Mar Biodiv (2018) 48:963–975
DOI 10.1007/s12526-016-0548-4

SENCKENBERG

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ORIGINAL PAPER

Deep-sea fishes from Senghor Seamount and the adjacent abyssal plain (Eastern Central Atlantic)

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Received: 26 September 2015 / Revised: 11 July 2016 / Accepted: 17 July 2016 / Published online: 9 August 2016

Abstract Senghor Seamount is an important fishing ground around the Cape Verde archipelago in the Eastern Central Atlantic. On an experimental field survey in October 2009 and December 2011, a total of 115 deep-sea fishes of 26 species belonging to 18 families were caught on the seamount summit, along the slopes and on the adjacent abyssal plane, using longlines, fish traps, beam trawl and otter trawl. Here we report seven new records for the Cape Verde deep-sea fish fauna. Most species are known from other areas of the Atlantic Ocean, but our findings are an important contribution to our understanding of the distribution of deep-water fish species. The co-occurrence of northern and southern Atlantic ichthyofauna components at Senghor Seamount, and the Cape Verde area in general, can be attributed to the large-scale hydrographic regime with two water masses merging at the Cape Verde Frontal Zone, the North Atlantic Central Water and the South Atlantic Central Water.

Communicated by R. Thiel

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Keywords Deep sea · Ichthyofauna · Seamounts · Zoogeography

Introduction

Seamounts are underwater mountains, globally distributed in the ocean basins (Wessel et al. 2010), often showing higher diversity than the surrounding abyssal plain (Shank 2010; Stocks et al. 2012). Seamounts are also known to provide habitat and foraging ground for fishes, including commercial species. Several studies have characterized the seamount ichthyofauna in regions of the temperate NE Atlantic (e.g., Pakhorukov 2008; Christiansen et al. 2009; Menezes et al. 2009, 2012; Christiansen et al. 2014). Knowledge of the distribution patterns of bathyal and abyssal fish species, however, is generally poor. In the eastern Atlantic, most studies have focused on the boreal and subtropical regions (e.g., Gordon and Duncan 1987; Merrett 1987; Haedrich and Merrett 1988; Merrett et al. 1991; Merrett 1992; Gordon et al. 1996; Martin and Christiansen 1997), and only scattered information is available from the tropics (e.g., Merrett and Marshall 1981; Merrett 1992; Vakily et al. 2002; Vieira et al. 2013).

Oceanographic research off the Cape Verde islands began in the mid-nineteenth century, and studies of the archipelago's wildlife are still continuing. Some of the original work on marine fishes from Cape Verde was conducted by Franca and Vasconcelos (1962) and Lloris et al. (1991). Reiner (1996) and Reiner (2005) reviewed the ichthyofauna of the Cape Verde Islands, while Brito et al. (2006), Monteiro et al. (2008), Almeida et al. (2010) and González et al. (2010, 2014) added new information on the marine fish communities of the archipelago. A compilation of data on coastal fish species, complementing the knowledge on the ichthyofauna from the Cape Verde archipelago with zoogeographic remarks, was provided by Wirtz et al. (2013) and Freitas (2014), and Hanel and John (2015) compiled data specifically on mesopelagic fishes. However, information on deep-sea species remains scarce.

Benthopelagic fishing surveys off the Cape Verde archipelago were conducted during the 1980s and 1990s to investigate stock sizes of commercially important species along the islands' shelves and the adjacent seamounts (e.g., Magnússon and Magnússon 1985, 1987; Thorsteisson et al. 1995). More recently, Menezes et al. (2004) investigated the demersal fish communities from several locations in the Cape Verde archipelago, including Senghor Seamount, but provided limited data on deeper-reaching species. Hanel et al. (2010) contributed valuable insight on the larval fish communities from the seamount, which were dominated by lanternfishes (Myctophidae).

The Senghor Seamount, known locally as Nova Holanda Bank, is an important fishing area for the regional longline fishery and also supports a small-scale crab and lobster fishery (MAAP/GEP 2004). Recent ROV surveys have revealed that the seamount features various habitats for benthopelagic and benthic fishes, including soft bottom and hard substrate with rich coral cover (Christiansen et al. 2011). Hanel et al. (2010) reported evidence of a seamount effect related to the topographic features and oceanographic conditions in the region. Denda and Christiansen (2014), however, detected no current topography-related effect on the distribution and concentration of mesozooplankton as potential prey for seamount-associated fishes at Senghor Seamount. No evidence was found for enhanced food availability at the seamount, such as higher concentrations of zooplankton biomass, compared to the surrounding ocean. Nevertheless, Senghor Seamount provides special habitats for benthic organisms, and hosts diverse and abundant communities of sponges, corals, hydroids, polychaetes, crustaceans and echinoderms (Christiansen et al. 2011; Chivers et al. 2013), and may be an attractive location in the open ocean for commonly dispersed oceanic pelagic fishes as well as for typical shelf species.

Official data about the type and effort of fishing exerted on the Cape Verde offshore seamounts is scarce. The artisanal fleets contribute to most captures in the region (D'Oliveira Fonseca 2000; Benchimol et al. 2009), but are limited to the near-shore areas. However, the extent of the impact caused by industrial fisheries, particularly if international fishing vessels are included, is likely underestimated (MAAP/GEP 2004; Benchimol et al. 2009). Taking this into account, it is important to evaluate the deep-sea resources in order to characterize the role and conservation status of the seamounts around the Cape Verde archipelago.

