidião-carnaval *Scarus hoefleri*. Relativamente à ictiofauna, Cabo Verde diverge consideravelmente dos outros grupos de ilhas da Macaronesia e essa singularidade requer especial atenção por parte das autoridades nacionais e organizações de conservação.

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## INTRODUCTION

The main factors driving coastal ichthyofaunal composition include regional latitudinal temperature gradients (Ferreira *et al.* 2004, Willig & Bloch 2006), evolutionary patterns (Harrison & Cornell 2008), coastline distance and depth (Floeter *et al.* 2007, Fox & Bellwood 2007) and biogeography (Lloris *et al.* 1991, Floeter *et al.* 2008, Almada *et al.* 2013).

Lloris *et al.* (1991) provided the first summary of the biogeography of the Macaronesian ichthyofauna using an inventory of 913 fish species, including fish data from ‘African sites’ (Morocco and Western Sahara), and for the first time proposed a hierarchy of biogeographic levels for the studied area. In comparing Cape Verde with other Macaronesian archipelagos, Brito *et al.* (2007) concluded that the zoogeographic composition of its coastal ichthyofauna is mainly tropical, with Afrotropical species clearly dominant, followed by amphi-Atlantic tropical and subtropical species (i.e. taxa distributed on both sides of the Atlantic), and then by Mediterranean and circum-tropical species. Later, Floeter *et al.* (2008) described reef fish biogeography and evolution for all Atlantic ‘provinces’ and clarified our understanding of how and when areas of endemism of the tropical Atlantic Ocean formed, how they relate to each other and

what processes contributed to their faunal composition. However, Lloris *et al.* (1991) were of the opinion that – from an ichthyological point of view – the Macaronesian archipelagos do not constitute a coherent marine biogeographical region and cannot be considered to constitute a ‘province’. Spalding *et al.* (2007), in their 62 provinces of marine ecoregions of the world, included the Cape Verde Islands and the Sahelian Upwelling marine ecoregions in the same province of ‘West African Transition’. In contrast, the nearby Lusitanian province, an often recognized biogeographical unit, has been considered a warm eastern Atlantic region by Almada *et al.* (2013), who partly evaluated the tropicality index and included Macaronesia (without Cape Verde) in the group.

From the mid 1980s onwards, taxonomic revisions, descriptions of new species and new records of fish in Cape Verde waters have increased significantly (e.g. Edwards 1986, Hensley 1986, Matallanas & Brito 1999, Brito & Miller 2001, Menezes *et al.* 2004, González & Tariche 2009, Wirtz 2009, González *et al.* 2010, Fricke *et al.* 2010, Wirtz & Schliewen 2012, Rocha *et al.* 2012a, Vieira *et al.* 2013, Wirtz *et al.* 2013, Freitas *et al.* 2014). These new data warrant an up-to-date review of the ichthyofauna of the Cape Verde archipelago.

## THE CAPE VERDE ISLANDS

The Cape Verde Islands are located in the central East Atlantic, 500-750 km west of Senegal, West Africa. There are 10 islands and eight islets, with a total area of 4,033 km<sup>2</sup> (Duarte & Romeiras 2009). The archipelago was formed by rock accumulation arising from eruptions from a hotspot under submarine platforms (Laborel 1974). The coastline is about 965 km long and the marine shelf (depth < 200 m) covers an area of 5,934 km<sup>2</sup> (Bravo de Laguna 1985, DGMP 1998). The archipelago is situated at the eastern border of the North Atlantic sub-tropical gyre and the southern limit of the Canary Current. The climate in the region is tropical, with two alternating seasons: a moderate (December to June, with an average seawater temperature of 22-23°C) and a warm (July to November, 26-27°C) (Almada 1993).

Hermatypic corals are widespread in Cape Verde rocky coastal areas (van der Land 1993),

and pavements of *Siderastrea radians* (hard coral) are very common in shallow waters (Moses *et al.* 2003). The seawater temperature gradient, which is affected by the cold Canary Current, does not allow the formation of true ‘coral reefs’ in the tropical Cape Verde archipelago (Laborel 1974). Thus, coral reefs in Cape Verde in fact consist of several reef organisms (i.e. sponges, corals and algae) that grow on hard substrata formed by the deposition of dead coral, coralline calcareous algae and other organisms, mainly above volcanic material (van der Land 1993). Consequently, the appropriately named ‘coralline community’ in Cape Verde (Almeida *et al.* 2007) is mostly based on a complex environmental framework of deposits (carbonates/corals plus biota). According to van der Land (1993), this community appears to be of minor importance in the coastal ecosystems of Cape Verde, which

have a predominantly tropical character with some subtropical elements. Wirtz *et al.* (2013) categorised ‘coastal fish’ as fish found in the first 60 m of depth from the shoreline, implying a

rather vague boundary. The term ‘reef fish’ is applied here to coastal fishes living and feeding in coralline communities.

