Helgol Mar Res (2015) 69:13–23
DOI 10.1007/s10152-014-0413-4

ORIGINAL ARTICLE

The fish fauna of Ampère Seamount (NE Atlantic) and the adjacent abyssal plain

Bernd Christiansen · Rui P. Vieira · Sabine Christiansen · Anneke Denda · Frederico Oliveira · Jorge M. S. Gonçalves

Received: 26 March 2014 / Revised: 15 September 2014 / Accepted: 24 September 2014 / Published online: 2 October 2014

Abstract An inventory of benthic and benthopelagic fishes is presented as a result of two exploratory surveys around Ampère Seamount, between Madeira and the Portuguese mainland, covering water depths from 60 to 4,400 m. A total of 239 fishes were collected using different types of sampling gear. Three chondrichthyan species and 31 teleosts in 21 families were identified. The collections showed a vertical zonation with little overlap, but indications for an affinity of species to certain water masses were only vague. Although most of the species present new records for Ampère Seamount, all of them have been known for the NE Atlantic; endemic species were not found. The comparison with fish communities at other NE Atlantic seamounts indicates that despite a high ichthyofaunal similarity, which supports the "stepping stone" hypothesis of species dispersal, some differences can be attributed to the local features of the seamounts.

Keywords Deep sea · Fish distribution · Ichthyofauna · Seamounts · Zoogeography

Communicated by H-D. Franke.

B. Christiansen (✉) · A. Denda
Institut für Hydrobiologie und Fischereiwissenschaft, Universität Hamburg, Große Elbstraße 133, 22767 Hamburg, Germany
e-mail: bchristiansen@uni-hamburg.de

R. P. Vieira · F. Oliveira · J. M. S. Gonçalves
CCMAR, Centre of Marine Sciences, University of Algarve, Campus de Gambelas, 8005-139 Faro, Portugal

R. P. Vieira
Departamento de Biologia and CESAM, Universidade de Aveiro, Aveiro, Portugal

Present Address:
R. P. Vieira
Ocean and Earth Science, National Oceanography Centre, European Way, Southampton SO14 3ZH, UK

S. Christiansen
Slipstek 41, 21129 Hamburg, Germany

Introduction

Due to their vertical range and habitat diversity, seamounts often support high fish diversity, as compared to the surrounding ocean, and some are known as hotspots of endemic species (e.g. Shank 2010; Stocks et al. 2012). Seamounts are considered to act as "stepping stones" for species dispersal (Almada et al. 2001; Ávila and Malaquias 2003; Santos et al. 1995; Shank 2010; Xavier and van Soest 2007), bridging large oceanic areas in particular for shelf and slope dwelling species. Recently, studies of seamount ecosystems have received a great deal of attention by the scientific community, due to their role as habitat providers for benthopelagic fishes and important spots for great pelagics (e.g. Clark et al. 2010; Morato et al. 2010). There is an ongoing concern that seamount stocks are overfished, and fishing is impairing the benthic communities (e.g. Clark 2001; 2010; Clark and Koslow 2007; Clark and Rowden 2009; Clark et al. 2006; Norse et al. 2012).

Little has been known about the ichthyofauna at most NE Atlantic seamounts, in particular in the deeper regions. Although commercial fisheries have targeted many banks and seamounts, detailed scientific studies of the demersal and benthopelagic fish fauna are available only for a few of them. In particular, extensive sampling programmes were conducted at Great Meteor Bank and other seamounts south of the Azores (Ehrich 1977; Kukuev 2004; Maul 1976 and literature cited therein), and at Seine and Sedlo

Seamounts (Christiansen et al. 2009; Menezes et al. 2009, 2012). Knowledge of the fish communities at Ampère Seamount is currently based on visual observations by Russian researchers covering the upper and middle slopes, but there is also anecdotal evidence that Ampère Seamount is a fishing ground for commercially valuable species, such as the black scabbardfish *Aphanopus carbo* (Bordalo-Machado et al. 2009) and the silver scabbardfish *Lepidopus caudatus* (personal observation).

The fish survey at Ampère Seamount reported here was part of a comprehensive, multidisciplinary sampling programme, which also included hydrography, phyto- and zooplankton, benthos, biogeochemistry and sedimentology. The studies aimed at an advanced understanding of the seamount ecology, in comparison with other seamounts in the NE Atlantic and the Eastern Mediterranean, and addressed, for example, the relationships between flow field and plankton distribution, fluxes of organic matter, the trophic structure and the biodiversity of benthic and pelagic seamount communities. First results show that the oligotrophic nature of the sea area around Ampère is reflected in low zooplankton standing stocks, with no indications of an enhanced biomass at the seamount as compared to the surrounding ocean (Denda and Christiansen 2013). The major aim of the fish studies conducted on the P384 cruise of R.V. Poseidon and the M83/2 cruise of R.V. Meteor was to characterize the benthopelagic fish community at different depths, using various fishing gears and considering several locations at and around Ampère Seamount, including the summit, the slopes and an abyssal reference station. The results are compared to fish assemblages found at other NE Atlantic seamounts.

Materials and methods

Study area

Ampère Seamount is part of the Horseshoe Seamounts Chain and located at 35°N, 13°W between the island of Madeira and the Portuguese southern coast, to the west of the Exclusive Economic Zone of Morocco (Fig. 1). Ampère rises from a base depth of ca. 4,500 to 55 m below the surface. It is separated from the neighbouring Coral Patch Seamount by a deep valley of 3,400 m depth. The seamount has a conical shape with an elongated base and a small, rough summit plateau at 110–200 m, with a single narrow peak reaching to 55 m (Fig. 2). The slopes are steep and rocky with canyon-like structures particularly at the northern, eastern and southern sides (Halbach et al. 1993; Hatzky 2005; Kuhn et al. 1996), but sediment-covered flat areas exist as well. For comparison, a reference

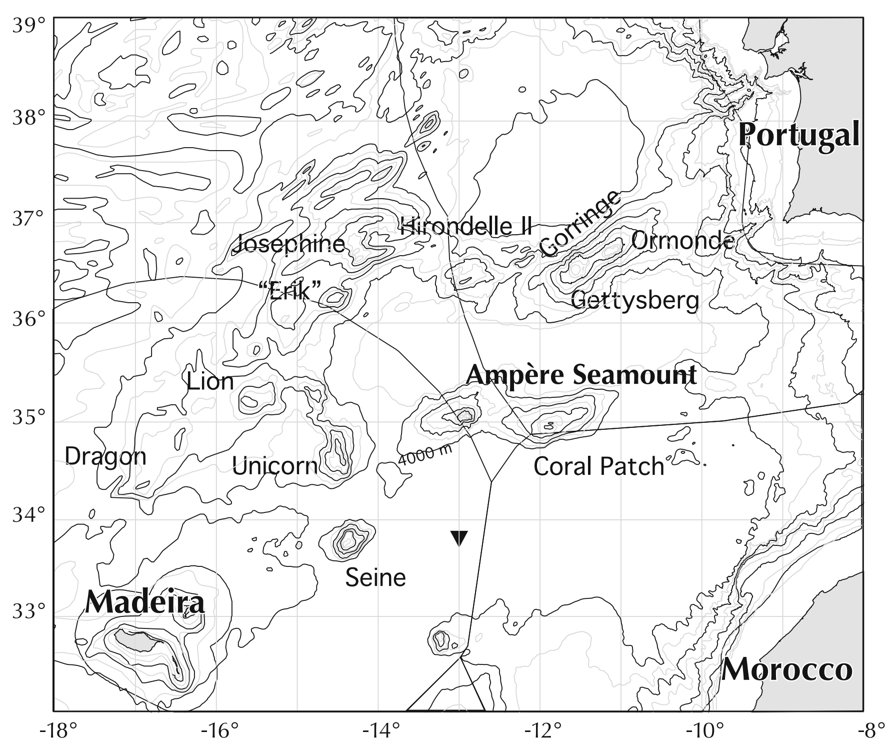

Fig. 1 The Horseshoe seamount chain. The location of the reference station south of Ampère Seamount is marked by a triangle. Depth contour interval 500 m. Bathymetric data source: GEBCO (IOC et al. 2003)

