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Ichthyofauna assemblages from two unexplored Atlantic seamounts: Northwest Bank and João Valente Bank (Cape Verde archipelago)

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SUMMARY: Underwater censuses by divers were used to study the fish assemblages from two unexplored Atlantic seamounts in the Cape Verde archipelago. Fifty three species of 27 families were recorded: 27 in Northwest Bank and 46 in João Valente Bank. Northwest Bank had dense schools, while João Valente Bank had higher species richness and smaller schools. Both seamounts were dominated mainly by coastal species directly depending on seabed habitat (Demersal or benthopelagic). Of the 53 fish species recorded, 22.6% were of continental African origin, while 9.4% and 5.7% were endemic of the Cape Verde Islands and of the Macaronesia province, respectively. Most species (64.2%) had a very wide biogeographic distribution: cosmopolitan (22.6%), amphi-Atlantic (28.3%) and Atlantic-Mediterranean (13.2%). Northwest Bank and João Valente Bank may have a permanent fish community supported by various oceanographic-topographic interactions. João Valente Bank seems more diverse, which is probably associated with algae cover and with a larger area providing additional suitable and more varied habitats. The geographic proximity to the coast and the presence of oceanic and/or oceanodromous species suggests that the upper part of these seamounts may act both as attraction points and as "stepping-stones" for the dispersal of coastal species.

Keywords: seamounts, underwater surveys, biogeography, Macaronesia, Northwest Bank, João Valente Bank, Cape Verde.

RESUMEN: Ictiofauna asociada a dos montes submarinos atlánticos no explorados: Banco Noroeste y Banco João Valente (Archipiélago de Cabo Verde). – Para estudiar las comunidades piscícolas, considerando las diferencias entre los montes submarinos en un contexto biogeográfico, fueron efectuados censos submarinos por buceo. Cincuenta y tres especies de 27 familias fueron registradas: 27 en el Banco Noroeste y 46 en el Banco João Valente. El Banco Noroeste fue caracterizado por bancos densos, mientras que el Banco João Valente presentó mayor riqueza de especies y bancos más pequeños. Ambos montes fueron dominados principalmente por especies costeras que dependen directamente del hábitat del lecho submarino (Demersal o bentopelágicos). De las 53 especies de peces registradas, 22.6% fueron de origen africano continental, mientras que 9.4% y 5.7% fueron endemias de las Islas de Cabo Verde y de la provincia Macaronesia, respectivamente. La mayoría de las especies tienen una distribución biogeográfica muy amplia (64.2%): cosmopolita (22.6%), amphi-atlántico (28.3%) y con una distribución atlántico-mediterránea (13.2%). Los Bancos Noroeste y João Valente deben tener una comunidad permanente de peces, sostenida por fenómenos oceanográficos. El Banco João Valente parece más diverso, hecho asociado probablemente con un área mayor, proporcionando hábitats adicionales, más propicios y variados. La presencia de especies oceánicas y/o oceanódromas y la proximidad geográfica a la costa, sugiere que la parte superior de estos montes puede actuar como punto de atracción y como "stepping-stones" para la dispersión de especies costeras.

Palabras clave: montes submarinos, censos subacuáticos, biogeografía, Macaronesia, Banco Noroeste, Banco João Valente, Cabo Verde.

INTRODUCTION

Seamounts are elevations similar to those located in continents, with peaks below sea level rising 1000 m or more from the sea floor (Kitchingman and Lai, 2004). Northwest Bank and João Valente Bank are seamounts within the Cape Verde archipelago EEZ, located in the eastern Atlantic about 243 nm off the coast of Senegal. Northwest Bank extends in a SW-NE direction and is formed by two peaks located 10 nm offshore of the westernmost island of the archipelago (Santo-Antão island), rising from 2500 m to close to 35 m below the surface (Fig. 1). João Valente Bank is located about 25 nm from Maio Island and 20 nm from Boavista Island, the easternmost island of the archipelago. It stands on a relatively shallow sea platform (around 100 m deep) that rises from 1000 m, with the peak 10 m below the surface (Fig. 1).

Rich migratory and non-migratory fish stocks often occur at offshore seamounts (Koslow, 1997; Dower and Perry, 2001). Although the reasons for this are not completely understood, it is broadly assumed that it may be closely linked to various current-topography interactions, including upwelling, enhanced turbulent mixing and the formation of closed recirculation currents (the "*Taylor column*") (e.g. Koslow, 1997; Koslow *et al*., 2001; Dower and Perry, 2001; Beckmann and Mohn, 2002; Trasvinã-Castro *et al*., 2003; Clemmesen and Röhrscheidt, 2004). Therefore, hydro-dynamic conditions over seamounts could create particular ecological processes and host high fish diversity and endemism (Goldner and Chapman, 1997; Beckmann and Mohn, 2002; Trasvinã-Castro *et al*., 2003).