## RESEARCH ON THE COASTAL ICHTHYOFAUNA

In an all-inclusive catalogue of the fishes of the Cape Verde Islands, Reiner (1996) listed 520 species, an important publication with meritorious data on Cape Verde fishes, but also including many erroneous records. Some older studies (e.g. Franca & Vasconcelos 1962) as well as more recent ones (e.g. Thorteinsson *et al.* 1995, Oddsson & Monteiro 1998, Menezes *et al.* 2004, González & Tariche 2009) investigated and evaluated the composition of the ichthyofauna of the Cape Verde Islands. Some recent studies were published as illustrated books and checklists, employing different zoogeographical approaches (e.g. Reiner 2005, Brito *et al.* 2007).

In particular, recent researches on the African hind *Cephalopholis taeniops* (Serranidae), one of the most important commercial demersal species caught in Cape Verde, have increased. Tariche *et al.* (2002) investigated the biology of the species and presented a preliminary stock assessment for the northern Cape Verde Islands. Medina *et al.* (2008) studied habitat fragmentation and average body-shape variation by canonical multivariate models and demonstrated that fish in the northern islands of Santo Antão, São Vicente and Santa Luzia and the eastern island of Boa Vista showed a similar direction in shape ontogeny, contrasting with Fogo Island, the southernmost locality. Lino *et al.* (2011) performed a preliminary acoustic telemetric study on artificial reefs off Sal Island using implanted underwater acoustic transmitters in four *C. taeniops* specimens monitored during 63 days, demonstrating site fidelity with no migrations to the nearby natural reef. Costa (2014) recently analyzed the reproductive biology of *C. taeniops*, focusing on reproductive seasonality, gonadal development and sex change, and concluded that multiple spawning occurs from April to October, while the species was considered diandric protogynous hermaphrodite, with primary and secondary males.

Using SCUBA and stationary visual census methods, Monteiro *et al.* (2008) compiled a check-list of 53 fish species of 27 families

(including data on biogeography, habitat, egg type, diet, conservation and fisheries status) at two seamounts in the Cape Verde archipelago, the Northwest Bank and João Valente Bank, and suggested that the upper part of these seamounts may act both as attraction points and as ‘stepping-stones’ for the dispersal of coastal species.

Fricke *et al.* (2010) described a new clingfish (Gobiesocidae) from Cape Verde, probably endemic to the archipelago, as *Apletodon barbatus*. More recently, Wirtz & Schliewen (2012) described a new species of serranid perch as *Liopropoma emanueli*, not endemic to Cape Verde (cf. Wirtz 2014), while Rocha *et al.* (2012a) recognized *Sparisoma choati* as a new Atlantic parrotfish from the West African-Guinean region. In the past, *S. choati* has been mistaken in Cape Verde and Senegal for Caribbean *S. rubripinne* (cf. Randall 1981, Reiner 1996, Brito *et al.* 1999, Santos *et al.* 2012). Feeding ecology and morphometric relationships of a ‘relic’ species (Summerer *et al.* 2001) of white seabream, *Diplodus sargus lineatus*, endemic to the Cape Verde archipelago, were studied by Soares *et al.* (2012), who considered it a generalist and moderately opportunistic omnivorous (but predominantly herbivorous) species with a preference for red algae. Freitas *et al.* (2014) reviewed dispersal in Brazilian reef fishes and reported the occurrence of western Atlantic Agassiz’s parrotfish *Sparisoma frondosum* in Cape Verde, suggesting that the North Equatorial counter-current should receive more attention as a potential dispersal route for marine organisms crossing the Atlantic in a west to east direction.

A SCUBA survey of the reef fish and benthic community structure of Santa Luzia Marine Reserve in Cape Verde was carried out in 2009-2010 and some of the results were summarized by Freitas (2012). Parallel to this survey, an investigation of cleaning mutualism, the prevalence of multi-specific reef fish cleaning stations and three new records of facultative cleaner fish species in Santa Luzia Island were reported by Quimbayo *et al.* (2012).