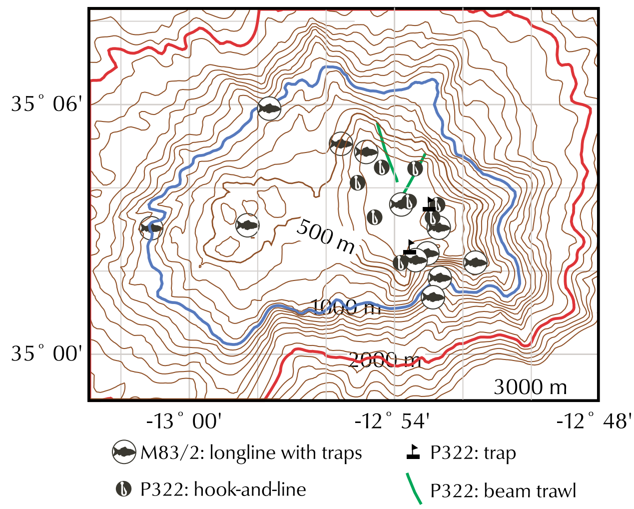

Fig. 2 Central area of Ampère Seamount with locations of stationary fishing gear and beam trawl tracks during cruise M83/2. Credit bathymetric data: J. Hatzky, AWI

station on a flat, sedimentary abyssal plain in 4,400 m depth, located ca. 70 nm south of Ampère Seamount at 33°56′N, 013°16′W, was also sampled (Fig. 1).

Sampling

The inventory of demersal fishes on Ampère Seamount was derived from sampling during the P384 cruise of R.V. Poseidon in May 2009 and the M83/2 cruise of R.V. Meteor in November/December 2010, using hooks-and-line, longlines, baited traps, beam trawl and otter trawl. The variety of sampling methods aimed at broadening the collection of fishes caught to several feeding types. However, the rough and steep terrain of the seamount made benthopelagic trawling in the upper 2,000 m extremely risky and led to the damage of the beam trawl during all tows and to the complete loss of one beam trawl. The otter trawl was deployed only below 2,000 m. Stationary fishing gears (longlines, hook-and-line and traps) were used down to a maximum depth of 1,200 m, except for small traps which were exposed in connection with lander deployments at 1,700–2,200 m.

During the P384 cruise, hook-and-line fishing was performed opportunistically in the vicinity of the summit area at depths between 70 and 213 m (Fig. 2). Different hooks and various types of bait were used, including commercial fish lures, aluminium foil and pieces of sardines. Fish traps (“Madeira type”, Fig. 3; Biscoito 1993) were baited with sardines and deployed for several hours, also in the summit area. A 2-m beam trawl with 6-mm mesh (see Christiansen et al. 2009 for details) was towed twice at 123–133 m depth on the summit plateau (Fig. 2); bottom time was 10–15 min each.

During the M83/2 cruise, a total of 12 demersal longline sets were deployed between 60 m and 1,200 m depth on the summit and on the upper slopes of the seamount (Fig. 2; Table 1). The basic design of the longline sets is shown in Fig. 4. From the third deployment on, a drift anchor was used instead of the weight at the end of the longline. In haul 7, a different design using 30 m long branch lines with 10 snoods each was employed, similar to the longline “Type B” used by Menezes et al. (2009). In hauls 8–12, small buoys and weights were alternately attached to the main rope every 10 hooks. A total of 48–83 hooks of different size (straight # 3 and # 6; twisted # 6/0 and # 8/0) per set were baited with mackerels and sardines, and up to 8 traps of different design (Madeira-type fish trap, eel trap, crab trap and flatfish trap; Fig. 3) were attached either to the anchor weight or to the end of the main rope. Soak time was usually 5–6 h. Of the 12 longline/trap deployments, one longline was completely entangled and did not fish, and two longlines were lost. The total number of recovered hooks was ca. 500. Small traps made from 1.5-l plastic bottles were also attached to a lander system in four deployments at depths from 1,700 to 2,172 m.

A 15-m semiballoon otter trawl was towed on a single warp at 2–3 knots on the western lower slope of the seamount (approximately 2,000–2,100 m depth, bottom time approximately 30 min) and on the abyssal plain at the reference station south of Ampère Seamount (two hauls, both at 4,415 m depth, bottom time approximately 180 and 120 min, respectively). The estimated horizontal net opening of the trawl was 8.6 m; the mesh size was 44 mm in the front part and 37 mm in the intermediate and rear parts, with a 13-mm inner liner in the cod end.

Immediately after recovery of the catch, specimens were identified to the lowest taxonomic level possible using the keys in Whitehead et al. (1986). Total and standard lengths and weights of all specimens were measured and, where possible, stomachs were dissected and tissue samples taken for later analysis of DNA and isotopic ratios. Fishes from cruise P384 could not be landed due to lack of freezing facilities during transport, whereas all fishes from M83/2 were frozen at −20 °C to be transported to the University of Hamburg. Here, the on-board identifications were checked using a variety of taxonomic keys and descriptions (Franco et al. 2009; Froese and Pauly 2013; Nielsen et al. 1999; Sulak 1977; Sulak and Shcherbachev 1997; Whitehead et al. 1986). Less common species are being finally deposited at the Zoological Museum, Hamburg.