The main objective of this study, therefore, was to extend the knowledge of the deep-water fish fauna of Cape Verde and Senghor Seamount, at different depths, including the summit plateau, the slopes and the adjacent abyssal plain.

Material and methods

Study site

Senghor Seamount is an isolated seamount located at 17°12′ N, 021°57′W ca. 60 nmi northeast of the island of Sal, Cape Verde (Fig. 1a), within the sphere of the NE Atlantic tropical gyre (e.g., Mittelstaedt 1991; Lathuilière et al. 2008). The hydrographic regime is characterized by the North Equatorial Current system and Mauritanian upwelling filaments (Mason et al. 2011), but also by northward-flowing South Atlantic Central Water (SACW), merging in the Cape Verde Frontal Zone (CVFZ, e.g., Zenk et al. 1991). Senghor Seamount is nearly circular in shape, with a base diameter of ca. 40 km, steep slopes and a small elliptical summit plateau, which is about 2.5 km wide and 5 km long. Water depth at the base of the seamount is about 3300 m; the

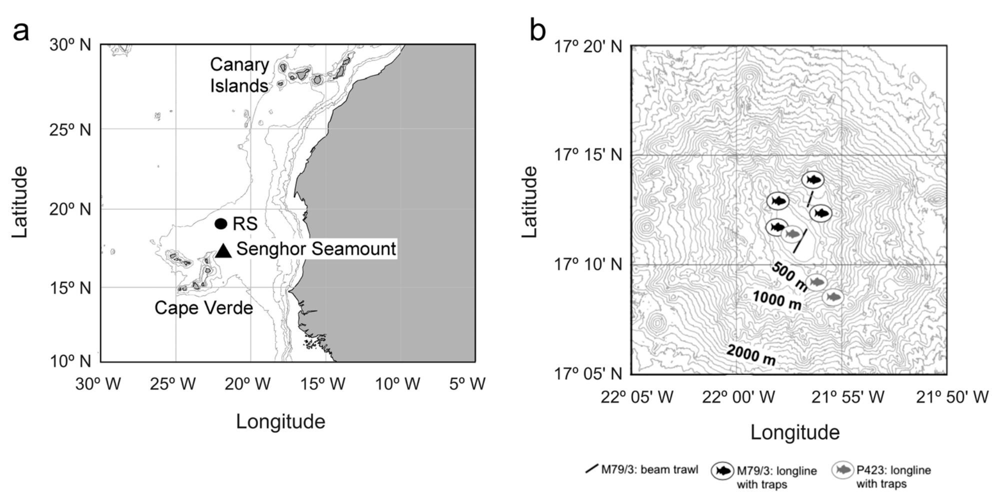

Fig. 1 **a** Cape Verde archipelago and the location of the Senghor Seamount (*triangle*) and abyssal sampling stations (*RS* reference station). **b** Central area of Senghor Seamount with locations of beam trawl tracks and longline deployments during cruises M79/3 and P423

minimum summit depth is 90 m. Video footage from the summit and upper slopes showed that the substrate structure varies between sediment-covered areas and rocky outcrops (Christiansen et al. 2011). The sediment-dominated reference station (RS) on the abyssal plain was located ca. 60 nm north of Senghor Seamount, at 18°05′N, 022°00′W, at a water depth of about 3300 m, which corresponds to the depth of the base of the seamount.

Sampling

During the cruises M79/3 of the RV *Meteor* in September/October 2009 and P423 of the RV *Poseidon* in December 2011, fishes were sampled at distinct depths on the summit plateau and along the slopes of Senghor Seamount and the adjacent bathyal plain (Fig. 1b, Table 1). Depending on the area, various types of fishing gear were used, including demersal longline, fish traps, beam trawl and otter trawl, aiming primarily at demersal fishes, but pelagic species were collected as well during slacking and heaving of the non-closing gears (Table 1).

The longline sets were used on the summit and on the upper slopes of the seamount at several depths ranging from 101 to 950 m. A total of 100 hooks of different shapes and sizes were attached to the main line by gangions approximately 60 cm in length and separated by approximately 2.5 m. The hooks were baited with squid. On seven of the longline sets, a fish trap baited with squid was also deployed at the end of the longline where the main anchor rope was attached.

The beam trawl (2 m beam length) was used to sample demersal fishes on the seamount summit at a depth of 103 m and on the upper slope at a depth of 260 m. The trawl was equipped with a 6-mm mesh net. The otter trawl (headrope length 15 m, mesh size 44 mm in the front part and 37 mm in the intermediate part, with 13-mm inner liner in the codend) was used in deep waters at the reference station, at ca. 3300 m.

Immediately after recovery of the catch, all fishes were identified to the lowest possible taxonomic level using Whitehead et al. (1984–1986), and were measured to total and standard length, respectively, and wet weight (TW). Stomachs and gonads of selected species were dissected, and tissue samples for DNA and isotopic ratios were taken for further analysis. Fishes from cruise P423 were discarded at sea due to a lack of freezing facilities during transport, whereas all fishes from M79/3 were frozen at −20 °C and transferred to the laboratory at the University of Hamburg to verify onboard identification. Here, the onboard identification was checked as far as possible (see Table 2). Rare specimens will be included in the collections of the Zoological Museum Hamburg.