The João Valente Bank has been surveyed several times, namely by acoustic methods, by handline, longline, pelagic and bottom trawl sampling for demersal fish identification (Stromme *et al.*, 1981; Magnússon and Magnússon, 1985; Pálsson, 1988; Thorsteinsson *et al*., 1995), and by preliminary underwater diver surveys carried out in 2001 (unpublished data from the authors). The Northwest Bank had never been visited by divers before the present study and its fish community was mainly known through the catches of fishermen (anecdotal information). A unique research event for this seamount took place using echo-sounder techniques in 1981 through collaboration between a local and a Nor-

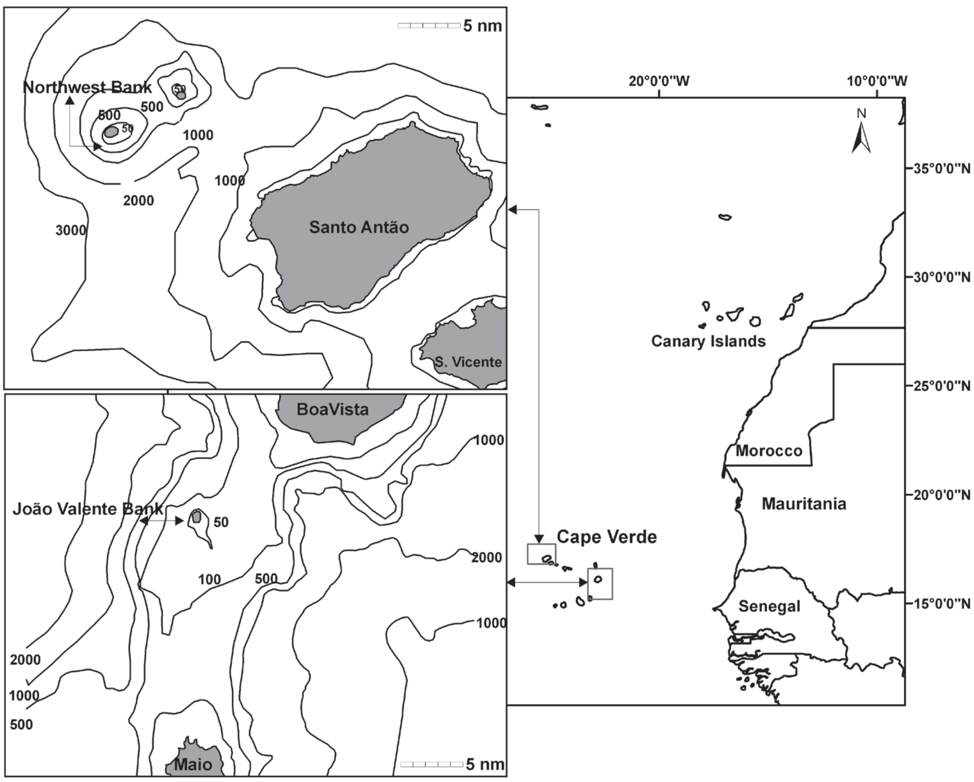

FIG. 1. – Map showing the location of Northwest Bank and João Valente Bank: Cape Verde archipelago (see inset). Note: depth contours in metres.

wegian research Institute (Stromme *et al.*, 1981). No detailed information concerning the biological and ecological characteristics of these seamounts exists for fish, as the grey literature references cited above are concerned mainly with fisheries-related information. In view of their proximity, the two seamounts are expected to have similar geological characteristics to those of the adjacent islands, which are in general composed of basalts rocks (Mitchell-Thomé, 1972) and have a common biological diversity.

Underwater surveys by divers are increasingly used to assess the ichthyofauna of Marine Protected Areas (MPA) and other areas with sensitive biotopes. Such surveys constitute a non-destructive method and may give a more precise idea of the habitat types and use, spatial organisation and behaviour of fish communities than traditional sampling methods (Harmelin-Vivien *et al.*, 1985). Underwater surveys by divers in extreme environments such as seamounts have increased greatly in recent years in the NE Atlantic, with studies of the Gorringe (Gonçalves *et al.*, 2004) and Ampère Banks (Gonçalves *et al.*, unpublished data) about 125 nm SW of Portugal and the João de Castro (Cardigos *et al.*, 2005) and Princesa Alice Banks (Cardigos *et al.*, pers. comm.) in the Azores archipelago.

Surveys of the tops of Northwest Bank and João Valente Bank using underwater sampling techniques (visual census, photography and video) were carried out in 2002. In the present paper the fish assemblage is examined with particular reference to comparisons between fish communities inhabiting one distinctive seamount (Northwest Bank) and one located on a relatively shallow sea platform between two main islands of the archipelago (João Valente Bank). Given the localisation of the Cape Verde archipelago, we also focus on the biogeography and diversity of the two seamounts. The Cape Verde archipelago is designated as the frontier between the Lusitanian province (Northeast Subtropical Atlantic, including the Azores) and the tropical West African sub-region, which extends along the African coastline to the south of Angola (Lloris *et al.*, 1991). The archipelago is in informal and controversial terms also included by ichthyologists in the Macaronesian province, along with other NE Atlantic archipelagos (Azores, Madeira and Canary Islands) and a coastal segment of the African continent boundary with the Canary Islands (Lloris *et al.*, 1991; Pérez-Ruzafa *et al.*, 2005).