Results

The list of fishes (Table 2) collected at Ampère Seamount includes a total of 239 specimens (pelagic bycatch in the otter trawl not included). Thirty-four species belonging to

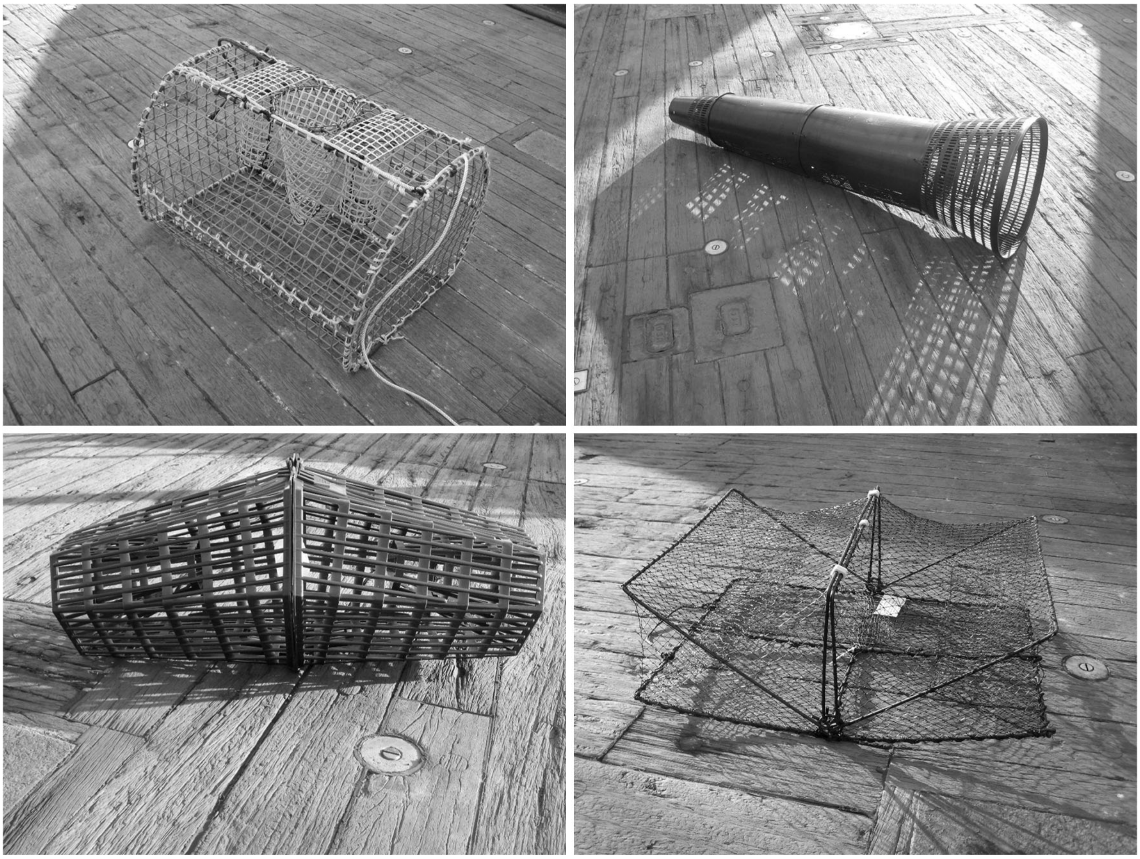

Fig. 3 Trap types used during cruises P322 and M83/2. *Upper left* “Madeira type” (Biscoito 1993); *upper right* “Apollo” eel trap; *lower left* crab trap; *lower right* flatfish trap

23 families were identified. Three species were Chondrichthyes, and 31 were Actinopterygii. Perciformes (seven species), Anguilliformes and Gadiformes (five species each) were the most speciose orders in the collections.

The collections showed a vertical zonation with little overlap. The upper depth guild, which included longline, hook-and-line, trap and beam trawl catches from 60 to 300 m, was the most diverse and comprised a total of 11 species belonging to 10 families. The most frequently caught species were the pelagic or benthopelagic horse mackerel *Trachurus picturatus* with 16 specimens, silver scabbard fish *Lepidopus caudatus* with 13 species, and the two mackerel species, *Scomber colias* and *Scomber scombrus* with 11 and 10 specimens, respectively. The scorpionfish *Pontinus kuhlii* (9 specimens), the Mediterranean moray *Muraena helena* (7) and the blacktailed comber *Serranus atricauda* (6) were also relatively abundant in the catches, whereas the other species were rare with only two or three specimens each.

The next depth guild from 300 to 500 m was covered by longline and traps. A total of five species were captured in this depth range including *Trachurus picturatus*, which was also caught above 300 m. Apart from the blackbelly rosefish *Helicolenus dactylopterus* with five specimens, only single fishes were caught from each family.

Longlines and traps were also employed between 900 and 1,200 m. The predominant species in this depth layer was the common mora *Mora moro* with 37 specimens. Further, a few specimens of the black scabbardfish *Aphanopus carbo*, Kaup’s arrowhead *Synaphobranchus kaupii*, and two shark species, the birdbeak dogfish *Deania calcea* and the smooth lanternshark *Etmopterus pusillus*, were captured.

Synaphobrancus. kaupii, was also caught on the lower slope of the seamount at about 2,000 m, where it was the predominant species in the otter trawl catch with 30 individuals, corresponding to nearly 75 % of all specimens. Other families included Alepocephalidae, Bythitidae, Ipnopidae, Ophidiidae and Halosauridae with one species and 1–3 specimens each. The small traps attached to the lander system at 1,700 m in two deployments captured six specimens of the Synaphobranchidae *Simenchelys parasitica*.

A total of 11 species were collected in the otter trawl on the abyssal plain at a depth of ca. 4,400 m. The most abundant families were Macrouridae with 26 specimens (3 species), Ipnopidae with 22 specimens (3 species) and

Table 1 Features of the longline deployments during cruise M83/2

Depl. no	Station no	Depth (m)	Position	No hooks	No traps	Observations
LL1	1,094	314	Upper slope SE	52	5	
LL2	1,095	444	Upper slope S	52		Entangled, not fishing
LL3	1,111	160	Rim NW	48	8	
LL4	1,112	490	Upper slope NW	49	8	
LL5	1,183	60	Peak	52	7	36 Hooks recovered. traps lost
LL6	1,184	330	Upper slope S			Rope snapped
LL7	1,195	127	Summit plateau	60	2	
LL8	1,216	938	Middle slope S	83	2	42 Hooks recovered
LL9	1,228	991	Middle slope NW	55	5	
LL10	1,257	416	Upper slope W	60	3	
LL11	1,271	981	Middle slope W			Lost
LL12	1,288	1,200	Middle slope S	55	2	