Results

We provide a list of 115 demersal fishes belonging to 26 species (excluding unidentified) in 18 families (Table 2). Two species in two families were Chondrichthyes, all others were Teleostei, Actinopterygii. Additionally, several pelagic fishes (44 specimens) were caught in the otter trawl during its descent or ascent through the water column, including members of families Nemichthyidae (1 species), Sternopthychidae (5 species and 2 unidentified), Phosichthyidae (1 species),

Table 1 Trawl and longline deployments during expedition M79/3 in Sept/Oct 2009 and P423 in Dec 2011 to Senghor Seamount

Station no.	Gear	Date	Position		Water depth (m)	Location
			Lat N	Long W		
M79/3		2009				
820	OT	30/09	18°01.70′	022°04.27′	3310	Abyssal plain
838	OT	02/10	18°05.50′	021°57.99′	3299	Abyssal plain
863	BT	04/10	17°11.05′	021°56.90′	103	Summit
976	BT	12/10	17°12.99′	021°56.04′	389	Upper slope NE
876	LL	05/10	17°11.42′	021°57.84′	116	Summit
886	LLT	06/10	17°13.04′	021°58.13′	350	Upper slope N
926	LLT	09/10	17°12.62′	021°56.13′	529	Upper slope NE
961	LLT	11/10	17°13.77′	021°56.45′	715	Middle slope NE
1004	LLT	15/10	17°13.84′	021°56.63′	739	Upper slope NE
P423		2011				
743	LLT	13/12	17°11.52′	021°57.19′	101	Summit
755	LLT	14/12	17°09.42′	021°56.16′	500	Upper slope S
770	LLT	15/12	17°08.83′	021°55.30′	950	Middle slope SE

Gear abbreviations: *BT* beam trawl, *OT* otter trawl, *LL* longline, *LLT* longline with traps

Table 2 List of fishes sampled at Senghor Seamount and adjacent abyssal plain

Species	Number	Gear	Site	Depth (m)	Size (cm)	Remarks
CHONDRICHTHYES						
HEXANCHIFORMES						
Hexanchidae	1					
Heptranchias perlo	1	LL	Upper slope	530	TL 96.5	Frequent in Cape Verde (Menezes et al. 2004)
SQUALIFORMES						
Etmopteridae	2					
Etmopterus pusillus	2	LL	Upper slope	530	TL 35.7	Caudal fin damaged in one specimen. Frequent in Cape Verde (Menezes et al. 2004)
ACTINOPTERYGII						
ANGUILLIFORMES						
Muraenidae	2					
Muraena helena	2	LL	Summit	101	ND	Common in Cape Verde
Myrocongridae	2					
Myroconger compressus	2	LLT	Upper slope	356	TL 34.0–47.5	These specimens were markedly smaller than those captured previously in Cape Verde (Menezes et al. 2004), representing the northernmost record in the eastern Atlantic and the first occurrence associated with offshore seamounts.
Colocongridae	1					
Coloconger cadenati	1	LL	Middle slope	950	TL 75.0	Also observed by ROV at 723 m during M79, associated with shallow rocks. This species has been known from the W African margin south of Cape Verde (Merrett and Marshall 1981) and was reported to be frequent in Cape Verde, including Senghor Seamount, at depths between 300 and 850 m (Menezes et al. 2004), but this specimen represents the deepest record for the species (Menezes et al. 2004).
Synaphobranchidae	14					
Ilyophis cf. *brunneus*	3	OT	Reference station	3285	TL 44.5–79.0	Both species are ubiquitous in deep waters of the Atlantic and Indo-Pacific. *S. kaupii* has also been found at Seine, Sedlo and Ampère seamounts in the NE Atlantic (Menezes et al. 2009; Christiansen et al. 2014).
Synaphobranchus kaupii	4	LLT	Upper slope	530	TL 15.5–27.1	
Unidentified Synaphobranchidae	7	LL	Middle slope	950	TL 45.0–62.5	
NOTACANTHIFORMES						
Halosauridae	1					
Aldrovandia rostrata	1	OT	Reference station	3300	TL 59.0	Description: anal opening dark, pre-oral portion of snout 1/2 snout length, ventral anterior of dorsal. This is the first record in Cape Verde. The species has been known from a few specimens off the Bahamas, at the margin of the Mid-Atlantic Ridge (Sulak 1977), at the base of Great Meteor (Shcherbachev et al. 1985) and south of the Canary Islands (Merrett and Marshall 1981).
OSMERIFORMES						
Alepocephalidae	13					
Bathytroctes macrolepis	13	OT	Reference station	3285–3300	TL 14.0–36.5	The occurrence of several specimens was reported along the W African margin above the lower slope (Merrett

Table 2 (continued)

