

Influence of near-bottom environmental conditions on the structure of bathyal macrobenthic crustacean assemblages from the Capbreton canyon (Bay of Biscay, NE Atlantic)

Mikel A. Marquiegui ^{a*}, Jean Claude Sorbe ^b

^a Sociedad Cultural INSUB, Zemoria 12, Apdo. 3223, 20013 Donostia-San Sebastian, Spain.

^b Laboratoire d'océanographie biologique (UMR 5805, CNRS/UBI), 2 rue Jolyet, 33120 Arcachon, France.

* Corresponding author (fax: +34 943 291920)

Received February 26, 1998; revised December 30, 1998; accepted February 26, 1999

Abstract—Sled and box-corer samplings were performed at two sites in the Capbreton canyon in order to appreciate the influence of near-bottom environmental conditions on the structure of their macrobenthic communities (crustaceans). Although located at similar depths (ca. 1 000 m), these two sites were characterised by different physicochemical conditions at the sediment-water interface, probably related with the morphology of the submarine valley (reduced environment, oxygen depletion and stagnation of bottom water at site A; normal oceanic conditions on the near-bottom environment of site B). The analysis of the collected fauna revealed a low similarity between the two sites, mainly due to the unusual dominance of three epibenthic species in sled samples from site A: the amphipod *Bonnierella abyssorum*, the tanaid *Apeudes spinosus* and the isopod *Arctuopsis giardi*. Due to their apparent rarity or absence in adjacent non-canyon communities, such epibenthic crustaceans may be considered as 'canyon indicator species' able to exhibit abundant populations within the peculiar confinement area of this canyon. © 1999 Éditions scientifiques et médicales Elsevier SAS

Benthos ecology / submarine canyon / bathyal zone / Bay of Biscay / NE Atlantic

1. INTRODUCTION

Located in the south-eastern part of the Bay of Biscay (NE Atlantic ocean), the Capbreton canyon is a 'gouf'-type submarine valley according to the morphological description of Shepard and Dill [29], Vanney and Mougénot, [38] and to the recent classification proposed by Teixeira Gomes [35]. Such a major topographic accident separates the northern Aquitanian shelf from the narrower southern Cantabrian platform. It begins at less than 250 m from the shoreline in front of Capbreton (early mouth of the Adour river) and extends through 135 nautical miles before ending on the abyssal plain at about 3 000 m water depth [38]. Deeply cutting the continental shelf between the coast and the meridian 2° W, its upper part is narrow and sinuous whereas its lower part widens out to the open ocean.

During the course of a French-Spanish co-operative research programme on the pelagic and benthic ecosystems from the Capbreton area, different sampling

operations from CAPBRETON cruises on board of the RV *Côte d'Aquitaine* [32] were performed all along the upper part of the submarine valley down to 1 000 m depth in order to study the megafauna as well as the supra- and endobenthic fauna of these deep muddy bottoms. This paper deals with a comparison of the structure of benthic communities (crustacean components) from two sites sampled at the same depth but under quite different environmental conditions.

2. STUDY AREA

Figure 1 shows the study area located in the south-eastern part of the Bay of Biscay and the geographical position of the sampling sites A and B within the Capbreton canyon.

According to earlier hydrographical observations from Le Floch [17] and Ogawa and Tauzin [18], as well as unpublished data recorded during the CAPBRETON cruises, these two sampling sites are under the influence of Mediterranean waters which flow