METHODS

Sampling area and method

Underwater surveys were carried out during July and August 2002 at Northwest Bank (17º04'41"N; 25º24'30"W) and João Valente Bank (15º38'33"N; 23º06'55"W), respectively. Surveys using underwater sampling techniques, namely visual census (direct observation by two divers), photography and video, were used. The last two methods were only used for species identification while visual census methods were used for quantification of demersal and pelagic ichthyofauna. Because of the extreme environments for diving (waves and strong currents), diving time limitations and general lack of knowledge of local conditions, two relatively safe visual census methods—the stationary sampling method and transect sampling method—were selected for studying the seamounts.

The stationary sampling method consisted of counting all fish species inside a virtual cylinder of a specific diameter (Bohnsack and Bannerot 1986; Bortone *et al.* 1986). Divers turn around a stationary point over the seabed for a fixed period of time recording every species present within the virtual cylinder. Since Northwest Bank had never been visited by divers and specific diving conditions were largely unknown, the static sampling method, with a virtual cylinder of 40 m of diameter during a fixed time period of 10 minutes was used. Seven non-overlapping samples were taken at waters depths of 35-38 m within a total area of 7540 m^2 on the seamount peak.

In contrast, diving has taken place before on João Valente Bank and conditions are generally known. Thus, the transect method was chosen because of the desire to survey as large an area of the peak as possible. This method consisted in a diver slowly swimming over the seabed and recording every species present in a specific area straight ahead (Harmelin-Vivien *et al.*, 1985; Bortone *et al.* 1986). Transects on João Valente Bank were 60 m long and 20 m wide. Five non-overlapping transects were taken at waters depths of 18-30 m within a total area of 6000 m^2 on the seamount peak.

Data analysis

For both methods frequencies of occurrence and relative abundances were obtained (Gonçalves *et al.*, 2004). The species frequency index was obtained according to the formula F = (f / ft) × 100, where f is the number of occurrences of a given species and ft is the total number of dives or number of transects at a specific seamount. The number of individuals was an average of the independent count recorded by each diver. Due to the need to standardise and record data obtained in rough sea conditions, relative abundance information was based on a three-point scale, with code 1 corresponding to less than 10 individuals, code 2 to between 10 and 50 individuals and code 3 to more than 50 individuals. Relative abundance at a discrete scale was used as an alternative to absolute values due to the need to get round the weakness of using two different sampling methods and make them comparable.

Habitat types were classified based on direct observations by divers and subsequently from photo and video imaging. All photos and videos are archived at the Centre of Marine Sciences (CCMar - Universidade do Algarve) and at the Atlantic Wildlife Association (AAS).

Differences in fish assemblages between Northwest Bank and João Valente Bank were examined using the statistical routines in the PRIMER 6.0 software package (Clarke and Warwick, 2001; Clarke and Gorley, 2006). Similarity matrices using the Bray-Curtis similarity coefficient of the presence/absence data instead of the absolute values were generated. The presence/absence data have the effect of giving potentially equal weight to all species, whether rare or abundant (Clarke and Warwick, 2001), once more getting round the weakness of using two different sampling methods. Non-metric multidimensional scaling nMDS two-dimensional ordination plots were created. A one-way analysis of similarities (ANOSIM) was used to test for differences between the fish assemblages of the two seamounts (see references in Clarke and Warwick, 2001). Species contributions for similarity/dissimilarity between the two seamounts were also assessed by SIMPER analysis.

The biogeographic origin, general and specific habitats, egg type, reproduction and diets of the species recorded were reviewed according to Whitehead *et al.* (1986), Lloris *et al.* (1991), Reiner (1996) and Froese and Pauly (2007). The conservation status of the species recorded in the eastern Atlantic was derived from IUCN (2007), while the fishery value was generally assessed from Froese and Pauly (2007).

RESULTS

Fish habitat

Both sites were characterised by strong oceanic currents and a hard bottom of basaltic rock. However, at Northwest Bank algae cover was almost absent, while at João Valente Bank extensive maerl beds mainly composed of species of the Corallinacea family were observed covering rock platforms as well as in patches between rocks. Brown algae (*Dictyota* sp.) were also present on the João Valente Bank bottom. João Valente Bank has more sedimentary rocks and sandy habitats than Northwest Bank, which has mainly solid rocks, with some biogenic sediment such as foraminiferan sands. Protected places such as small caves were in contrast very similar, and were almost dominated in both banks by corals, sponges and other conspicuous invertebrate species.

Fish diversity

A total of 53 fish species within 27 families were recorded by the survey, with 27 (50.9%) at Northwest Bank and 46 (86.8%) at João Valente Bank (Table 1). Carangidae (5 species) and Pomacentridae (4) at Northwest Bank and Pomacentridae (5) and Muraenidae (4) at João Valente Bank were the most species-rich families. Among all the fish species found, 20 (37.7%) were common to both sites, while 7 (13.2%) were only found at Northwest Bank and 26 (49.1%) were only found at João Valente Bank.