Species	Number	Gear	Site	Depth (m)	Size (cm)	Remarks
						and Marshall 1981). The species is known to occur in several locations in the North Atlantic (Haedrich and Merrett 1988; Santos et al. 1997), but also in the Pacific and Indian Oceans (Froese and Pauly 2016).
Platytroctidae	1					
Maulisia microlepis	1	OT	Reference station	3285	SL 9.5 TL 11.0	This species has mainly been collected in the eastern part of the Atlantic at locations northern than 40°N, but scattered reports exist also from the western African margin (Whitehead et al. 1984–1986; Froese and Pauly 2016).
AULOPIFORMES						
Ipnopidae	9					
Bathypterois grallator	2	OT	Reference station	3285	SL 9.5–12.0 TL 12.0–14.5	This species has been known from scattered records along the Atlantic Ocean and Mediterranean Sea, but also in the Pacific Ocean (Franco et al. 2009). It has also been found on the lower slope of Ampère Seamount (Christiansen et al. 2014).
Bathypterois longipes	1	OT	Reference station	3285	SL 16.5 TL 22.5	This is a deep-sea species known from several locations in the NE Atlantic (Merrett and Marshall 1981), including seamounts south of the Azores (Shcherbachev et al. 1985) and in the vicinity of Ampère Seamount (Christiansen et al. 2014).
Ipnops murrayi	6	OT	Reference station	3285–3300	SL 13.5–15.0 TL 14.8–17.0	The specimens represent the first records in the Cape Verde area, but the species is known from NW Africa (Merrett and Marshall 1981), the western and southern Atlantic Ocean (Nielsen 1966; Franco et al. 2009) and the Caribbean (Marshall and Staiger 1975).
GADIFORMES						
Macrouridae	37					
Coryphaenoides armatus	15	OT	Reference station	3285–3300	TL 54.5–83.0	*C. armatus* is ubiquitous in the world's oceans, but the specimens caught north of Senghor Seamount include 9 females with ripening ovaries, representing a rare record for this species.
Coryphaenoides cf. *carapinus*	5	OT	Reference station	3300	TL 11.0–23.5	Description: all specimens in bad condition. Branchiostegal rays 6, barbel present, upper jaw reaches below posterior third of orbit, inner tubular gill rakers on anterior arch 9, outer rakers present, pelvic fin rays 10, mandibular teeth in 2 rows. This combination points to *C. carapinus* (Cohen et al. 1990). *C. carapinus* is a common species widely distributed in the Atlantic.
Coryphaenoides cf. *profundicolus*	1	OT	Reference station	3285	TL 99.8	Preliminary shipboard identification only; re-examination not possible. This would represent the southernmost record of this species and the first in Cape Verde waters. The species has been known to occur along the western African margin north of 20° N (Merrett and Marshall 1981) and in the temperate North Atlantic (Haedrich and Merrett 1988).

Table 2 (continued)

Species	Number	Gear	Site	Depth (m)	Size (cm)	Remarks
Coryphaenoides spp.	8	OT	Reference station	3285	TL 12.0–59.3	Description: specimens in bad condition; gill rakers on anterior arch tubular, branchiostegal rays 6, chin barbel present, rakers present on lateral side of first gill arc, pelvic fin rays >9.
Unidentified Macrouridae	8	OT	Reference station	3285–3300	TL 10.5–36.8	Strongly damaged, proper identification not possible.
OPHIDIIFORMES						
Aphyonidae	1					
Barathronus cf. *parfaiti*	1	OT	Reference station	3300	SL 10.0	Description (derived from photo of freshly caught specimen): mouth oblique, caudal body part 43.6 % SL, predorsal 50.5 %, preanal 57.4 %. This combination and the catch locality suggest that it is *B. parfaiti*, as opposed to *B. bicolor* from the W Atlantic (Nielsen 1969). It clearly differs from another Atlantic species, *B. multidens*, by the strong pigmentation of the peritoneum (Whitehead et al. 1984–1986). However, the identification must be confirmed by checking the meristics of the preserved specimen.
					TL 10.5	This specimen is the first record of the genus *Barathronus* in Cape Verde. If finally confirmed, it will be the second *B. parfaiti* caught in tropical waters. This is an extremely rare species (Nielsen et al. 1999) with only three records previously reported, from west of the Azores, off the Bay of Biscay (Nielsen 1969) and west of Cape Blanc (Merrett and Marshall 1981).
Ophidiidae	13					
Acanthonus armatus	3	OT	Reference station	3285	TL 31.2–32.5	First registered record in Cape Verde waters. This is a common species in tropical deep waters of all oceans (Froese and Pauly 2016).
Bassozetus levistomatus	4 1*	OT	Reference station	3285–3300	SL 60.5–65.0 TL 64.0–68.0 TL 59.0	Description: pelvic fins below preopercle, close together (tips broken), eye small, head length ca. 50 % preanal length, 10–11 long gill rakers on anterior arch, pectoral fin rays 27, no median basibranchial tooth patch, small vomerine circular tooth patch. *One specimen not re-examined. This is a new record for Cape Verdean waters. *B. levistomatus* is a rare species and has been known in the eastern Atlantic from only 4 specimens caught further north between 21°N and 43°N; otherwise it is reported from the western Atlantic and the Caribbean, the Indian and Pacific Oceans (Nielsen and Merrett 2000). Remarkable is the presence of a circular vomerine tooth patch in all specimens, which was found previously in only one *B. levistomatus* (Nielsen and Merrett 2000).
Bassozetus taenia	1	OT	Reference station	3300	TL 26.0	Description: pelvic fins under preopercle, long gill rakers on anterior arch 15, short gill rakers 4 + 3, pectoral fin rays 26, body depth 10 % SL, median basibranchial tooth patch 1, vomer flat V, relatively broad. First record for Cape Verdean waters and shallowest record in the open Atlantic (Nielsen and Merrett 2000).