Employing the same SCUBA routines as mentioned above, Carvalho (2014) used remote video and introduced a new approach in Cape Verde, quantifying and comparing feeding rates of a reef fish community in order to identify the main contributing species on the coralline benthos across depth and exposure.

Ramos *et al.* (2011) performed a stakeholder perceptions study of the decision making process for marine biodiversity conservation off Sal Island, suggesting that limiting activities was the preferred management option to be considered in the future. Linked with this study, Santos *et al.* (2012) carried out a comparative study on the fish assemblages of natural and artificial reefs off Sal in light of the increase in diving ecotourism in Cape Verde.

A long-line bottom fishery survey (using 20 long-line sets up to 1,200 m depth) caught 97 demersal species from 49 families, including 12 species new for Cape Verde (Menezes *et al.* 2004). Pereira *et al.* (2012) presented weight-length relationship data for 27 demersal fish species, based on the long-line fishery data of Menezes *et al.* (2004). Oliveira *et al.* (2014) provided weight-length and length-length relationship data of 29 species from Cape Verde. González *et al.* (2010) reviewed Moridae (Gadiformes) from the archipelago, using data from several deep-sea fisheries surveys (González & Tariche 2009) and reported the first record for Cape Verde of the benthonic species *Physiculus cyanostrophus*, collected off northern Santiago Island.

#### RATE OF ENDEMISM AND FUNCTIONAL CATEGORIES

The most recent validated check-list of coastal fish from the Cape Verde Islands (Wirtz *et al.* 2013) includes 24 new records and lists a total of 315 fish species, of which 88% are Teleostei (bony fish) and the remainder Elasmobranchii (sharks, rays and skates). At the species level, 20 of these (6.3%) appear to be endemic to the archipelago, mostly reef-associated species. Wirtz *et al.* (2013) also included *ca.* 110 species the identification of which is doubtful or in need of confirmation, as well as definitely invalid records from the older literature. An alternative interpretation of this list was performed in which 105 species (33%) were rejected for being oceanic-pelagic and/or bottom-deep-water species. A renewed analysis of the data employed by Wirtz *et al.* (2013) showed a more realistic rate of endemism of 10.2% for the Cape Verdean coastal ichthyofauna. In this new analysis, reef-associated elasmobranchs (25 species) are mostly represented by Carcharhinidae, Dasyatidae and Myliobatidae. Teleost fishes of six families (morays, gobiids, carangids, seabreams, damselfishes and wrasses) comprise 31% of reef fish diversity in Cape Verde, with the number of species per family ranging from 7 to 15. The new analysis of 185 coastal osteichthyes comprised 61 families and a total of 135 genera, dominated by morays (*Gymnothorax* and *Muraena*, with six and four species respectively), followed by damselfish *Abudefduf* and seabreams *Diplodus*, with four species each, five genera with three species (e.g. gobies *Didogobius* and parrotfish *Sparisoma*), 26 genera with two species and 100 genera with

only a single representant. Ichthyogeographically, coastal bony fish species of Cape Verde are dominated by amphi-Atlantic (40%), tropical West African and eastern Atlantic (both 22%), and Macaronesian (5.4%) taxa.

Based on a new approach towards the analysis of functional diversity of Atlantic reef fish communities (Halpern & Floeter 2008), Cape Verde coastal fishes can be grouped as follows: median to small fish (with a length of 10-50 cm) comprise 50% of the total, small fish (< 10 cm) comprise 14% and large fish (> 50cm) comprise 36%. Of 13 dietary groupings, a little over 25% consisted of macro-carnivores and another 25% concerned benthic invertivores or cleaners, 13% of omnivores, 7% of piscivores, 7% of coral/colonial sessile invertivores and around 20% were combined in eight functional groupings (e.g. planktivores 6.5%, sand invertivores, scrapers, macroalgae browsers, territorial algae/detritus feeders and three others).

Floeter *et al.* (2008) calculated the endemism rate of reef fishes of oceanic islands of the Atlantic Ocean and rated Cape Verde with 8.3% of 207 species. The newly obtained value of 10.2% places Cape Verde between St Peter and St Paul Rocks (9.3%) and Ascension Island (11.0%), both isolated islands with less than 100 species recorded. However, a recent survey (Wirtz *et al.* 2014) considered Ascension to have 132 coastal fish species, of which 11 (8.3%) appear to be endemic, while 16 species (12.1%) appear to be shared endemics with St Helena Island.