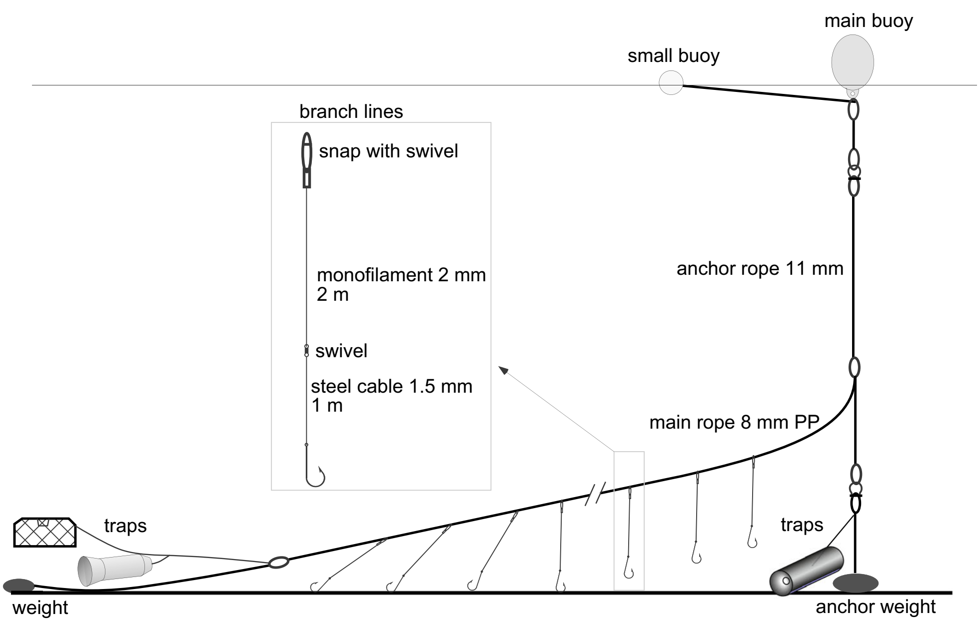

Fig. 4 Basic design of the longline used during cruise M83/2

Alepocephalidae with 12 specimens (2 species). The families Synaphobranchidae and Ophidiidae were caught with one species and one specimen each. The most common species were the abyssal grenadier *Coryphaenoides armatus* and the abyssal spiderfish *Bathypterois longipes*, with 15 specimens each. One species was found in the otter trawl collections from both 2,400 and 4,400 m, the salmon smooth-head *Conocara salmoneum*.

In addition to the benthopelagic species, the otter trawl also collected pelagic species. Only a few particularly rare pelagic species have been analysed in detail so far, such as the first record in the North Atlantic of the cetomimid *Cetichthys indagator* (Vieira et al. 2012) and two large females of the anglerfish *Gigantactis vanhoeffeni*, and one unidentified *Gigantactis* female, which represent, to our best knowledge, the first records of adult *Gigantactis* females in the region (Bertelsen 1986; Santos et al. 1997; Swinney 1995).

Discussion

Contrary to the relatively well-known fish fauna of seamounts and islands around the Azores and Madeira (Arkhipov et al. 2004; Christiansen et al. 2009; Ehrich 1977; Kukuev 2004; Maul 1976; Menezes et al. 2006, 2009, 2012; Pakhorukov 2008; Santos et al. 1997; Shcherbachev et al. 1985), the ichthyofauna of the Horseshoe Seamount

Table 2 Fishes collected at and around Ampère Seamount, arranged according to depth of occurrence

Species	Order	Family	*N*	Gear	Min depth (m)	Max depth (m)	Size (mm)
Muraena helena	Anguilliformes	Muraenidae	7	LL,T	60	164	940–1,100 TL
Lepidopus caudatus	Perciformes	Trichiuridae	13	LL,HL	73	180	790–1,380 SL
Serranus atricauda	Perciformes	Serranidae	6	LL,HL	75	213	210–375 SL
Trachurus picturatus	Perciformes	Carangidae	16	LL,HL	106	489	275–375 SL
Coris julis	Perciformes	Labridae	2	T	127	127	125–145 SL
Scomber scombrus	Perciformes	Scombridae	10	LL	127	164	335–415 SL
Scomber colias	Perciformes	Scombridae	11	LL,HL	127	180	310–480 SL
Callanthias ruber	Perciformes	Callanthiidae	2	BT	134	177	60–70 SL
Capros aper	Zeiformes	Caproidae	2	BT	134	177	90–110 SL
Pontinus kuhlii	Scorpaeniformes	Scorpaenidae	9	LL,HL,BT,T	164	170	150–330 SL
Conger conger	Anguilliformes	Congridae	3	LL, T	164	314	735–1,305 TL
Helicolenus dactylopterus	Scorpaeniformes	Sebastidae	5	LL,T	314	489	125–275 SL
Malacocephalus laevis	Gadiformes	Macrouridae	1	LL	420	420	250 TL
Dipturus batis[a]	Rajiformes	Rajidae	1	LL	420	420	580 TL
Zenopsis conchifer	Zeiformes	Zeidae	1	LL	489	489	705 SL
Aphanopus carbo	Perciformes	Trichiuridae	2	LL	938	938	1,000–1,080 SL
Deania calcea	Squaliformes	Centrophoridae	5	LL	938	992	570–890 TL
Mora moro	Gadiformes	Moridae	37	LL,T	938	1,200	300–585 TL
Etmopterus pusillus	Squaliformes	Etmopteridae	2	LL	992	992	395–430 TL
Synaphobranchus kaupii	Anguilliformes	Synaphobranchidae	30	LL,OT,T	992	2,050	335–730 TL
Simenchelys parasitica	Anguilliformes	Synaphobranchidae	6	T	1,700	1,700	n.a.
Bathypterois grallator	Aulopiformes	Ipnopidae	1	OT	2,050	2,050	295 SL
Halosauropsis macrochir	Notacanthiformes	Halosauridae	3	OT	2,050	2,050	550–640 TL
Cataetyx laticeps	Ophidiiformes	Bythitidae	1	OT	2,050	2,050	645 SL
Bajacalifornia megalops	Osmeriformes	Alepocephalidae	1	OT	2,050	2,050	480 SL
Conocara salmoneum	Osmeriformes	Alepocephalidae	7	OT	2,050	4,416	250–720 SL
Histiobranchus bathybius	Anguilliformes	Synaphobranchidae	1	OT	4,416	4,416	1,210 SL
Bathypterois sp.	Aulopiformes	Ipnopidae	1	OT	4,416	4,416	125 TL
Holcomycteronus squamosus	Ophidiiformes	Ophidiidae	1	OT	4,416	4,416	375 SL
Bathymicrops regis	Aulopiformes	Ipnopidae	6	OT	4,416	4,419	90–110 SL
Bathypterois longipes	Aulopiformes	Ipnopidae	15	OT	4,416	4,419	65–195 SL
Coryphaenoides armatus	Gadiformes	Macrouridae	15	OT	4,416	4,419	660–860 TL
Coryphaenoides profundicolus	Gadiformes	Macrouridae	7	OT	4,416	4,419	270–410 TL
Coryphaenoides sp.	Gadiformes	Macrouridae	2	OT	4,416	4,419	540–665 TL
Echinomacrurus mollis	Gadiformes	Macrouridae	2	OT	4,416	4,419	50–205 TL
Rinoctes nasutus	Osmeriformes	Alepocephalidae	5	OT	4,416	4,419	125–195 SL

Gear abbreviations: *HL* hook-and-line, *LL* longline, *T* trap, *BT* beam trawl, *OT* otter trawl. Size abbreviations: *SL* standard length, *TL* total length

[a] The taxonomic status of *D. batis* is currently under discussion. *D. batis* may actually consist of two nominal species, *D.* cf. *flossada* and *D.* cf. *intermedia* (Iglésias et al. 2010)

Chain (Fig. 1) and in particular of Ampère Seamount has been little studied until now. Visual observations were conducted on the summit area of Gorringe Bank (Abecasis et al. 2009; Gonçalves et al. 2004) and on the upper and middle slopes at Ampère Seamount and Josephine Bank; the latter was also trawled (Pakhorukov 2008). Recently, Wienberg et al. (2013) reported some fish species at Coral Patch Seamount from ROV observations above the middle slope.