Table 2 (continued)

Species	Number	Gear	Site	Depth (m)	Size (cm)	Remarks
						Most *B. taenia* have been caught in the tropical western Atlantic, but three records exist from the eastern Atlantic south of the Cape Verde region and one from west of the Canary Islands (Nielsen and Merrett 2000).
Bathyonus laticeps	4	OT	Reference station	3285–3300	TL 12.5–19.2	Description: 2 joined pelvic fin rays, base under preopercle, long gill rakers on anterior arch 11, median basibranchial tooth patches 2, vomer flat narrow V, pectoral fin rays 16–17, lower ones prolonged, caudal fin rays 6? Several records from the Cape Verde region, otherwise in tropical and subtropical waters of the eastern and western Atlantic (Haedrich and Merrett 1988; Merrett 1992).
BERYCIFORMES						
Berycidae	3					
Beryx splendens	3	LL	Upper slope	530	TL 38.3	Only one specimen complete; two heads only. The species is frequently found at seamounts and on the continental slopes (Paxton 1999). Reported by Menezes et al. (2004) for Senghor Seamount. Records for NE Atlantic seamounts include Seine and Sedlo seamounts (Menezes et al. 2009), Ampère Seamount and seamounts south of the Azores (Shcherbachev et al. 1985; Pakhorukov 2008). It is an important target for commercial fishery.
SCORPAENIFORMES						
Sebastidae	9					
Helicolenus dactylopterus	9	BT, LL	Summit-slope	100–734	TL 6.8–38.0	Frequent in Cape Verde (Menezes et al. 2004). This species is widely distributed and has been found, e.g., at several seamounts in the NE Atlantic and in the eastern Mediterranean (Christiansen et al. 2014; Christiansen et al. 2015).
PERCIFORMES						
Caproidae	1					
Antigonia capros	1	BT	Summit	100	SL 17.5 TL 20.5	This is the first record for Senghor Seamount, but the species has been caught before in the Cape Verde area at several stations close to the islands (Strømme et al. 1982). The species was common on the Great Meteor Bank and other seamounts south of the Azores (Ehrich 1977; Shcherbachev et al. 1985; Pakhorukov 2008), and at Ampère and Josephine in the Horseshoe seamount chain (Pakhorukov 2008), but has not been reported from the NE Atlantic seamounts Seine, Sedlo and Gorringe (Abecasis et al. 2009; Christiansen et al. 2009; Menezes et al. 2009; Menezes et al. 2012).
Caristiidae	1					
Paracaristius sp.	1	OT	Reference station	ND	SL 17.2	Description (from photographs of freshly caught specimen): proportions HL = 29 % SL, body depth 52 %, pre-dorsal 12 %. This combination points to either *P. nemorosus* or *P. nudarcus* (Stevenson and Kenaley 2011), closer inspection necessary.

Table 2 (continued)

Species	Number	Gear	Site	Depth (m)	Size (cm)	Remarks
					TL 20.3	Only one specimen was collected in the otter trawl as pelagic bycatch. It is a rare bathypelagic genus. Three species of the family Caristiidae (*Paracaristius nemorosus, P. aquilus* and *Platyberyx opalescens*) were reported to occur in the greater Cape Verde region (Trunov et al. 2006; Stevenson and Kenaley 2011; Kukuev et al. 2012).
Gempylidae	4					
Promethichthys prometheus	4	LL	Upper slope	530	TL 57.5–62.0 ($N = 2$)	Two specimens complete, two with heads only. This species is found at continental slopes and around oceanic islands and submarine rises in tropical and warm temperate waters of all oceans (Nakamura and Parin 1993). Frequent in Cape Verde, caught at several locations, including Senghor Seamount (Menezes et al. 2004). It has not been reported from the more northern E Atlantic seamounts Seine, Sedlo, Ampère and Josephine (Pakhorukov 2008; Christiansen et al. 2009; Menezes et al. 2009; Menezes et al. 2012; Christiansen et al. 2014), but was caught at Great Meteor, Ewing and Jer seamounts south of the Azores (Shcherbachev et al. 1985).
TOTAL	115					

N number of specimens, *BT* beam trawl, *OT* otter trawl, *LL* longline, *LLT* longline with traps, *ND* no data, *TL* total length, *SL* standard length

Stomiidae (5 species and several unidentified specimens), Myctophidae (3 species), Melanocetidae (1 species), Melamphaidae (2 species). These small mesopelagic fishes are not included in the list presented here.

Most of the bathyal fishes belonged to the family Macrouridae, making up 46 % of all fishes caught in the otter trawl, followed by Alepocephalidae (16 %), Ophidiidae (16 %) and Ipnopidae (11 %). At the slopes and summit of the seamount, Synaphobranchidae and Sebastidae were the most frequently caught fishes. The most species-rich families were the Ophidiidae (four species) and Ipnopidae (three species), but since among the macrourids many specimens could not be identified to species level the number of three species representing the family is likely to be underestimated. The most common identified species at bathyal depths were the abyssal grenadier *Coryphaenoides armatus* (Family Macrouridae) and the slimehead *Bathytroctes macrolepis* (Family Alepocephalidae), with 15 and 13 individuals, respectively. It is particularly worth mentioning that 9 individuals of the grenadier *Coryphaenoides armatus* were adult females, with large ovaries containing ripening oocytes.