## REEF FISH ENDEMISM

Wirtz *et al.* (2013) found that species endemic to Cape Verde were on average smaller than non-endemics, presumably because large fish can better pass oceanic barriers. The presence of 20+ endemic taxa (Brito *et al.* 2007, Wirtz *et al.* 2013) suggests speciation in Cape Verde waters, which is further supported by the occurrence of the endemic 'monotypic subgenus' *Virididentex* (Sparidae) (Poll 1971; Fig. 1B). A high degree of coastal endemism is also found in small cryptobenthic fishes (Fig. 2) of the family Blenniidae, as well as in Labrisomidae and Gobiidae. Furthermore, two additional small cryptic species of *Malacoctenus* (Labrisomidae) and *Didogobius* (Gobiidae) are currently under description (cf. Wirtz *et al.* 2013). Almost half of the total small cryptobenthic species richness of Cape Verde is comprised of endemics recently discovered and described (e.g. three Blenniidae in the early 1990s, one by Wirtz & Bath 1989 and two by Bath 1990a, b and two Gobiidae by Brito & Miller 2001), some of which have arisen from recent colonization events (Rocha *et al.* 2005).

A phylogenetic analysis of *Diplodus* spp. based on 461 bp of the D-loop (Summerer *et al.* 2001), positioned the Cape Verde endemic *D. sargus lineatus* (Fig. 1E) as the sister taxon of the remainder of the *D. sargus* assemblage, showing *D. sargus sensu lato* to be paraphyletic, with *D. sargus lineatus* not being closely related to other *D. sargus* ssp. Summerer *et al.* (2001) suggested that the diversification and spread of the *D. sargus* assemblage to other Atlantic provinces originated in the tropical eastern Atlantic. Sparid fishes represent one of the major radiations of predominantly temperate to tropical benthic fishes (Santini *et al.* 2014). This is consistent with the presence of four diplodid sparids (seabreams) in Cape Verde waters, of which three are endemic species (Bauchot *et al.* 1981, Bauchot & Hureau 1990), probably the result of a relatively rapid diversification event (De la Paz *et al.* 1973). Summerer *et al.* (2001) suggested that all of these taxa should either be classified as subspecies of *D. sargus* or that *D. sargus lineatus* should be given specific rank as *D. lineatus*.

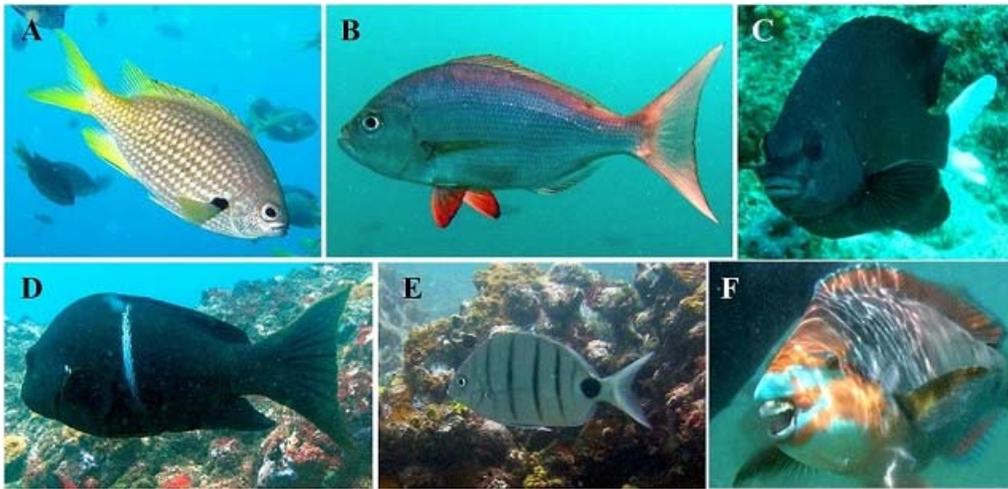


Fig. 1. Endemic Cape Verde reef fish. (A) Lubbock's chromis *Chromis lubbocki*; (B) Bulldog dentex *Dentex (Virididentex) acromegalus*; (C) Cape damsel *Similiparma hermani*; (D) Blackfish drummer *Girella stuebeli*; (E) White seabream *Diplodus sargus lineatus*; (F) Guinean parrotfish *Scarus hoefleri*. Photos by Sergio R. Floeter, Rui Freitas & Carlos Rangel.