The Northwest Bank seascape was largely dominated by dense schools of three species (code 3 of the abundance scale), namely Lubbock's damselfish (a Cape Verde endemic species) *Chromis lubbocki*, the black jack *Caranx lugubris* and the triggerfish *Canthidermis sufflamen* (Table 1). The Cape Verde endemic damselfish species *Similiparma hermani* and the angelfish *Holacanthus africanus* were grouped in relatively dense schools and were also very important in terms of abundance (relative abundance code 2). The above species were, with the wrasse *Bodianus speciosus* and the parrotfish *Sparisoma cretense*, among the most visually frequent species recorded at this site. The remaining species records were mainly characterised by small group formations or isolated individuals. However, despite its lower density the grouper *Cephalopolis taeniops* was also very frequent at Northwest Bank (100%

TABLE 1. – Frequency of occurrence and relative abundance of each species recorded at Northwest Bank and João Valente Bank. Note: the symbol * means that the species was only identified by photo or video, or outside the area of the transects.

Species	Family	Northwest Bank Frequency (%)	Northwest Bank Abundance	João Valente Bank Frequency (%)	João Valente Bank Abundance
Abudefduf luridus, (Cuvier, 1830)	Pomacentridae	46.4	2	91.1	2
Abudefduf saxatilis, (Linnaeus, 1758)	Pomacentridae			(*)	(*)
Acanthocybium solandri , (Cuvier, 1832)	Scombridae	75.0	1		
Acanthurus monroviae, Steindachner, 1876	Acanthuridae	87.5	2	91.1	2
Aluterus scriptus, (Osbeck, 1765)	Monacanthidae	7.1	1	19.6	1
Apogon imberbis, (Linnaeus, 1758)	Apogonidae	67.9	2	58.9	3
Aulostomus strigosus, Wheeler, 1955	Aulostomidae			51.8	1
Bodianus speciosus, (Bowdich, 1825)	Labridae	100.0	2	91.1	2
Canthidermis sufflamen, (Mitchill, 1815)	Balistidae	100.0	3	98.2	2
Canthigaster rostrata, (Bloch, 1786)	Tetraodontidae	85.7	2	85.7	1
Caranx crysos, (Mitchill, 1815)	Carangidae			(*)	(*)
Caranx latus, Agassiz, 1831	Carangidae	46.4	2		
Caranx lugubris, Poey, 1860	Carangidae	100.0	3		
Cephalopholis taeniops, (Valenciennes, 1828)	Serranidae	100.0	1	98.2	2
Chaetodon robustus, Günther, 1860	Chaetodontidae	14.3	1	78.6	1
Chilomycterus reticulatus, (Linnaeus, 1758)	Diodontidae			26.8	1
Chromis lubbocki, Edwards, 1986	Pomacentridae	80.4	3	71.4	2
Diodon holacanthus, Linnaeus, 1758	Diodontidae			12.5	1
Diplodus fasciatus, (Valenciennes, 1830)	Sparidae			91.1	2
Diplodus prayensis, Cadenat, 1964	Sparidae			66.1	2
Ginglymostoma cirratum, (Bonnaterre, 1788)	Ginglymostomatidae	66.1	1	19.6	1
Girella stuebeli, Troschel, 1866	Kyphosidae			39.3	1
Gymnothorax unicolor, (Delaroche, 1809)	Muraenidae			19.6	1
Heteropriacanthus cruentatus, (Lacepède, 1801)	Priacanthidae			85.7	2
Holacanthus africanus, Cadenat, 1951	Pomacanthidae	92.9	2	91.1	2
Kyphosus sectator, (Linnaeus, 1766)	Kyphosidae	26.8	1	39.3	1
Manta birostris, (Walbaum, 1792)	Mobulidae			(*)	(*)
Mulloidichthys martinicus, (Cuvier, 1829)	Mullidae			71.4	2
Muraena helena, Linnaeus, 1758	Muraenidae	58.9	1	19.6	1
Muraena robusta, Osório, 1911	Muraenidae			(*)	(*)
Muraena melanotis, (Kaup, 1860)	Muraenidae			39.3	1
Mycteroperca fusca, (Lowe, 1838)	Serranidae			64.3	1
Myripristis jacobus, Cuvier, 1829	Holocentridae	80.4	2	98.2	2
Pomadasys rogerii, (Cuvier, 1830)	Haemulidae			26.8	1
Priacanthus arenatus, Cuvier, 1829	Priacanthidae			85.7	2
Prognathodes marcellae, (Poll, 1950)	Chaetodontidae	78.6	1	53.6	1
Pseudocaranx dentex , (Bloch and Schneider, 1801)	Carangidae	33.9	1		
Pseudupeneus prayensis, (Cuvier, 1829)	Mullidae			51.8	1
Remora remora, (Linnaeus, 1758)	Echeneidae			(*)	(*)
Rhincodon typus, Smith, 1828	Rhincodontidae			(*)	(*)
Rypticus saponaceus, (Bloch and Schneider, 1801)	Serranidae	39.3	1	32.1	1
Sargocentron hastatus, (Cuvier, 1829)	Holocentridae	33.9	2	71.4	2
Scarus hoefleri, (Steindachner, 1881)	Scaridae			78.6	1
Seriola cf. rivoliana, Valenciennes, 1833	Carangidae	(*)	(*)		
Seriola dumerili, (Risso, 1810)	Carangidae	41.1	2		
Similiparma hermani, (Steindachner, 1887)	Pomacentridae	100.0	2	85.7	1
Sparisoma cretense, (Linnaeus, 1758)	Scaridae	92.9	1	91.1	2
Sphoeroides marmoratus, (Lowe, 1838)	Tetraodontidae			39.3	1
Stegastes imbricatus, Jenyns, 1840	Pomacentridae			19.6	1
Stegastes leucostictus, (Müller and Troschel, 1848)	Pomacentridae	19.6	1		
Taeniura grabata, (Geoffroy St. Hilaire, 1817)	Dasyatidae			19.6	1
Thalassoma pavo, (Linnaeus, 1758)	Labridae			66.1	1
Trachinotus ovatus, (Linnaeus, 1758)	Carangidae			98.2	1