Top predator species collected in the longline sets included the elasmobranchs smooth lanternshark *Etmopterus pusillus*, the sharpnose sevengill shark *Heptranchias perlo* and bony fishes such as the escolar *Promethichthys prometheus*. Some commercially important species were captured on the summit and slopes with the longlines, including the splendid alfonsino *Beryx splendens* and the blackbelly rosefish *Helicolenus dactylopterus*. The *H. dactylopterus* collected on the summit with the beam trawl were much smaller in size (8.4–13.2 cm TL and 10–25 g TW; $N = 3$) than those caught on the slopes with longlines (35.5–44.0 cm TL and 660–1390 g TW; $N = 6$).

Discussion

All species encountered in our surveys are known from other areas of the Atlantic Ocean, but several are new for the Cape Verde region, thus contributing to a better understanding of the distribution of deep-water fish species.

Senghor Seamount features an ichthyofauna that includes both northern and southern elements. In the depth range influenced by SACW (down to 700 m), we captured a total of eight species. Two of these were caught for the first time at this seamount: the red eel *Myroconger compressus* and the deep-body boarfish *Antigonia capros*. Both species have been reported in the coastal waters of the Cape Verde archipelago but not in the offshore area (Strømme et al. 1982; Menezes et al. 2004), supporting the importance of seamounts for the oceanic dispersal of typical shelf species between continental slopes or archipelagos. Commercially important species in the catches included *Helicolenus dactylopterus* and *Beryx splendens*. The bottom-living *Helicolenus dactylopterus* was found over a wide depth range from the summit to the mid-slope (100–734 m) of Senghor Seamount. Individuals were larger at the deep stations, suggesting a size segregation of this species around the seamount, as was also observed by Morales-Nin et al. (2003) and Colloca et al. (2010). However, the number of specimens caught in our samples is too small for final conclusions, and gear selection may also play a role. *Beryx splendens* is frequently found at seamounts and on the continental slopes in the NE Atlantic (Paxton 1999; Pakhorukov 2008; Menezes et al. 2009) in layers of the North Atlantic Central Water (NACW), but also deeper in the saltier waters of the Mediterranean Outflow (600–1300 m, see Christiansen et al. 2014).

Most of the demersal fishes caught at Senghor are typical of the NE Atlantic seamounts and shelfs, for example, *Etmopterus pusillus*, *Helicolenus dactylopterus*, *Beryx splendens* and *Antigonia capros*. Others, such as *Myroconger compressus* and *Coloconger cadenati*, have not been recorded at the more northern seamounts (see Christiansen et al. 2014) and can be regarded as southern species. Similarly, *Promethichthys prometheus* has not been reported from the NE Atlantic Seine and Horseshoe seamounts, but has been caught at seamounts south of the Azores (Great Meteor, Ewing, Jer; Shcherbachev et al. 1985). It is known from landings in the Azores (Santos et al. 1997) and Morocco (Iglésias 2013), and spawning has been observed in waters around Madeira (Nakamura and Parin 1993). Other southern species have been reported by Menezes et al. (2004) for Senghor Seamount. The mixture of temperate- and warm-water species can be attributed to the large-scale hydrographic regime with two water masses merging at the CVFZ, NACW and SACW (Pérez-Rodríguez et al. 2001). The water mass distribution indicates that Senghor Seamount and the reference site lie within the so-called shadow zone, south of the CVFZ (see Tomczak 1981; Zenk et al. 1991; Pierre et al. 1994), but the CVFZ is a strongly meandering feature and may reach near Senghor Seamount at times (Lázaro et al. 2005). At both sampling sites, temperature and salinity were characteristic for SACW (9.7–15.2 °C; 35.2–35.7) between 150 and 600 m, lying below a warm mixed surface layer of about 30 m depth, followed by a thermocline (Fig. 2, see Denda and Christiansen 2014). Between 700 and 1200 m, an intermediate layer of minimum salinity (34.92–34.98) corresponds to the Antarctic Intermediate Water (AAIW); underneath, North Atlantic Deep Water (NADW) lies between 1200 and 3300 m (6.1–2.5 °C; 34.9–35.0). In the lower bathyal and abyssal water layers, a temperature of about 2.0 °C would be the common indicator for the Antarctic Bottom Water (AABW, Pierre et al. 1994).

The fishes collected on the bathyal plain adjacent to Senghor Seamount are typical deep-sea species, but to the best of the authors' knowledge, most have never before been reported from Cape Verde waters. First registered records in the

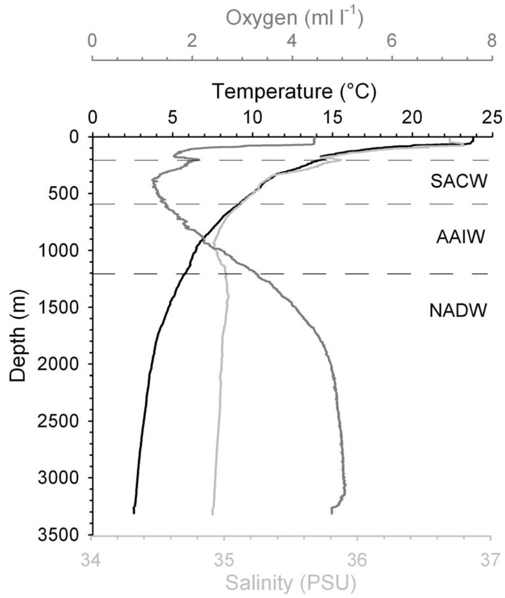

Fig. 2 Profiles of temperature (°C), salinity (PSU) and oxygen concentration (ml l^{-1}) at the reference site of Senghor Seamount (*RS* reference station)