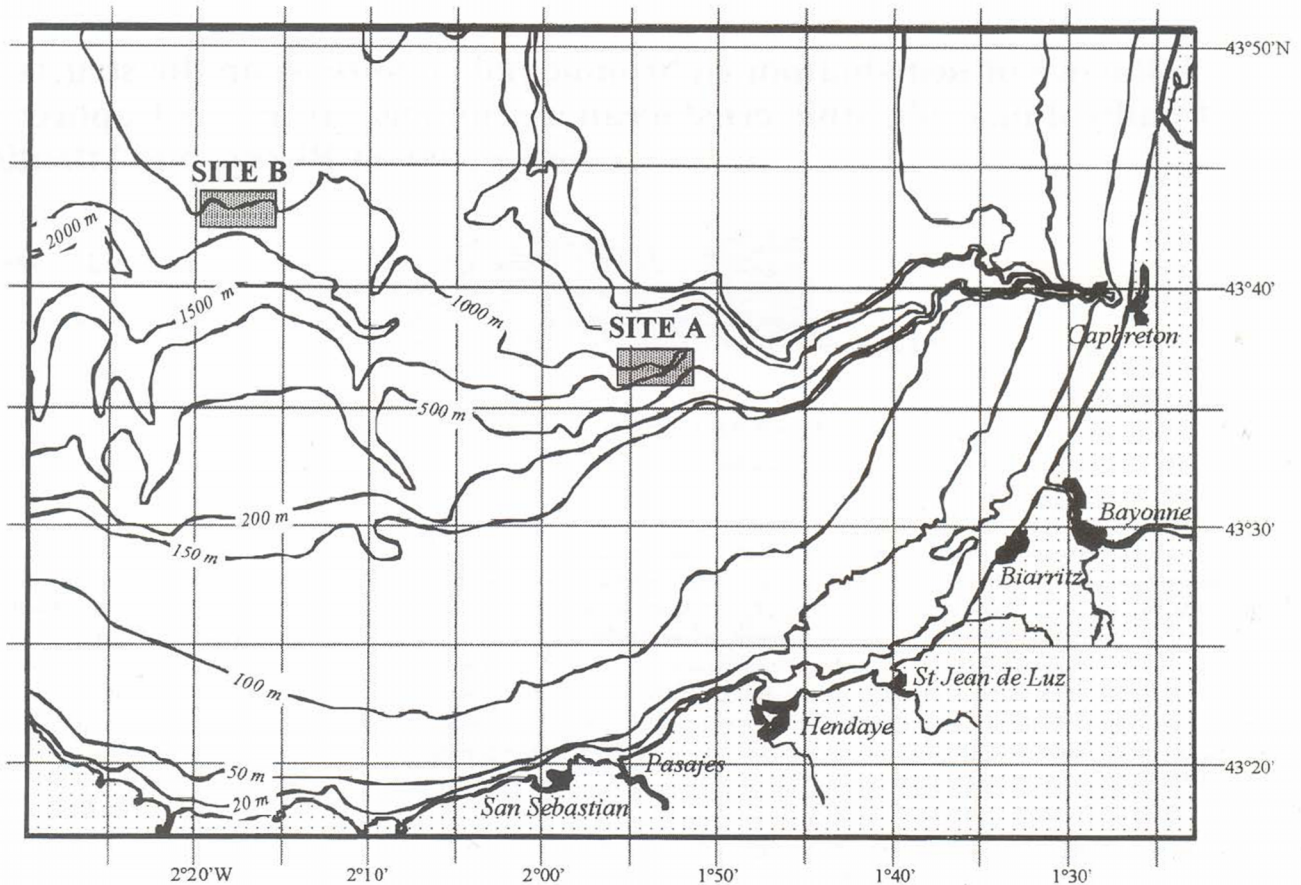


Figure 1. Geographical location of sites A and B within the upper part of the Capbreton canyon (Bay of Biscay, NE Atlantic).

northwards between 800 and 1 200 m depth, well characterised by their temperature (9–10.5 °C), high salinity (35.80 ‰) and low oxygen content (minimum value slightly inferior to 4.38 mL·L⁻¹ at about 850 m water depth). According to the disposition of isotherms and isohalines on a longitudinal profile of the canyon depicted by Ogawa and Tauzin [18] and Sorbe ([32], CAPBRETON 87 data), the near-bottom waters at the two sampling sites probably show similar temperature and salinity values while their oxygen content is quite different (see below).

Tauzin [34] mapped the sediment covering of the canyon as well as of its adjacent shelves. Except in its uppermost part (< 200 m depth) where sandy bottoms are known to occur, the whole submarine valley is covered by muddy sediments with a variable proportion of silt and clay.