The endemic sparid *Virididentex* (Fig. 1B), originally described as *Dentex acromegalus* by Osório (1911), was coined as a monotypic subgenus by Poll (1971). Apparently, both of these authors considered the bulldog dentex from Cape Verde to be closely related to the common dentex *Dentex dentex* (L.) from the eastern

Atlantic. Subsequently, *Virididentex* was elevated (without further comment) to generic rank by Bauchot *et al.* (1981) and has since been commonly applied as such (e.g. Bauchot & Hureau 1990, Santini *et al.* 2014; also various FAO sheets and Clofeta checklists). Santini *et al.* (2014) listed *V. acromegalus* as a benthopelagic

non-durophagous species, with a trophic index of 4.2, and placed it in a group consisting of various northeastern Atlantic and Mediterranean sparids.

The herbivorous species *Girella* (Kyphosidae, Girellinae) shows a disjunct distribution, which indicates either extinction in the western Atlantic or recent colonization of the eastern Atlantic from the Indian Ocean (Floeter *et al.* 2008). Therefore, this local kyphosid macroalgal browser (*Girella stuebeli*, Fig. 1D), which tends to bite or graze the algae, leaving the

basal stem (Halpern & Floeter 2008, R. Freitas pers. obs.), has been hypothesized to be a paleoendemic in the Atlantic Ocean with origins in the Tethys Sea (Rocha *et al.* 2005, Brito *et al.* 2007) and, as the sole Atlantic *Girella*, is endemic to the Cape Verde archipelago (Desoutter 1990). Records of *G. zonata* in the Cape Verde region and adjacent areas are considered doubtful (cf. Brito *et al.* 2007, Wirtz *et al.* 2013).



Fig. 2. Some (partially) endemic cryptobenthonic fish from the Cape Verde Islands: (A) *Scartella caboverdiana* (endemic blennioid); (B) *Ophioblennius atlanticus* (amphi-Atlantic blennioid); (C) juvenile *Similiparma hermani* (endemic, not a cryptic species); (D) *Gobius tetrophthalmus* (endemic gobioid); (E) *Parablennius salensis* (endemic blennioid); (F) *Gnatholepis thompsoni* (amphi-Atlantic gobioid); (G) *Labrisomus nuchipinnis* (amphi-Atlantic labrisomid); and (H) adult *Microlipophrys caboverdensis* (endemic blennioid). Photos by A. Boyra, Sergio R. Floeter, Rui Freitas & Carlos Rangel.

The endemic damselfish *Similiparma hermani* (Fig. 1C) was described by Steindachner (1887) as *Glyphidodon hermani*. Hensley (1986) showed that *Glyphidodon* Agassiz, 1846 is an unjustified emendation of spelling and therefore a junior objective synonym of *Glyphisodon* Lacépède, 1802, which in turn is a synonym of *Abudefduf* Forsskål, 1775, and coined *Similiparma* as a replacement name for *Glyphidodon*. *S. hermani* is considered

a paleoendemic, whose nearest relatives are mainly found in the southwestern Pacific (Rocha *et al.* 2005). Cooper *et al.* (2009) found *Abudefduf luridus* from the eastern Atlantic to fall outside *Abudefduf sensu stricto* and recovered it as the sister taxon of *S. hermani*. Subsequently, Cooper *et al.* (2014) reassigned it as *Similiparma lurida*. Both taxa are similar in ecology and are members of a subclade that also includes the genera *Microspathodon* and

*Hypsypops*. *A. luridus* is the only pomacentrid known to occur throughout Macaronesia (Lloris *et al.* 1991). As the juvenile stages are similar in shape and color pattern, *Similiparma hermani* (Fig. 2C) has sometimes been confused with the Beaugregory damselfish *Stegastes leucostictus* of the western Atlantic (e.g. Debelius 1997).