Cape Verde region include *Aldrovandia rostrata*, *Ipnops murrayi*, *Acanthonus armatus*, *Bassozetus levistomatus*, *Bassozetus taenia*, *Barathronus* cf. *parfaiti* (Fig. 3). These species are generally rare, but all are known in the subtropical and tropical eastern Atlantic, usually north of 20°N (Merrett and Marshall 1981; Merrett 1992; Nielsen 1990; Nielsen and Merrett 2000), and most of the species belong to one or more of the three latitudinally distinct deep-sea fish assemblages of the eastern North Atlantic described by Merrett (1992). Among the three assemblages, the composition of the dominant species changes, and species richness increases from north to south (Merrett and Fasham 1998), with increasing importance of Ophidiidae and Ipnopidae, and decreasing importance of Macrouridae. *Coryphaenoides armatus*, for example, is the dominant species in the northerly assemblage, becoming less important south of 38°N in the waters off Morocco and NW Africa (Haedrich and Merrett 1988; Merrett 1992). It was also the dominant species in trawl catches from the Iceland Basin at 59°N, 020°W, accounting for ~60 % of the total catch, whereas at 47°N, 020°W, the species had a lower share of ~30 % (Martin and Christiansen 1997). In the southerly assemblage described by Merrett (1992), *C. armatus* made up only 4 %; however, in our samples on the bathyal plain adjacent to Senghor Seamount, it was the most abundant species, at 46 %, which is consistent with baited camera observations by Henriques et al. (2002) on the Cape Verde terrace (~120 nm SE of our abyssal station) and the Cape Verde abyssal plain (~210 nm SE of our abyssal station), which showed *C. armatus* as the main species attracted to bait. Ophidiidae, Alepocephalidae and Ipnopidae, on the other hand, represented a substantial share of our samples, making up 43 % of all deep-water fishes. Christiansen and Martin (2000) concluded that high relative abundance of Ophidiidae and Ipnopidae might be typical for low-latitude deep-sea fish assemblages.

Merrett (1992) associated the faunal change between the southerly and northern assemblages with the influence of upwelling and increased surface production along the continental margin of NW Africa. The less intense productivity at our bathyal station (18°N) south of the CVFZ than in the upwelling zone (20–22°N) to the north or within the CVFZ may be

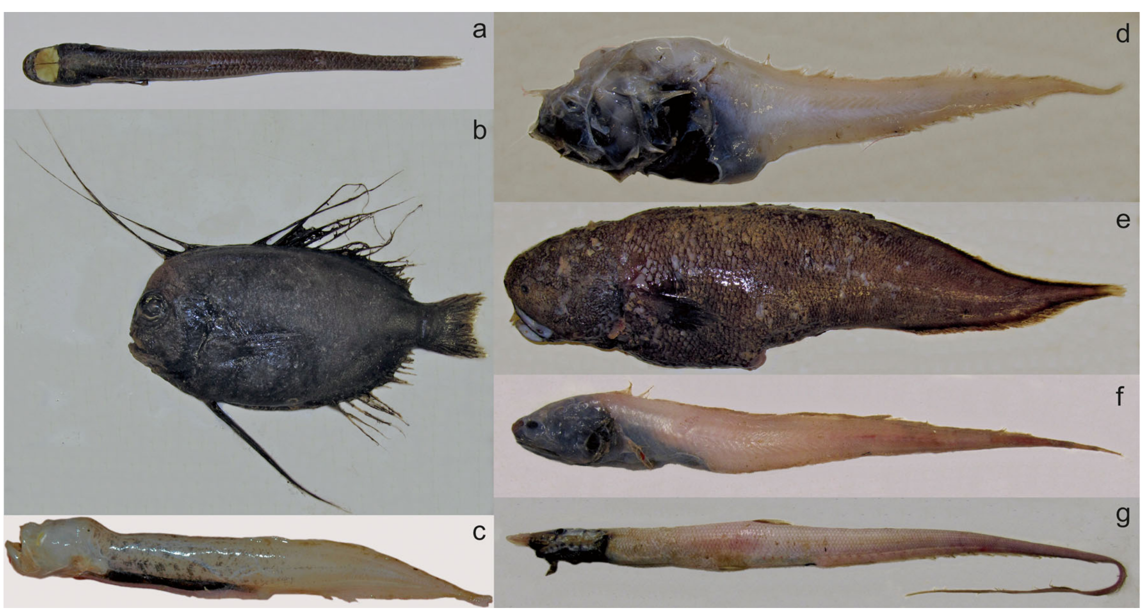

Fig. 3 Rare fishes collected on the abyssal plain adjacent to Senghor Seamount: **a** *Ipnops murrayi* (16.6 cm TL); **b** *Paracaristius* sp. (20.3 cm TL); **c** *Barathronus* cf. *parfaiti* (10.5 cm TL); **d** *Acanthonus armatus* (31.6 cm TL); **e** *Bassozetus levistomatus* (68.0 cm TL); **f** *Bassozetus taenia* (26.0 cm TL); **g** *Aldrovandia rostrata* (59.0 cm TL)