Ogawa and Tauzin [18] described the physico-chemical environment at the water-sediment interface at different stations all along the canyon (some of them

not very far from the present sampling sites). Except for the uppermost part of the canyon where some water renewal actually occurred, the near-bottom waters generally showed a low oxygen content due to their stagnation westward from the meridian 1°38' W as demonstrated by the presence of monosulphide as well as pyrite microspheres in surficial sediments (more or less reduced environment). Their mean level of oxygen saturation was about 50 % but locally some values were less than 25 % (hypoxia). Furthermore, between 1°50' and 1°58' W, very low oxygen contents were measured in the near-bottom waters (minimum value at 20 cm above the sea-floor: 1.96 mL·L⁻¹) showing some tendency to confinement in this sinuous part of the canyon. Westwards from the meridian 2° W, the near-bottom waters showed a higher oxygen content (5.74 mL·L⁻¹ at about 1 600 m depth) probably due to a better circulation of water masses in this enlarged part of the canyon (oxygen saturation level: 75 %).

Tauzin [34] measured the organic carbon content (% of dry sediment) of surficial sediments all along the bottom and the flanks of the canyon. The observed values fluctuated between 0.44 and 5.39 % and an organic-rich area was detected at a bathymetric level located just above the aforementioned confinement area.

According to such environmental features, the Capbreton canyon may be classified as 'inactive', i.e. without any role in the transport of organic nutrients down to the depauperate abyssal communities. Furthermore, at least in its uppermost portion, it probably acts as a depocenter by trapping large aggregates of shallow water detritus which contribute to increase the organic content of the underlying sediments.

Before the present research programme on the Capbreton ecosystem, the deep benthic macrofauna of the canyon was poorly known. Le Danois [16] established a first list of invertebrate species from this area, allowing to distinguish a faunal boundary at 500 m depth for the epibenthic megafauna. Lagardère [15] described the vertical zonation of the benthic decapods between 130 and 1 000 m depth within the Capbreton canyon, showing a lower diversity and abundance of

these crustaceans above 400 m depth. Peypouquet [19] discovered the presence of Mediterranean benthic ostracods in the epibathyal Capbreton area, probably related with the deep northward outflow of Mediterranean water. Although the analysis of the benthic material collected during the Capbreton sampling programme is still not achieved, some partial observations have already been published on the macrofauna of this canyon [1, 20, 21, 22, 26, 32, 36, 37]. The DI19 sample from site A was partially analysed at a higher taxonomic level (major zoological groups) by Urzelai et al. [36].

3. MATERIALS AND METHODS

The bathyal benthic material examined in this study was collected in the two sampling sites A and B at approximately 1 000 m depth during the two oceanographic cruises CAPBRETON 88 and CAPBRETON 89 (figure 1, table 1). Within each site, the benthic fauna was sampled with two different gears: one qualitative sample performed in the uppermost surficial substratum (ca. 5 cm thick) with a Sanders-Hessler type epibenthic sled (DI; gear designed by INSUB,

Table 1. Main characteristics of the sled and box-corer stations within sampling sites A and B of the Capbreton canyon during CAPBRETON 88 and CAPBRETON 89 cruises. DI, Epibenthic sled; KF, Flusha box-corer.

Cruise/Station	Site	Date d/m/y	Hour h:m	Position		Depth (m)
				N	W	
CAPBRETON 88						
DI19*	A	07/07/88	09:15	43°38.00'	1°51.79'	923
CAPBRETON 89						
DI66*	B	16/09/89	07:36	43°43.73'	2°17.36'	1 009
KF38	B	12/09/89	08:12	43°41.90'	2°18.54'	993
KF39	B	12/09/89	08:55	43°41.88'	2°19.05'	1 007
KF40	B	12/09/89	09:39	43°42.01'	2°18.52'	971
KF41	B	12/09/89	10:34	43°42.02'	2°18.30'	1 026
KF42	B	12/09/89	11:21	43°41.95'	2°18.41'	1 018
KF43	B	12/09/89	12:50	43°41.95'	2°18.40'	1 015
KF44	B	12/09/89	13:40	43°41.95'	2°18.39'	1 027
KF45	B	12/09/89	14:27	43°42.00'	2°18.35'	1 010
KF50	A	14/09/89	10:19	43°35.35'	1°55.15'	1 000
KF51	A	14/09/89	11:14	43°35.37'	1°54.89'	996
KF52	A	14/09/89	12:57	43°35.27'	1°55.04'	999
KF53	A	14/09/89	13:30	43°35.27'	1°54.96'	997
KF57	A	14/09/89	17:46	43°35.37'	1°54.90'	995
KF58	A	14/09/89	18:30	43°35.26'	1°55.28'	1 002
KF60	A	14/09/89	20:30	43°35.41'	1°54.01'	996

* Hour, depth and position of the boat at the beginning of the haul.