Parrotfish (*Scarines sensu* Westneat & Alfaro 2005) are considered the dominant consumers of benthic primary production on reefs. These corallivorous excavating fishes play a major role in reef dynamics and sedimentation while rasping algal communities (e.g. Bellwood & Choat 1990, Bernardi *et al.* 2000, Comeros-Raynal *et al.* 2012, Bonaldo *et al.* 2014). According to Choat *et al.* (2012), the Guinean parrotfish *Scarus hoefleri* (Fig. 1E) is 'basal' in the tropical Atlantic clade and the sole *Scarus* species that ranges from Mauritania to Congo (Wirtz *et al.* 2007). It is very common in the archipelagos of Cape Verde and São Tomé

(Rocha *et al.* 2012b) and is considered endemic to the West African-Guinean region. A notable feature in the distribution of the allopatric sister species *S. hoefleri* (eastern Atlantic) and *S. perrico* (eastern Pacific), which have a mean divergence age of 3.4 Mya (Choat *et al.* 2012), is that the closure of the Isthmus of Panama resulted in distinct regional endemism of *Scarus* parrotfish. *S. hoefleri* inhabits shallow/ coastal rocky reefs areas from 3-30m, feeds mainly on algae and is found as solitary males or in small groups with female harems (Randall 1990, Rocha *et al.* 2012b). Because of its relatively large size and colour, but not because of its market value, adult males are intensively targeted by spearfishing in Cape Verde. Coral reef loss, fisheries and declining habitat conditions are threatening this iconic group (Comeros-Raynal *et al.* 2012). Bonaldo *et al.* (2014) presented suggestions for future directions in parrotfish research.

#### SENGHOR SEAMOUNT

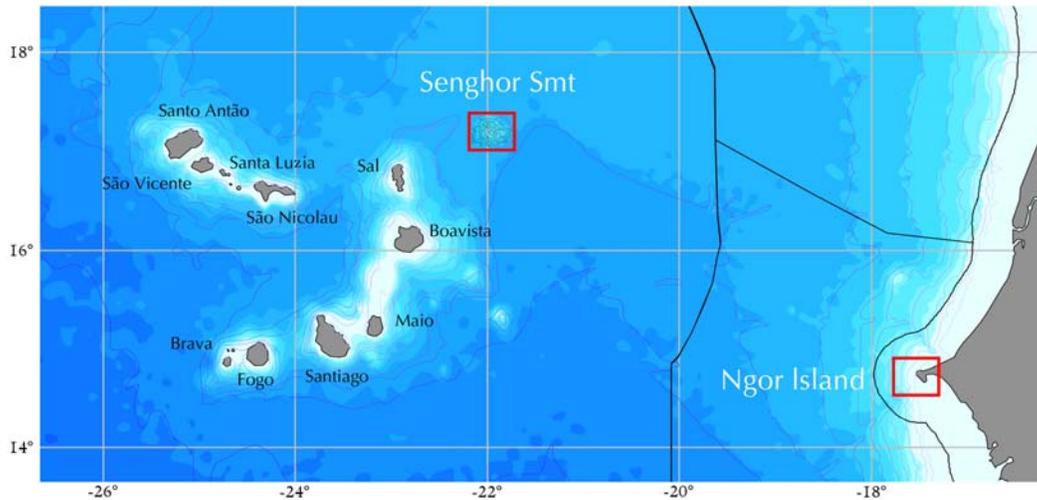


Fig. 3. Map of the Cape Verde Islands, showing the position of Senghor Seamount and Ngor Island, Senegal. Partial borders of the Exclusive Economic Zones (EEZ) of Cape Verde and adjacent countries are indicated (after Christiansen 2012).

Based on collections from trawl- and neuston net stations within the Cape Verde archipelago, John & Hanel (2008) studied the larval development of the Cape Verde damselfish *Chromis lubbocki* (Fig. 1A) and also suggested the occurrence of *Chromis cyanea* in Cape Verdean waters. Using complementary data of IKMT (Isaacs-Kidd Mid-water Trawl) and multi-net hauls from Cape Verde waters, five specimens of *C. lubbocki* and

two *C. cf. cyanea* were identified (John & Hanel 2008). More recently, Hanel *et al.* (2010) expanded on these data and focused on larval fish abundance, composition and distribution at the Senghor Seamount, northeast of the Cape Verde archipelago. So far, the data suggest that the fish community at this location is diverse (IKMT captured 68 specimens of 37 species) and

is mainly comprised of larvae of meso- and bathypelagic species.

Senghor Seamount, which lies within the Cape Verde Frontal Zone (CVFZ) and in the pathway of the south-westward North Equatorial Current, rises from a depth of 3,000 m, with its summit reaching to 93 m beneath sea level (Fig. 3). It is typical of several seamounts in the tropical northeastern Atlantic (Hanel *et al.* 2010). Senghor Seamount plays an important role in regional fisheries and information on larval abundance would help in determining the extent and health of these fishing grounds. Other shallow Cape Verdean seamounts, such as the Northwest Bank and João Valente Bank also deserve to be more intensively studied.