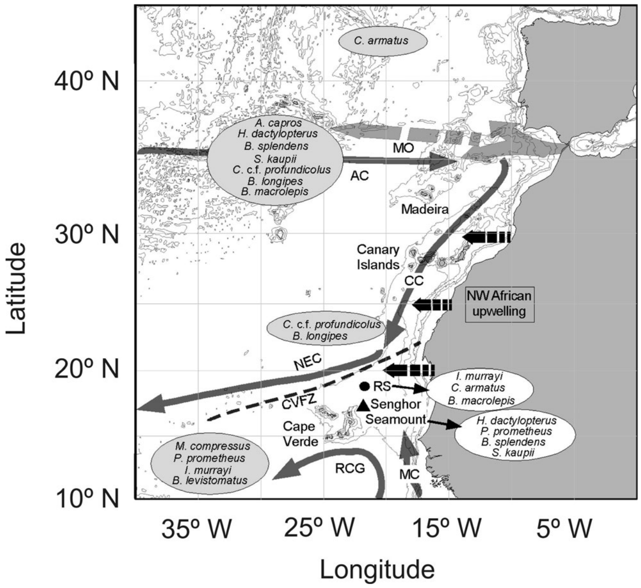

Fig. 4 Locations of Senghor Seamount and the reference site (RS) in the eastern Atlantic with schematic surface circulation, NW African upwelling zones and fish assemblages. Representative fish species caught at Senghor Seamount and the abyssal plain are grouped according to their common distribution in the eastern Atlantic (see text for literature) and arranged according to depth of occurrence within one assemblage. *AzC* Azores Current, *CC* Canary Current, *CVFZ* Cape Verde Frontal Zone, *MO* Mediterranean Outflow, *NEC* North Equatorial Current, *RCG* Recirculation Gyre

responsible for the observed differences in species composition between the deep-sea fish assemblages, due to differences in food supply and feeding preferences. However, the patterns involving distribution and connectivity among the different deep-sea fish assemblages of the eastern Atlantic seamount populations are still poorly known or are limited to commercially valuable species (White et al. 2009; Carlsson et al. 2011; Varela et al. 2013).

Since there is still little knowledge about the reproduction of the common deep-water species *C. armatus*, the collection of the nine adult *C. armatus* females with large ovaries containing ripening oocytes in our samples is remarkable. The only record of *C. armatus* with ripe or close to ripe eggs was reported by Stein (1985) for individuals larger than 74 cm TL. The female with the ripest eggs was 96 cm long. The author concluded that 1) only very large females become sexually mature, 2) reproduction may not be simultaneous within one population, because not all females with ripening eggs were at the same stage of ovarian development, and 3) the reproduction of the species may be semelparous. In our collection, *C. armatus* females with ripening eggs were smaller in size, ranging from 54.5 to 83.0 cm TL (corresponding to 610–3280 g TW), which may challenge the hypotheses made by Stein (1985). Our findings, rather, support the assumption that *C. armatus* females can mature at medium size (probably with simultaneous reproduction), making semelparous reproduction very unlikely.

Conclusions

In our study, the area around Senghor Seamount is shown to be a transition between northern and southern Atlantic fauna (Fig. 4), underscoring the role of the Cape Verde archipelago in a broader biogeographic context. The similarity between the demersal fauna of Senghor Seamount and that of subtropical NE Atlantic seamounts supports the role of seamounts as "stepping stones" for oceanic dispersal of benthopelagic fishes, particularly typical shelf and slope species, across large distances—for example, between continental margins and mid-ocean ridges. The relatively high number of new records for the area at the reference station, including rarely caught species, just indicates that abyssal and bathyal depths are undersampled in the tropical eastern Atlantic.

Acknowledgments The authors would like to thank the crew of the RV *Meteor* and RV *Poseidon* for their professional support on the cruises, and Ralf Thiel (Zoological Museum, Universität Hamburg) for his valuable advice. An anonymous reviewer made important comments, which helped to improve the manuscript considerably.

Compliance with ethical standards

Financial support Rui Pedro Vieira received financial support from CCMAR and funds from DAAD - Deutscher Akademischer Austauschdienst (German Academic Exchange Service) for a short-term scholarship at the IHF – Universität Hamburg (Germany). Rui Pedro Vieira is currently supported by a Portuguese doctoral grant (FCT/SFRH/BD/84030/2012) and partially by European Funds through COMPETE and by National Funds through the Portuguese Science Foundation (FCT) within project PEst-C/MAR/LA0017/2013. Rui Coelho is supported by an Investigador-FCT contract from the Portuguese Science Foundation (FCT, *Fundação para a Ciência e Tecnologia*) supported by the EU European Social Fund and the Programa Operacional Potencial Humano (Ref: IF/00253/2014). The Deutsche Forschungsgemeinschaft (DFG) provided the ship time and financial support for the *Meteor* cruise M79/3, and the Universität Hamburg for the *Poseidon* cruise P423.

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