Table II. Species richness (number of species), density (ind·100 m⁻²) and diversity (H', Shannon index; J, evenness) of the macrobenthic crustaceans sampled with sled and box-corer within sites A and B of the Capbreton canyon.

	Site A				Site B			
		Sled	Box-corer			Sled	Box-corer	
No. species (%)								
Mysidacea	5	7.9	0	0.0	0	0.0	0	0.0
Amphipoda	35	55.5	11	64.6	27	42.8	9	34.6
Cumacea	8	12.7	2	11.8	18	28.6	4	15.4
Isopoda	9	14.3	2	11.8	11	17.4	9	34.6
Tanaidacea	2	3.2	2	11.8	3	4.8	3	11.5
Euphausiacea	1	1.6	0	0.0	1	1.6	0	0.0
Decapoda	3	4.8	0	0.0	3	4.8	1	3.9
Total	63		17		63		26	
Density								
Mysidacea	-	0.7	0.0	0.0	-	0.0	0.0	0.0
Amphipoda	-	38.0	85.8	75.0	-	47.4	51.8	45.0
Cumacea	-	4.1	8.8	7.7	-	32.9	7.6	6.8
Isopoda	-	32.6	4.4	3.8	-	11.3	40.4	35.0
Tanaidacea	-	24.0	15.4	13.5	-	7.8	13.4	11.7
Euphausiacea	-	0.2	0.0	0.0	-	0.2	0.0	0.0
Decapoda	-	0.4	0.0	0.0	-	0.4	1.9	1.7
Total	-		114.4		-		115.1	
Diversity								
H'	3.04		3.76		5.03		4.29	
J	0.51		0.92		0.84		0.91	

San Sebastian; aperture dimensions: 28 cm wide, 23 cm high; weight: 160 kg; mesh size of the net: 0.5 mm); and one series of quantitative samples performed with a Flusha box-corer (KF; area sampled by the core box: 650 cm²). Each KF sample (10 cm surficial sediment layer) was passed through a 0.5-mm mesh size sieve. The DI and KF collected material was preserved in 10 % buffered formaldehyde before subsequent laboratory analysis (identification of crustacean species and counts of individuals in each of these species; the non-crustacean components sorted from this material were not considered in this study). In both sites, the mean density of taxa (expressed in ind·100 m⁻² in order to compare with other studies on suprabenthic crustaceans from the SE Bay of Biscay area) was calculated from the KF samples (site A: seven samples; site B: eight samples) whereas only specific abundance percentages were given by non-quantitative sled samples (see *appendix I, II*). *The species diversity of each site was depicted by the Shannon index H' (log₂) and evenness J [27]. Finally, the faunistical similarity between benthic*

communities from the two sites was estimated by means of the Schoener index [28].

4. RESULTS

4.1. Sled samples (DI19; DI66)

The analysis of the qualitative samples obtained from the two sites A and B is presented in *table II* and *appendix I*. Although the two samples contained the same number of species (63 species), the high difference in the abundance of collected individuals is certainly related to the duration of the sled contact with the sea-floor (ca. 15 min for DI19, only 5 min for DI66). The species collected by this sled at the water-sediment interface and in the uppermost surficial sediments were mainly represented by amphipods, cumaceans and isopods. Mysids were curiously absent from the more oceanic sample. The relative abundance of the main dominant taxa was slightly different in the two sites: amphipods, isopods and tanaids at site A; amphipods, cumaceans and isopods at site B (decreasing rank of abundance). The species diversity indices

Table III. Percentage contribution of the main dominant benthic crustaceans in sled and box-corer samples from sites A and B of the Capbreton canyon. AMP, Amphipoda; CUM, Cumacea; ISO, Isopoda; TAN, Tanaidacea.