frequency), occurring mainly as solitary individuals associated with caves and other shelters.

João Valente Bank was in contrast characterised by higher species richness but with fish generally being recorded in lower densities. The schools of cardinal fish *Apogon imberbis* living in small cavities were an exception, with the highest recorded density among the observed fish species (Table 1). The seamount seascape was largely dominated by moderately-sized schools in terms of density (code 2 of abundance) of species such as the triggerfish *Canthidermis sufflamen*, the soldier fish species *Myripristic jacobus* and the grouper *Cephalopolis taeniops* (≈98% frequency). Many other species were also very frequently observed at this site, in particular the surgeon fish *Acanthurus monroviae*, the wrasse *Bodianus speciosus*, the parrotfish *Sparisoma cretense*, the Macaronesian blue fin damselfish *Abudefduf luridus*, the porgy *Diplodus*

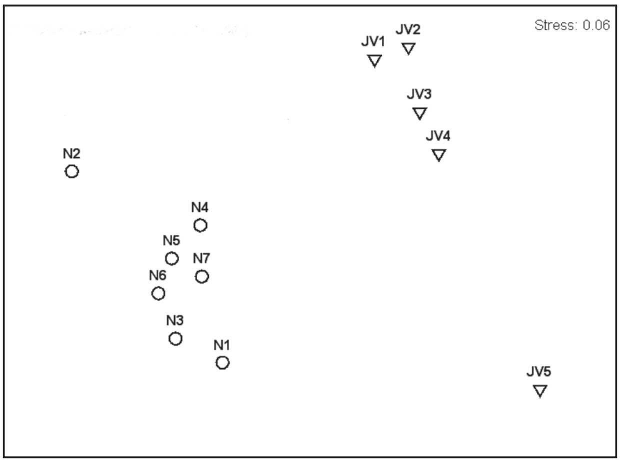

FIG. 2. – Non-metric multi-dimensional scaling ordination plot of the presence/absence data for fish assemblages sampled at Northwest Bank (Nn, ○) and Joao Valente Bank (JVn, ▽). Stress value for the plot is given in the top right hand corner.

fasciatus and the angelfish *Holacanthus africanus* (≈91% frequency). Among the most abundant species only two bigeye species, *Heteropriacanthus cruentatus* and *Priacanthus arenatus*, two Cape Verde endemic porgy species *Diplodus fasciatus* and *Diplodus prayensis*, and the goatfish *Mulloidichthys martinicus* were only recorded at João Valente Bank. Although present in low densities (relative abundance code 1), the pompano *Trachinus ovatus* was very frequent at this seamount, occurring mostly as isolated individuals swimming straight ahead far away from divers.

Fish assemblage composition

The nMDS ordination plot (Fig. 2) based on presence/absence data clearly shows the dissimilarity between the assemblages sampled from Northwest Bank and João Valente Bank. Samples from the same seamount were clustered together and separately from those from a different seamount, indicating relatively high similarity between assemblages at the same site compared with those at the other site. The ANOSIM test indicated that the fish assemblages associated with the two sites were significantly different in composition (R-statistic = 0.864, P<0.001). Table 2 shows species that contributed more than 50% to the cumulative percentage of dissimilarity (SIMPER analysis) between Northwest Bank and João Valente Bank. According to the ratio of dissim/SD , the species that most consistently contributed to the dissimilarity between the assemblages on the two seamounts (dissim/SD>5) were the wahoo *Acanthocybium solandri*, *Heteropriacanthus cruentatus*, *Priacanthus arenatus*, *Caranx lugubris* and *Trachinotus ovatus*.

General habitat

Northwest Bank and João Valente Bank fish assemblages were dominated by coastal reef-associated species depending directly on the seabed habitat. Demersal and benthopelagic species accounted for 93 and 96% of the species at Northwest Bank and João Valente Bank, respectively (Table 3). One oceanic (Almaco jack *Seriola* cf. *rivoliana*) and four oceanodromous species (*S. dumerili*, *Acanthocybium solandri*, *Caranx lugubris* and the Horse-eye jack *C. latus*) were only recorded from Northwest Bank. At João Valente Bank two oceanodromous species, namely the whale shark *Rhincodon typus* and the giant manta *Manta birostris*, were recorded.

TABLE 2. – Results of SIMPER analysis between Northwest Bank (N) and João Valente Bank (JV): average of presence (Av. Pres.), average of dissimilarity (Av. diss.), dissimilarity deviation (Diss./SD.) and contribution for dissimilarity between seamounts (Contrib. %). Note: only species that contributed more than 50% to the cumulative percentage of dissimilarity and the ratio of dissim/SD>1 are shown.