The results presented here increase the number of fish species described from Ampère seamount substantially. Most of the 34 species collected at and around the

Table 3 Inventory of fish species recorded at Ampère Seamount from the present study (C) and from Pakhorukov (2008, P), and comparative occurrences and depth ranges at NE Atlantic seamounts

Species	Ampère		JB	GB	SS	SSAz	Depth range (m) at NE Atlantic smts		Water mass
	C	*P*					Min	Max	
Muraena helena	X			X			60	164	ENACW
Serranus atricauda	X			X			75	213	
Coris julis	X			X			127	127	
Scomber scombrus	X			X			127	164	
Macrorhamphosus scolopax		X	X	X	X	X	50	380	
Anthias anthias		X		X	X	X	50	390	
Antigonia capros		X	X			X	50	620	
Callionymus spp.		X	X			X	100	480	
Trachurus picturatus	X	X	X		X	X	100	500	
Hyperoglyphe sp.		X				X	125	600	
Scomber colias	X		X		X	X	127	330	
Callanthias ruber	X	X	X		X	X	134	345	
Capros aper	X		X	X	X	X	134	620	
Bothidae		X	X	X	X	X	160	340	
Pontinus kuhlii	X				X		160	350	
Zenopsis conchifer	X				X	X	160	489	
Conger conger	X			X	X		160	550	
Raja sp.		X	X	X	X		180	180	
Lophius piscatorius		X					200	450	
Malacocephalus laevis	X	X	X		X	X	420	420	
Dipturus batis[1)]	X						420	420	
Beryx splendens		X			X	X	27	1,200	MOW
Polyprion americanus		X			X	X	50	1,000	
Lepidopus caudatus	X	X	X		X	X	73	1,000	
Helicolenus dactylopterus	X	X	X	X	X	X	180	760	
Hoplostethus mediterraneus		X	X			X	200	1,200	
Hymenocephalus gracilis		X				X	260	1,200	
Setarches guentheri		X	X			X	300	1,140	
Epigonus telescopus		X			X	X	400	900	
Maurolicus amethystinopunctatus		X				X	430	1,100	
Deania calcea	X	X	X		X	X	480	1,400	
Argyropelecus aculeatus		X				X	500	1,000	
Etmopterus pusillus	X				X	X	500	1,200	
Mora moro	X		X		X	X	500	1,300	
Aphanopus carbo	X			X	X	X	500	1,600	
Ruvettus pretiosus		X					760	900	
Alepocephalus bairdi		X				X	980	1,200	
Synaphobranchus kaupii	X				X		550	2,050	Bathyal NADW
Simenchelys parasitica	X				X		1,700	1,700	
Bajacalifornia megalops	X						2,050	2,050	
Cataetyx laticeps	X						2,050	2,050	
Halosauropsis macrochir	X						2,050	2,050	
Bathypterois grallator	X						2,050	2,050	
Conocara salmoneum	X						2,050	4,416	Abyssal NADW/ANBW
Holcomycteronus squamosus	X						4,416	4,416	
Histiobranchus bathybius	X						4,416	4,416	
Bathymicrops regis	X					X	4,300	4,419	
Bathypterois longipes	X					X	4,300	4,419	
Rinoctes nasutus	X						4,416	4,419	
Coryphaenoides armatus	X						4,416	4,419	
Coryphaenoide profundicolus	X						4,416	4,419	
Echinomacrurus mollis	X						4,416	4,419	

This study; Abecasis et al. (2009), Christiansen et al. (2009), Ehrich (1977), Menezes et al. (2009), Pakhorukov (2008), Shcherbachev et al. (1985)

JB Josephine Bank, *GB* Gorringe Bank, *SS* Seine Seamount, *SSAz* seamounts south of the Azores

[a] See remark in Table 2

seamount in this study are widely distributed in the Atlantic and in the Mediterranean (e.g. Froese and Pauly 2013; Haedrich and Merrett 1988; Menezes et al. 2006, 2009, 2012; Merrett 1992; Merrett and Marshall 1981; Pakhorukov 2008). Endemic species were not found. Except for the abyssal fishes *Conocara salmoneum*, *Bathymicrops regis*, *Coryphaenoides profundiculus* and *Echinomacrurus mollis*, all species have also been reported from waters around the Azores (Menezes et al. 2006, 2012; Santos et al. 1997). Of all species listed here, *Conocara salmoneum* is reported explicitly in Portuguese waters for the first time, but data from Merrett (1992) already suggest its presence in the Madeiran EEZ.

In the 1980s, Soviet investigators surveyed Ampère Seamount together with Josephine Bank and most of the seamounts south of the Azores down to 1,200 m depth by a submersible, the so-called underwater inhabited device (UID), and partly also with bottom trawls (Pakhorukov 2008). Table 3 lists all fish species at Ampère Seamount reported from Pakhorukov (2008) and the present study. Species are organized according to the main depth of catch/observation in these studies and include occurrence and depth range at other NE Atlantic seamounts. The resulting inventory comprises a total of 52 identified species of benthic and benthopelagic fishes. From the visual observations at Ampère, Pakhorukov (2008) reports of 24 fish species, complemented by observations of their behaviour and the type of habitat. Only 6 of these species were recovered in this study, but on the other hand, an additional

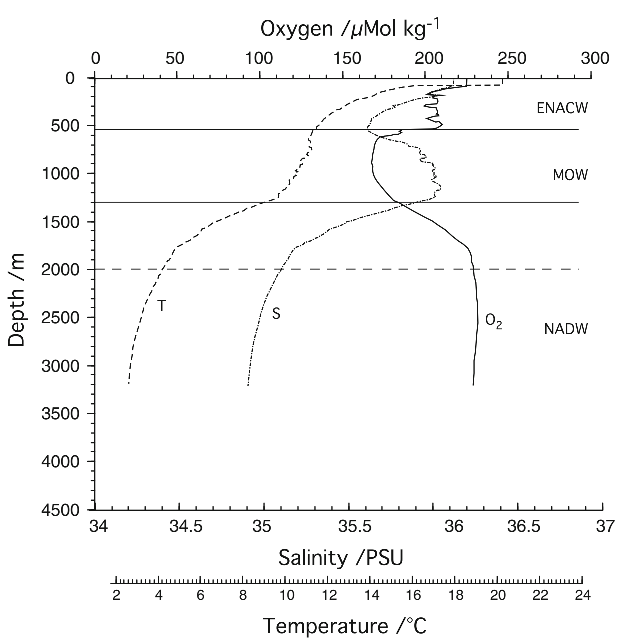

Fig. 5 Profiles of temperature, salinity and oxygen concentration at the southern slope of Ampère Seamount

14 species were found between summit and middle slope at 1,200 m. On the lower slope and surrounding abyssal plain at 1,700, 2,050 and 4,400 m depth, a further 14 species add to the ichthyocoenoses of Ampère Seamount. The little overlap between Pakhorukov's (2008) and the results from this study in the upper layers points to the importance of applying a wide variety of methods in order to assess the ichthyofauna as completely as possible.

The results from this study suggest a clear vertical zonation of the fishes at Ampère; however, part of this can probably be attributed to the rather small sample size and the few discrete sampling depths in our study, particularly in the upper 1,200 m. Information which includes depth ranges at other NE Atlantic seamounts shows that many of the same species occur along a wide depth range (Table 3), thus, making the allocation of single species to vertically discrete assemblages difficult.