		Site A		Site B		
Sled	DI19		(%)	DI66	(%)	
	AMP	<i>Bonnierella abyssorum</i>	26.5	AMP	<i>Chevreuxius grandimanus</i>	10.6
	TAN	<i>Apseudes spinosus</i>	23.9	AMP	<i>Ampelisca pusilla</i>	8.4
	ISO	<i>Arcturopsis giardi</i>	21.7	CUM	<i>Leucon (Leucon) serratus</i>	7.0
	ISO	<i>Chelator insignis</i>	9.6	AMP	<i>Arrhis mediterraneus</i>	4.0
	CUM	<i>Makrokyllindrus longipes</i>	2.4	CUM	<i>Procampylaspis armata</i>	3.4
		Total	84.1	Total	33.4	
Box-corer	KF50-60		%	KF38-45	%	
	AMP	<i>Ampelisca pusilla</i>	13.5	AMP	<i>Harpinia latipes</i>	13.3
	AMP	<i>Harpinia latipes</i>	11.6	AMP	<i>Leptophoxus falcatus</i>	11.6
	AMP	<i>Harpinia truncata</i>	9.6	TAN	<i>Sphyrapus malleolus</i>	8.3
	AMP	<i>Metaphoxus simplex</i>	5.8	ISO	<i>Bullowantura aquitanica</i>	6.6
	TAN	<i>Apseudes spinosus</i>	5.8	ISO	<i>Desmosoma elongatum</i>	6.6
		Total	46.3	Total	46.4	

(H' and J) showed lower values at site A due to the numerical dominance of a few species, namely the amphipod *Bonnierella abyssorum*, the tanaid *Apseudes spinosus* and the isopod *Arcturopsis giardi* which represented 72.1 % of the total collected fauna in DI19 (table III). Such a dominance of some species is also reflected in the low similarity between the two sled samples (Schoener index: 17.3 %). In contrast, the five dominant species from DI66 did not represent more than 33.4 % of the total collected fauna (table III).

4.2. Box-corer samples (KF50-60; KF38-45)

Results are presented in table II and appendix II. In each KF sample from both series, the number of species as well as the abundance of individuals were very low in comparison to the corresponding sled samples. The cumulative number of identified species was lower at site A (17 species) than at site B (26 species). The crustacean fauna was represented by endobenthic amphipods, isopods and cumaceans, as expected with this kind of sampler. The more motile taxa such as mysids and euphausiids were not sampled at all by the box-corer. Calculated from the overall material collected in each series, the Shannon diversity index was higher at site B than at site A while evenness J showed the same high value at both sites. Furthermore, both indices from box-corer samples were higher than the corresponding values from sled samples. The overall mean density values from both sites were not statistically different (114.1 and 115.1 ind·100 m⁻² at sites A and B, respectively; $t_{\text{obs}} =$

0.01; $df = 13$; $P > 0.05$). However, both communities differed with respect to the rank and contribution of their main dominant components, especially in the case of isopods which were more abundant at the oceanic site B. As shown in table III, the five dominant species from each series did not represent more than 46.4 % of the total collected fauna. Finally, although slightly higher than for the sled samples, the low similarity between sites A and B calculated from the KF sample series (Schoener index: 33.1 %) confirmed the existence of distinct macrobenthic communities in these areas.

5. DISCUSSION

First of all, it must be emphasised that the two samplers used in this study give different complementary information on the structure of the macrobenthic communities from the two sampling sites. The Fusha box-corer samples only a very small area. It allows the estimation of the density of endobenthic taxa but generates a bow-wave on the sea-floor which sweeps away the motile near-bottom fauna (mysids and euphausiids). The epibenthic sled samples simultaneously the uppermost surficial sediment layer as well as the near-bottom water layer allowing the more motile animals from the water-sediment interface to be caught. Such methodological remarks on benthic samplers were also discussed by Rallo et al. [21]

(epibenthic sled and dredge, otter trawl) and Elizalde et al. [9] (box-corer, multiple corer, Smith-McIntyre grab).

Although located at the same depth within the Capbreton canyon, the sampling sites A and B shelter two different macrobenthic communities as demonstrated by the comparison of their main characteristics derived from the analysis of the sled and box-corer samples. Furthermore, such a difference in the community structure of these sites is more evident in the case of the epibenthic fauna sampled by the sled at the sediment-water interface than for the endobenthic components from the box-corer samples. The low diversity indices at site A as well as the low similarity between sites result from the dominance of a few number of epibenthic species, which were mainly or exclusively collected by the sled within the confinement area of the upper canyon, such as the amphipod *Bonnierella abyssorum*, the tanaid *Apseudes spinosus* and the isopod *Arcturopsis giardi*. These species respectively represented 26.5, 23.9 and 21.7 % of the total abundance in the DI19 sled sample. The first two species were also present although with low abundances in sled samples from site B, whereas the last one was not sampled at this site.