Species	Av. Pres.	Av. Pres.	Av. Diss.	Diss/SD	Contrib%	Cum.%
Acanthocybium solandri	1	0	2.43	5.66	4.65	4.65
Heteropriacanthus cruentatus	0	1	2.43	5.66	4.65	9.30
Priacanthus arenatus	0	1	2.43	5.66	4.65	13.95
Caranx lugubris	1	0	2.43	5.66	4.65	18.60
Trachinotus ovatus	0	1	2.43	5.66	4.65	23.25
Thalassoma pavo	0	0.8	1.96	1.82	3.75	27.00
Diplodus fasciatus	0	0.8	1.80	1.94	3.44	30.44
Diplodus prayensis	0	0.8	1.80	1.94	3.44	33.88
Scarus hoefleri	0	0.8	1.80	1.94	3.44	37.32
Chaetodon robustus	0.29	0.8	1.48	1.26	2.82	40.14
Seriola dumerili	0.57	0	1.37	1.11	2.63	42.77
Manta birostris	0	0.6	1.36	1.20	2.60	45.37
Mulloidichthys martinicus	0	0.6	1.34	1.20	2.56	47.93
Ginglymostoma cirratum	0.57	0.2	1.32	1.04	2.53	50.46
Abudefduf luridus	0.43	0.8	1.32	1.06	2.52	52.98

TABLE 3. – General biogeographic origin, habitat, egg type, diet, and conservation and fisheries status of the fish species recorded at Northwest Bank and João Valente Bank, according to Whitehead *et al.* (1986), Lloris *et al.* (1991), Reiner (1996), Froese and Pauly (2007) and IUCN (2007).

	Northwest Bank		João Valente Bank			
	n	(%)	n	(%)	Total	(%)
General habitat						
Coastal	22	81.5	43	93.5	45	84.9
Oceanic	1	3.7	1	2.2	2	3.8
Oceanodromous	4	14.8	2	4.3	6	11.3
Specific habitat						
Pelagic	2	7.4	2	4.3	4	7.5
Benthopelagic	5	18.5	7	15.2	11	20.8
Demersal	20	74.1	37	80.4	38	71.7
Biogeographic origin						
African	7	25.9	12	26.1	12	22.6
Amphi-Atlantic	7	25.9	13	28.3	15	28.3
Cosmopolitan	7	25.9	7	15.2	12	22.6
Atlantic-Mediterranean	3	11.1	7	15.2	6	11.3
Cape Verde (endemic)	2	7.4	5	10.9	5	9.4
Macaronesian (endemic)	1	3.7	2	4.3	3	5.7
Status						
Vulnerable (IUCN Red List)	0	0.0	2	4.3	2	3.8
Near threatened (IUCN Red List)	0	0.0	1	2.2	1	1.9
Commercial species	14	51.9	24	52.2	30	56.6
Egg type/Reproduction						
Pelagic/External, non-guarded	19	70.4	33	71.7	39	73.6
Benthic/External, guarded	7	25.9	9	19.6	10	18.9
Internal/ovoviviparous	1	3.7	4	8.7	4	7.5
Diet						
Invertebrates	5	18.5	13	28.3	13	24.5
Fishes + invertebrates	11	40.7	18	39.1	24	45.3
Others (Planktonic, herbivorous)	11	40.7	15	32.6	16	30.2

Biogeographic affinities

From the biogeographic point of view, the recorded data seem similar for the two surveyed sites (Table 3). Most species (64.2%) recorded at both seamounts have a very wide biogeographic distribution: cosmopolitan (22.6%), amphi-Atlantic (28.3%) and Atlantic-Mediterranean (13.2%). Of the 53 fish species recorded at both sites, 37.7% had a regional origin, 22.6% being from Africa and 9.4 and 5.7% being endemic to the Cape Verde Islands and the Macaronesia province, respectively.

The Northwest Bank assemblage was mainly dominated in terms of abundance by two Cape Verde endemic species (*Chromis lubbocki, Similiparma hermani*), one cosmopolitan species (*Caranx lugubris*) and an amphi-Atlantic species (*Canthidermis sufflamen*) with a wide distribution in the western Atlantic (Table 1). Species with a wide distribution along the African coast were, however, among the most visually frequent species recorded at this site (*Holacanthus africanus*, *Bodianus speciosus*, *Sparisoma cretense*, *Cephalopolis taeniops*). The dominant fish species of the João Valente Bank assemblage was in contrast characterised by more diversity in terms of biogeographic origin. This site was mostly dominated by moderate schools in terms of density and occurrence of species with African origin (*Heteropriacanthus cruentatus*, *Sargocentron hastatus*, *H. africanus*, *B. speciosus*, *C. taeniops*, *Acanthurus monroviae*), Amphi-Atlantic origin (*Priacanthus arenatus*, *Myripristic jacobus*, *Mulloidichthys martinicus*, *C. sufflamen*), Atlantic-Mediterranean (*S. cretense*, *Trachinotus ovatus*) or Macaronesian and Cape Verde endemic species (*Diplodus fasciatus*, *D. prayensis*, *C. lubbocki*, *Abudefduf luridus*). Most of the species that were common to the two sites were of western Atlantic origin (65%), including African (35%), Atlantic-Mediterranean (15%), Cape Verde (10%) and Macaronesian endemic origins (5%). Species only found at Northwest Bank were of amphi-Atlantic and cosmopolitan origin, while species that were only found at João Valente Bank had a wide range of biogeographic origins.