Menezes et al. (Menezes et al. 2006, 2009 and literature quoted therein) identified vertically structured fish assemblages around the Azores archipelago and at Seine Seamount and related them to the water mass properties in the areas. During the Meteor cruise in December 2010 (Christiansen et al. 2012), Eastern North Atlantic Central water (ENACW; 10–20 °C, 35.2–36.7 °C) characterized the upper 500 m below a 50–80 m thick, warm mixed layer. Between 600 and 1,300 m depth Mediterranean Outflow Water (MOW; 13 °C, 38.4 PSU) was found, and underneath a mixing zone from 1,400 to 2,000 m, North Atlantic Deep water (NADW; 1.5–4 °C, 34.8–35 PSU) and probably Antarctic Bottom water (ANBW) formed the water layers in the lower bathyal and abyssal zones (Fig. 5).

Both the summit and upper slope regions of Ampère Seamount down to about 600 m are under influence of the Eastern Atlantic Central Water/Azores current. The benthic and benthopelagic fish communities in this depth stratum comprise 35 species (Table 3). Among this shallow fish community, 21 fish species seem to occur exclusively in this depth range, with four species being confined to the summit area down to 200 m. The remaining 14 species, including commercially exploited fish like alfonsino *Beryx splendens* Lowe, silver scabbardfish *Lepidopus caudatus* and silver roughy *Hoplostethus mediterraneus*, have also been found deeper in the Mediterranean Outflow water between 600 and 1,300 m. Only two species, *Ruvettus pretiosus* and *Alepocephalus bairdii*, seem to be restricted to this water mass of Mediterranean origin; however, this is based on only a small number of observations and should be judged with some caution. Generally, indications for an affinity of species to certain water masses are vague. Most of the fishes on the upper and middle slope of Ampère Seamount occur in a wide range of temperatures, salinities and oxygen concentrations.

The majority of the shallower species at Ampère were found in common with Gorringe Bank on the northern arc of the Horseshoes seamounts: *Conger conger*, *Muraena helena*, *Capros aper*, *Coris julis* and *Serranus atricauda*. However, *Pontinus kuhlii* (also observed at Seine and Great Meteor, Christiansen et al. 2009; Ehrich 1977; Menezes et al. 2009) and the widely distributed *Lepidopus caudatus,* which has been known from other NE Atlantic seamounts like the neighbouring Seine and Josephine and the more southern Great Meteor, Atlantis, Flamingo and Hyères (Ehrich 1977; Menezes et al. 2009; Pakhorukov 2008), were not observed at Gorringe (Abecasis et al. 2009), see Table 3. On the other hand, several species common at Gorringe were not found at Ampère, most of them being littoral fishes like Blenniidae or Labridae. However, the survey at Gorringe employed visual observations from divers and covered only the peaks at depths from 29 to 50 m, so the different methodologies involved do not allow for a comprehensive comparison of the fish communities between these seamounts, and *Lepidopus caudatus*, for example, has been known from commercial catches in the Gorringe area.

The upper and mid-slope collections included species that are usually found at the continental and island slopes, and, with the exception of the blue skate *Dipturus batis* (taxonomic status of this species is under discussion, see Iglésias et al. 2010), have been reported also from other seamounts in the NE Atlantic (Table 3). In particular, *Helicolenus dactylopterus*, *Aphanopus carbo*, *Mora moro* and *Deania calcea* have been observed at several seamounts in the Horseshoe region and to the north and south of the Azores (Abecasis et al. 2009; Menezes et al. 2009; Pakhorukov 2008). *Synaphobranchus kaupii* were also observed at Seine and Sedlo Seamounts (Menezes et al. 2009), but not at other Horseshoe seamounts or at seamounts south of the Azores, which is probably due to the limited depth range of the samples there, since Almeida and Biscoito (2007) reported their presence at the Lucky Strike vent field on the mid-Atlantic Ridge south of the Azores.

Due to the depth limitation to 1,200 m in the observations of Pakhorukov (2008), the ichthyocoenoses found in this study on the lower slope of Ampère (1,700 and ~2,000 m depth) and on the adjacent deep-sea abyssal plain (4,400 m) supplement the species described from the regional seamounts substantially. With the exception of *Cataetyx laticeps*, which is restricted to the Atlantic and Mediterranean, all of the fishes caught on the lower slope are species with a circumglobal distribution (Froese and Pauly 2013). They are usually found at bathyal depths, often with a wide depth range. However, no overlap was observed with the upper/mid-slope species, except for the predominating species on the lower slope of Ampère, *Synaphobranchus kaupii*, which has been reported, for example, from Porcupine Seabight at depths from 230 to 2,420 m (Merrett et al. 1991).

The Alepocephalidae *Conocara salmoneum* was the only species present on both the lower slope and the abyssal plain adjacent to Ampère Seamount. The fishes found here are typical abyssal species belonging to the northern and intermediate deep-sea fish assemblages as proposed for the NE Atlantic by Merrett (1992). Only the Ophidiidae *Holcomycteronus squamosus* was not included in those assemblages, but it is a particularly rare species known from a few scattered locations in the North Atlantic, with a certainly incomplete distribution record.

Despite the general similarities of the ichthyofaunal assemblages of the Northeast Atlantic seamounts, the comparisons also show some differences. These can partly be attributed to differing methodologies, as already indicated above, and to sampling effort. For example, the higher number of species collected with longlines by Menezes et al. (2009) at Seine Seamount is most probably due to the much higher fishing effort (>14,000 hooks at Seine Seamount, as compared to ca. 500 recovered hooks at Ampère), and to the deeper-reaching sets (max. 2,000 vs. 1,200 m). On the other hand, despite the differences in sampling effort, seven of the 20 species captured down to 1,200 m at Ampère Seamount in this study had not been collected at Seine (all gears considered). Apart from possible dissimilarities in gear selectivity, true differences between the two seamounts like summit depth, topography, substrate or coral cover may play a role. For example, most of the species missing at Seine, including *Muraena helena*, *Serranus atricauda*, *Coris julis* and *Capros aper*, were captured at depths shallower than the Seine summit plateau. Furthermore, the much more rugged topography with basaltic outcrops of the Ampère summit area, as compared to the flat, sedimentary summit plateau of Seine, may provide suitable habitat for species, such as the moray eel *M. helena*, which depend on or prefer richly structured, rocky substrate (e.g. Bauchot 1986).

The relatively similar inventory of shelf and slope fish species in the summit and upper slope regions of the seamounts of the Horseshoe Chain and of the seamounts around the Azores supports the hypothesis of these topographic features being “stepping stones” for species dispersal within the larger NE Atlantic region, possibly powered by the large-scale current system (Azores Current, Canary Current) and westward propagating meddies. This may also apply to the benthopelagic deep-water fishes found at the seamount slopes, which are also dependent on suitable substrate at appropriate depths. However, a higher sampling effort and the use of genetic tools will be necessary to evaluate the biogeographic significance of Ampère Seamount and to assess the biogeographic links between the NE Atlantic seamounts.