Oceanographic considerations (Wirtz *et al.* 2013) and the short distance (*ca.* 549 km) between Senghor Seamount and NGor Island,

near Dakar, Senegal (Fig. 3), combined with the south-easterly direction of the Canary Current during the weak upwelling season, may possibly explain the occurrence of *Chromis* sp. outside the Cape Verde archipelago through rafting or larval dispersal. The recent observation of *Chromis lubbocki* at NGor Island may concern a hybrid pomacentrid, a stray individual or a genuine dispersal event (Wirtz 2012). *Chromis lubbocki* is a small planktivorous endemic species, occurring in large schools in Cape Verde seas, with high densities mainly in coastal areas with strong currents, e.g. off Santa Luzia (Freitas 2012). Although more evidence is needed, this could be the first example of dispersal by an endemic reef fish from the Cape Verde archipelago.

#### FINAL REMARKS

Other endemic coastal fishes of Cape Verde that have not yet been mentioned include skate *Raja herwigi* (Rajidae), mullet *Chelon bispinosus* (Mugilidae), needlefish *Platybelone argalus lovii* (Belonidae), possibly grunt *Parapristipoma humile* (Haemulidae), seabreams *Diplodus fasciatus* and *Diplodus prayensis* (Sparidae), sole *Pegusa cadenati* (Soleidae), *Gobius ateriformis* and *Mauligobius nigri* (Gobiidae; three small cryptic endemic species, such as the clingfish *Apletodon barbatus*, are not included in Fig. 2). Excluding the pelagic and deep water species from the reef fish, a percentage of endemic coastal reef fish of 10.2% is calculated, emphasizing the need for a differential approach.

Medina *et al.* (2007) proposed that reef fish communities of insular ecosystems are structured by island or island group according to their degree of physical isolation and environmental variability. Pérez-Ruzafa *et al.* (2005) suggested that, within the spatial scales between islands found in the Cape Verde archipelago, habitat characteristics are no longer relevant and other factors, such as biological productivity or seawater temperature, are important. However, Floeter *et al.* (2008) proposed that the high endemism of the Cape Verde Islands may be related to isolation (from West Africa and/or between islands), high heterogeneity of habitats and maintenance of warm tropical waters during glacial periods. Cape Verde has high spard endemism, attributed to multiple radiations by

populations with different trophic ecologies (Santini *et al.* 2014).

González & Tariche (2009) presented baseline data for the sustainable management of marine biodiversity in the Cape Verde archipelago, together with checklists of fish for potential new deep-sea fisheries. Recent oceanographic surveys that have been conducted in the region strongly suggest that validated check-list methodologies (such as those of Wirtz *et al.* 2007, 2013, 2014) should also be applied to the deep sea fishes of the Cape Verde Islands. Meanwhile, listing doubtful species or those in need of confirmation (e.g. Wirtz *et al.* 2013) may not be the best solution, since it can easily create misunderstandings. Indeed, it was one of the reasons why this approach has been criticized.

Only low levels of endemism exist in Macaronesia as a whole, which is probably related to the distance between these archipelagos and mainland Africa and Europe (Almada *et al.* 2013). The Cape Verde Islands have a much higher degree of coastal fish endemism than the other Macaronesian archipelagos (i.e. the Azores, Madeira, Salvage and Canary Islands) and, in terms of the number of endemic taxa, Cape Verde is more similar to the islands in the Gulf of Guinea than to the Northwest African coast (Wirtz *et al.* 2013). From the point of view of marine biota community structure and ichthyo-geography, Cape Verde diverges considerably from the other Macaronesian islands (Brito *et al.* 1999, 2007,

Morri *et al.* 2000, Floeter *et al.* 2008) and inclusion of the Cape Verde Islands in a marine biogeographic ‘Macaronesian’ unit does not hold (Wirtz *et al.* 2013).

As reef fish in Cape Verde have only recently been more intensively studied, newly recorded species likely resulted from more

research being carried out rather than being an indicator of recent biological events. New discoveries are still to be expected and, based on reef fish endemism and zoogeography, Cape Verde may perhaps be designated a distinct Atlantic biogeographic province in its own right in the future.

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