Conservation and fishery status

More than 50% of the species recorded at both seamounts were of commercial value, with almost all of the most important in terms of market price (*Caranx latus, C. lugubris, Seriola* cf. *rivoliana, S. dumerili, Acanthocybium solandri*) being recorded from Northwest Bank. Both the near-threatened (giant manta *Manta birostris*) and vulnerable species (butterflyfishes *Chaetodon robustus* and the whale shark *Rhincodon typus*) (IUCN, 2007) were of non-commercial value and were only recorded from João Valente Bank.

Reproduction and diet

A reproduction pattern based on pelagic eggs and external fertilisation dominated among the species observed at Northwest Bank and João Valente Bank (≈70% of species). Species with benthonic eggs that are guarded by adults with nesting behaviour were also observed, although the proportion differed somewhat between seamounts (≈26% and 20% for Northwest Bank and João Valente Bank, respectively). Four elasmobranch species with internal and ovoviviparous fertilisation were identified (*Manta birostris*, stingrays *Taeniura grabata*, nurse sharks *Ginglymostoma cirratum*, *Rhincodon typus*) at the studied seamounts, although only one of these species (*G. cirratum*) occurred at the Northwest Bank site. The fish of the assemblages identified were associated with three diet types, namely a fish plus invertebrate diet, a planktonic or herbivore diet and a singular diet of invertebrates.

DISCUSSION

Fish assemblages and general habitat

Underwater sampling methods showed that Northwest Bank and João Valente Bank support rich assemblage species, including oceanic and coastal fishes, particularly in comparison with the assemblage species observed at Ampère Bank (Gonçalves *et al*., unpublished data) or Gorringe Bank (Gonçalves *et al*., 2004). The clearly lower diversity found at the latter, a very distinctive seamount, could be due to some extent to its isolation (Gonçalves *et al*., 2004), because it is more than 120 nm from coastal areas. Using a similar sampling effort to that used in the present study the authors observed only 14 fish species at two peaks belonging to the Gorringe Bank: Ormond (6) and Gettysburg (9). Northwest Bank and João Valente Bank fish assemblage species are nevertheless comparable to those observed at the Azores seamounts, i.e. João de Castro Bank (Cardigos *et al*., 2005) and Princesa Alice Bank (Cardigos *et al*., pers. comm.). The similarity in the number of species observed was expected since these seamounts are both relatively close to coastal areas, which might be important for their biodiversity and species richness.

The Cape Verde banks and the related seamounts located in the NE Atlantic share several oceanic species (*Manta birostris*, *Remora remora*, *Seriola* cf. *riviolana* and *S. dumerili*). This result and the strong presence of many oceanodromous species, particularly at Northwest Bank (*Acanthocybium solandri, Caranx latus*, *C. lugubris* and *S. dumerili*) but also on João Valente Bank (*M. birostris*, *Rhincodon typus*), agree with Koslow (1997), who argues that the upper part of seamounts are points of attraction for many fish species. *R. typus* and *M. birostris* could in fact be attracted to João Valente Bank by the permanent upwelling found at this site (Stromme *et al*., 1981).

Northwest Bank and João Valente Bank are both characterised by strong waves and oceanic currents, with roughly comparable habitats of hard basalt bottoms. The present surveys showed that exposed sites have similar biotopes almost clean of algae, particularly at Northwest Bank. However, the gravel platforms on João Valente Bank are covered by maerl beds (Family: Corallinacea), which are important biotopes for a wide variety of marine invertebrates and consequently for fish species (Wilson *et al*., 2004). Thus, differences in algae cover and in seamount depth in association with a difference in the amount of area appropriate for coastal fish communities, might be the reasons for dissimilarity between Northwest Bank and João Valente Bank. João Valente Bank is positioned on a relatively shallow platform between Boavista and Maio Islands which might provide large and varied habitats suitable for coastal marine animals. The permanent strong upwelling on the western side of João Valente Bank (Stromme *et al*., 1981) might also help to create more suitable conditions.

The fish fauna of João Valente Bank was basically dominated by a great number of demersal coastal species, moderate in terms of density, and other visually recurrent species. In contrast, reflecting its lower richness, the Northwest seascape was characterised by dense schools of limited numbers of oceanic species with a few restricted and less dense but very common coastal species. These results, associated with the importance of oceanodromous species at Northwest Bank, highlight the difference between the two seamounts.