This effort will also be important for designing conservation and management measures in order to mitigate eventually unsustainable impacts of fishing activities on the commercially targeted species such as several species found at Ampère, which are important in the southern Portuguese longline fisheries (Borges 2007), like *Lepidopus caudatus*, *Aphanopus carbo*, *Mora moro*, *Helicolenus dactylopterus* and *Pontinus kuhlii*, and, usually restricted to coastal areas, *Conger conger* and *Muraena helena*.

In conclusion, the data show, despite the comparatively low sampling effort, that Ampère Seamount hosts a rich and diverse fish community. Generally, the seamounts in the subtropical NE Atlantic appear to be very similar with respect to their ichthyofauna. However, the differences, for example between the adjacent and relatively well-sampled Ampère and Seine Seamounts, point to the role of properties like substrate type and habitat complexity in shaping the final expression of community composition.

Acknowledgments We would like to thank the crews of RVs Meteor and Poseidon for their skilful support on the cruises. Shiptime and financial support were provided by the Deutsche Forschungsgemeinschaft and the Universität Hamburg. R. P. V. would like to thank DAAD—Deutscher Akademischer Austauschdienst (German Academic Exchange Service) in support of short-term scholarship for research in the IHF—Universität Hamburg (Germany) and CCMAR for the financial support. R. P. V. is currently supported by a doctoral grant from the Portuguese Science Foundation (SFRH/BD/84030/2012).

References

Abecasis D, Cardigos F, Almada F, Gonçalves JMS (2009) New records on the ichthyofauna of the Gorringe seamount (Northeastern Atlantic). Mar Biol Res 5(6):605–611. doi:10.1080/17451000902729696

Almada VC, Gonçalves EJ, Oliveira RF, Almeida AJ, Santos RS, Wirtz P (2001) Patterns of diversity of the north-eastern Atlantic Blenniid fish fauna (Pisces: Blenniidae). Glob Ecol Biogeog 10(4):411–422

Almeida AJ, Biscoito M (2007) New records of *Synaphobranchus* (Anguilliformes, Synaphobranchidae) from the Azores, (eastern Atlantic Ocean). Cybium 31(3):391–392

Arkhipov AG, Kozlov DA, Sirota AA, Shnar VN (2004) Structure of waters and distribution of fish at different ontogenetic stages around seamounts of the Central-Eastern Atlantic Ocean. Arch Fish Mar Res 51(1–3):201–214

Ávila SP, Malaquias MAE (2003) Biogeographical relationships of the molluscan fauna of the Ormonde Seamount (Gorringe Bank, Northeast Atlantic Ocean). J Mollusc Stud 69:145–150

Bauchot M-L (1986) Muraenidae. In: Whitehead PJP, Bauchot M-L, Hureau J-C, Nielsen J, Tortonese E (eds) Fishes of the Northeastern Atlantic and the Mediterranean, vol II. UNESCO Press, Paris, pp 537–544

Bertelsen E (1986) Gigantactinidae. In: Whitehead PJP, Bauchot M-L, Hureau J-C, Nielsen J, Tortonese E (eds) Fishes of the North-eastern Atlantic and the Mediterranean, vol III. UNESCO Press, Paris, pp 1406–1407

Biscoito M (1993) An account on the shrimps of the family Pandalidae (Crustacea, Decapoda, Caridea) in Madeiran waters. In Proceedings of the 5th Symposium “Fauna and Flora of the Cape Verde Islands”, Leiden, 4-7 October, 1989. Courier Forschungsinstitut Senckenberg 159:321–325

Bordalo-Machado P, Fernandes AC, Figueiredo I, Moura O, Reis S, Pestana G, Gordo LS (2009) The black scabbardfish (*Aphanopus carbo* Lowe, 1839) fisheries from the Portuguese mainland and Madeira Island. Sci Mar 73S2:63–76. doi:10.3989/scimar.2009.73s2063

Borges TC (ed) (2007) Biodiversity in fisheries off South Coast of Portugal (Algarve). MARE Research Programme, Impriluz, Lisbon

Christiansen B, Martin B, Hirch S (2009) The benthopelagic fish fauna of Seine Seamount, NE Atlantic: composition, population structure and diets. Deep-Sea Res II 56(25):2705–2712. doi:10.1016/j.dsr2.2008.12.032

Christiansen B, Albers L, Brand T, Chivers A, Christiansen H, Christiansen S, Denda A, Diniz T, George K-H, Irion I, Janßen T, Kaufmann M, Kullmann B, Lamont P, Molodtsova T, Montgomery J, Peine F, Schneehorst A, Schuster A, Springer B, Stahl H, Stefanowitsch B, Turner G, Turnewitsch R, Vieira R, Vogel S, Wehrmann H (2012) Biodiversity and biological production at a shallow NE Atlantic seamount (Ampère Seamount), 2010, METEOR-Berichte, Cruise No. M83/2. DFG-Senatskommission für Ozeanographie. doi:10.2312/cr_m83_2

Clark M (2001) Are deepwater fisheries sustainable? The example of orange roughy (*Hoplostetus atlanticus*) in New Zealand. Fish Res 51:123–135

Clark MR (2010) Effects of trawling on seamounts. Oceanogr 23:132–133

Clark MR, Koslow JA (2007) Impacts of fisheries in seamounts (chapter 19). In: Pitcher TJ, Morato T, Hart PJB, Clark MR, Haggan N, Santos RS (eds) Seamounts: ecology, fisheries and conservation. Blackwell Publishing, Oxford, pp 413–441

Clark MR, Rowden AA (2009) Effect of deepwater trawling on the macro-invertebrate assemblages of seamounts on the Chatham Rise, New Zealand. Deep-Sea Res I 56(9):1540–1554. doi:10.1016/j.dsr.2009.04.015

Clark MR, Tittensor D, Rogers AD, Brewin P, Schlacher T, Rowden A, Stocks K, Consalvey M (2006) Seamounts, deep-sea corals and fisheries: vulnerability of deep-sea corals to fishing on seamounts beyond areas of national jurisdiction. UNEP regional seas report and studies no 183. UNEP-WCMC biodiversity series no 25. UNEP-WCMC, Cambridge

Clark MR, Rowden AA, Schlacher T, Williams A, Consalvey M, Stocks KI, Rogers AD, O'Hara TD, White M, Shank TM, Hall-Spencer JM (2010) The ecology of seamounts: structure, function, and human impacts. Ann Rev Mar Sci 2(1):253–278. doi:10.1146/annurev-marine-120308-081109

Denda A, Christiansen B (2013) Zooplankton distribution patterns at two seamounts in the subtropical and tropical NE Atlantic. Mar Ecol. doi:10.1111/maec.12065

Ehrich S (1977) Die Fischfauna der Großen Meteorbank. Meteor Forsch Ergebn (D) 25:1–23

Franco MAL, Braga AC, Nunan GWA, Costa PAS (2009) Fishes of the family Ipnopidae (Teleostei: Aulopiformes) collected on the Brazilian continental slope between 11° and 23° S. J Fish Biol 75:797–815. doi:10.1111/j.1095-8649.2009.02324.x

Froese R, Pauly D (2013) FishBase. World Wide Web electronic publication. Version (06/2013)

Gonçalves JMS, Bispo J, Silva JA (2004) Underwater survey of ichthyofauna of eastern Atlantic seamounts: gettysburg and Ormond (Gorringe Bank). Arch Fish Mar Res 51(1–3):233–240