The abundance of fish species with a straight dependence on seabed habitat (demersal and benthopelagic species) suggests that both banks may have permanent fish communities supported by oceanographic and ecological phenomena that can take place on distinctive seamounts. Theories on ‘‘seamount effects’’ suggest that interruption of ocean currents with consequent formation of eddies and circular currents (the ‘‘Taylor column’’) as well as local upwelling are contributing factors for increased local primary and secondary production (e.g. Fock *et al.* 2002; Diekmann and Piatkowski, 2004; Gad and Schmitnke, 2004). Larval and particle retention and accumulation of local production are also influenced by these currents (Goldner and Chapman, 1997; Beckmann and Mohn, 2002). Thus, Northwest and João Valente coastal species might be resident and self-sustaining since the recruitment of various fish species might take place locally on each bank.

Most fish species observed at Northwest Bank and João Valente Bank are non-guarder nesters and have a pelagic larval stage, which provides a powerful means of dispersal (Lessios *et al.*, 1998). This result raises the question of whether there is larval and demersal fish exchange between the banks and closest islands, as Stromme *et al.* (1981) noted that deep zones of Cape Verde archipelago are an impoverished environment. In fact, species assemblages of both banks are characterised by species with a broad distribution among the islands of the archipelago (Lloris *et al.*, 1991; Reiner, 1996; Froese and Pauly, 2007). Future studies of these banks might address this particular question of the isolation level, which may be very important from the viewpoint of biodiversity.

Of particular interest is the absence or rarity of the two endemic species of the family Sparidae (*Diplodus fasciatus* and *D. prayensis*) and two species of the family Priacanthidae (*Heteropriacanthus cruentatus* and *Priacanthus arenatus*) at Northwest Bank, although they are consistently abundant in the Cape Verde coastal reefs. Furthermore, these demersal-spawning species do not seem to have special larval dispersal restrictions as the genera have successfully colonised extremely isolated sites. Thus, dispersal limitation could not be the reason for the absence/rarity of these species. Northwest Bank could be an inappropriate habitat for these genera and future studies might also address this question.

Biogeographic perspective

From a biogeographic point of view the data recorded at Northwest Bank and João Valente Bank are similar, and they show fish species that are well-known on the islands’ coasts and have wide biogeographic distributions. Most species recorded at both sites have an amphi-Atlantic, cosmopolitan or Atlantic-Mediterranean origin. This result was expected because, according to Lloris *et al.* (1991), the Cape Verde Islands are designated as the frontier between the Lusitanian province and the tropical West African sub-region. Another important role for this pattern might be the location in the vicinity of the North Equatorial Current and the southern part of the Canary Current, which is part of the clockwise ocean current system of the North Atlantic Ocean (Zhou *et al.*, 2000).

Particularly interesting is the distribution pattern of those amphi-Atlantic species observed at Northwest Bank and João Valente Bank. Despite the mid-Atlantic barrier from the biogeographic perspective, some reef fish species occur with suitable established populations on both sides of the Atlantic (Joyeux *et al.*, 2001). Among the fifteen amphi-Atlantic species observed at Northwest Bank and João Valente Bank, only three species have the largest area of occurrence on the eastern side of the Atlantic (*Gymnothorax unicolor*, *Muraena robusta* and *Muraena melanotis*). This could be in agreement with the proposal of Luiz-Júnior *et al.* (2004) that most amphi-Atlantic species appear to have migrated from west to east. According to these authors, the origin of dispersion of fish may be inferred by analysing the distributional range of the species, with the origin more likely to be where the species has the largest area of occurrence. Furthermore, they only identified four (3.7%) out of 106 reef-species that appear to have migrated from east to west (*Acanthurus monroviae*, *Aulostomus strigosus*, *Epinephelus marginatus* and *Parablennius pilicornis*).

The beaugregory, *Stegastes leucostictus*, observed at Northwest Bank, is a common species in the western Atlantic but is only known on the eastern Atlantic from the Cape Verde Islands. The distribution pattern of amphi-Atlantic species and the presence of oceanic or oceanodromous species, especially at Northwest Bank, suggests that the upper part of these features may act as both attraction points for oceanic species and "stepping-stones" for trans-oceanic dispersal of coastal species.

Despite the relative dominance of species of especially wide biogeographic distribution at both seamounts, regional fish species assemblage was also very important. In the present study African sub-region or endemic species represented 38% of observed fish species, which is not surprising when compared with fish assemblages observed at Cape Verde Island coast, where this group of species represents around 37% according to Lloris *et al.* (1991).

Since these seamounts, and especially Northwest Bank, are small and relatively isolated geographically, they could be quite vulnerable to overfishing. There is no official information about type and intensity of fishing on these seamounts, which are in general exploited with low effort by artisanal fleets. In order to ensure proper management in the near future a lot more can be done to control fisheries exploitation and to preserve species and habitat. Therefore, the establishment of a marine protected area (MPA) on the Northwest Bank would be recommendable. Special attention must also be given to the presence of the oceanodromous whale shark *Rhincodon typus* and the giant manta *Manta birostris* at João Valente Bank, classified respectively as "vulnerable" and "data deficient" according to the IUCN (2007).

On the present preliminary assessment of fish species assemblages of the upper part of the Northwest and João Valente seamounts the methods used were non-destructive and provided precise information on the habitat types and fish communities. However, both seamounts need more scientific research, especially involving the collection of physical, geophysical and geological data and a more complete set of biological information based on the capture of species for laboratory identification.

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