Haedrich RL, Merrett NR (1988) Summary atlas of deep-living demersal fishes in the North Atlantic Basin. J Nat Hist 22:1325–1362

Halbach P, Maggiulli M, Plieske B, Kuhn T (1993) Technical cruise report of RV Sonne cruise 83—Marflux 4. Freie Universität Berlin

Hatzky J (2005) Ampère Seamount. In: Wille PC (ed) Sound images of the ocean in research and monitoring. Springer, Berlin, pp 131–132

Iglésias SP, Toulhoat L, Sellos DY (2010) Taxonomic confusion and market mislabelling of threatened skates: important consequences for their conservation status. Aquatic Cons 20(3):319–333. doi:10.1002/aqc.1083

IOC, IHO, BODC (2003) Centenary edition of the GEBCO digital atlas, published on CD-ROM on behalf of the Intergovernmental Oceanographic Commission and the International Hydrographic Organization as part of the General Bathymetric Chart of the Oceans. British Oceanographic Data Centre. Available via British Oceanographic Data Centre

Kuhn T, Halbach P, Maggiulli M (1996) Formation of ferromanganese microcrusts in relation to glacial/interglacial stages in Pleistocene sediments from Ampere Seamount (Subtropical NE Atlantic). Chem Geol 130:217–232

Kukuev EI (2004) 20 years of ichthyofauna research on seamounts of the North-Atlantic Ridge and adjacant areas. A review. Arch Fish Mar Res 51(1–3):215–232

Maul GE (1976) The fishes taken in bottom trawls by R.V. "Meteor" during the 1967 seamounts cruises in the Northeast Atlantic. Meteor Forsch Ergebn (D) 22:1–69

Menezes G, Sigler MF, Silva HM, Pinho MR (2006) Structure and zonation of demersal fish assemblages off the Azores Archipelago (mid-Atlantic). Mar Ecol Prog Ser 324:241–260

Menezes GM, Rosa A, Melo O, Pinho MR (2009) Demersal fish assemblages off the Seine and Sedlo Seamounts (Northeast Atlantic). Deep Sea Res II 56(25):2683–2704. doi:10.1016/j.dsr2.2008.12.028

Menezes GM, Rosa A, Melo O, Porteiro F (2012) Annotated list of demersal fishes occurring at Sedlo Seamount, Azores north-east central Atlantic Ocean. J Fish Biol 81:1003–1018. doi:10.1111/j.1095-8649.2012.03355.x

Merrett NR (1992) Demersal ichthyofaunal distribution in the abyssal eastern North Atlantic, with special reference to *Coryphaenoides (Nematonurus) armatus* (Macrouridae). J Mar Biol Ass UK 72:5–24

Merrett NR, Marshall NB (1981) Observations on the ecology of deep-sea bottom-living fishes collected off northwest Africa (08°–27°N). Prog Oceanog 9:185–244

Merrett NR, Gordon JD, Stehmann M, Haedrich RL (1991) Deep demersal fish assemblage structure in the Porcupine Seabight (eastern North Atlantic): slope sampling by three different trawls compared. J Mar Biol Ass UK 71:329–358

Morato T, Hoyle SD, Allain V, Nicol SJ (2010) Seamounts are hotspots of pelagic biodiversity in the open ocean. PNAS. doi:10.1073/pnas.0910290107

Nielsen JG, Cohen DM, Markle DF, Robins CR (1999) FAO species catalogue. Volume 18. Ophidiiform fishes of the world (Order Ophidiiformes). An annotated and illustrated catalogue of pearlfishes, cusk-eels, brotulas and other ophidiiform fishes known to date. FAO Fish Synop 125(18):178

Norse EA, Brooke S, Cheung WWL, Clark MR, Ekeland I, Froese R, Gjerde KM, Haedrich RL, Heppell SS, Morato T, Morgan LE, Pauly D, Sumaila R, Watson R (2012) Sustainability of deep-sea fisheries. Mar Pol 36(2):307–320. doi:10.1016/j.marpol.2011.06.008

Pakhorukov NP (2008) Visual observations of fish from seamounts of the Southern Azores region (the Atlantic Ocean). J Ichthyol 48(1):114–123. doi:10.1134/S0032945208010104

Santos RS, Hawkins S, Monteiro LR, Alves M, Isidro EJ (1995) Marine research, resources and conservation in the Azores. Aquatic Cons 5(4):311–354

Santos RS, Porteiro FM, Barreiros JP (1997) Marine fishes of the Azores. Annotated checklist and bibliography. A catalogue of the Azorean marine ichthyodiversity. Arquipel Suppl 1:1–242

Shank TM (2010) Seamounts: deep-ocean laboratories of faunal connectivity, evolution, and endemism. Oceanogr 23(1):108–122

Shcherbachev YN, Kukuev EI, Shlibanov VI (1985) Composition of the benthic and demersal ichthyocenoses of the submarine mountains in the southern part of the North Atlantic range. J Ichthyol 25:110–125

Stocks KI, Clark MR, Rowden AA, Consalvey M, Schlacher TA (2012) CenSeam, an international program on seamounts within the census of marine life: achievements and lessons learned. PLoS ONE 7(2):e32031. doi:10.1371/journal.pone.0032031

Sulak KJ (1977) The systematics and biology of *Bathypterois* (Pisces, Chlorophthalmidae), with a revised classification of benthic myctophiform fishes. In: Wolff T (ed) Galathea report. Scientific Results of The Danish Deep-Sea Expedition Round the World 1950–1952, vol 14. Copenhagen, pp 49–108

Sulak KJ, Shcherbachev YN (1997) Zoogeography and systematics of six deep-living genera of synaphobranchid eels, with a key to taxa and description of two new species of *Ilyophis*. Bull Mar Sci 60(3):1158–1194

Swinney GN (1995) Ceratioid anglerfish of the families Gigantactinidae and Linophrynidae (Lophiiformes, Ceratioidea) collected off Madeira, including two species new to the north-eastern Atlantic. J Fish Biol 47:39–49

Vieira RP, Christiansen B, Christiansen S, Gonçalves JMS (2012) First record of the deep-water whalefish *Cetichthys indagator* (Rofen, 1959) (Actinopterygii: Cetomimidae) in the North Atlantic. J Fish Biol 81:1133–1137. doi:10.1111/j.1095-8649.2012.03378

Whitehead PJP, Bauchot M-L, Hureau J-C, Nielsen J, Tortonese E (eds) (1986) Fishes of the North-eastern Atlantic and the Mediterranean 1-3. UNESCO Press, Paris

Wienberg C, Wintersteller P, Beuck L, Hebbeln D (2013) Coral Patch seamount (NE Atlantic)—a sedimentological and megafaunal reconnaissance based on video and hydroacoustic surveys. Biogeoscience 10(5):3421–3443. doi:10.5194/bg-10-3421-2013

Xavier J, van Soest R (2007) Demosponge fauna of Ormonde and Gettysburg Seamounts (Gorringe Bank, north-east Atlantic): diversity and zoogeographical affinities. J Mar Biol Ass UK 87(06):1643–1653. doi:10.1017/S0025315407058584