Apart from the preliminary data published by Urzeilai et al. [36] on the deep macro- and megabenthic communities (major zoological groups) from the Capbreton canyon which revealed an heterogeneous distribution of the fauna within the submarine valley, the present results can be compared to the data published by Elizalde et al. [8] on the structure of a bathyal suprabenthic community located at about 1 000 m depth on the southern margin of the Cap Ferret canyon (SE Bay of Biscay). Within the 10–40-cm water layer sampled by the sled above the sea-floor, the structure of this suprabenthic community was similar to the one from the oceanic site B (sled sample): high species richness (97 species, mainly amphipods, cumaceans, isopods and mysids); high diversity values ($H' = 5.75$; $J = 0.87$); numerical dominance of amphipods (50.2 %); and cumaceans (28.6 %) and low contribution of the five dominant species which represented no more than 26.1 % of the total. Furthermore, *A. spinosus* and *B. abyssorum* were also recorded from the Cap-Ferret bathyal community whereas *A. giardi* was apparently absent from this area [7].

Bonnierella abyssorum [3] was first described as *Gammaropsis abyssorum* from the material collected by the RV *Caudan* at 950 m depth (station 13; three specimens) in the south-eastern Bay of Biscay and later assigned to the genus *Bonnierella* by Che-

vreux [4]. Apart from recent notations from bathyal communities of the south-eastern Bay of Biscay [6, 7, 8, 33], this amphipod was apparently not recorded after its discovery although it was actually mentioned by Le Danois [16] in a list of macrobenthic species from the Capbreton canyon. Its systematic position is dubious (Ischyroceridae? according to Barnard and Karaman [2]) and almost nothing is known about its ecology except it shows a bathyal distribution [2].

Apseudes spinosus (M. Sars, 1858) is a common tanaid collected on a variety of sediments between 18 and 1 300 m depth from Iceland to the Bay of Biscay [12] and recently mentioned in coarse sand from the Portuguese continental shelf [5]. It was reported by Bonnier [3] in the south-eastern Bay of Biscay (*Caudan* cruise; station 13, 950 m depth) and also mentioned by Le Danois [16] in the Capbreton canyon. According to Holdich and Jones [12], several *Apseudes* species are known to burrow into the surficial sediment with their antennules, antennae and pereopod 1.

Arcturopsis giardi [3] was first described as *Astacilla giardi* from the material collected by the RV *Caudan* at 650 m (station 11; fourteen specimens) and 950 m depth (station 13; two specimens) in the south-eastern Bay of Biscay and later assigned to the genus *Arcturopsis* by Koelher [14]. It was also mentioned by Le Danois [16] from the Capbreton canyon. Surprisingly, it was not recorded during a recent intensive sampling programme in an area located near *Caudan* station 11 ([7, 8] and unpubl. data). This species is morphologically characterised by its sexual dimorphism related to the lengthening of pereonite 4 and to the presence of a curious median appendix on the ventral face of pereonite 3 in adult males. As for the other mentioned species, little information is available on their benthic ecology. This new finding of an abundant population in the south-eastern Bay of Biscay will allow a detailed morphological and biometric redescription of this interesting species.

Unusual at 1 000 m depth in the south-eastern Bay of Biscay [7, 8, 33], the lower diversity values recorded at site A suggests that the macrobenthic community from this deeply embanked and sinuous portion of the Capbreton canyon is not biologically but physically controlled by some restraining environmental factors, as demonstrated for coastal suprabenthic communities mainly structured by hydrodynamism [30, 31]. Due to their relatively high abundance at site A (more than 900 individuals in one sled sample) and their apparent rarity or absence in other bathyal sampling stations from the south-eastern Bay

of Biscay, the three dominant epibenthic species are certainly linked with the anteriorly described environmental conditions in the confinement area of the submarine valley (reduced substratum, oxygen depletion and stagnation of near-bottom water). Such a dominance of a few species in canyon communities in comparison with adjacent non-canyon slope communities was also reported for the epi- and megabenthic fauna of the Hatteras, Alvin and Hudson canyons from the east coast of North America [10, 11, 23, 24]. However, this peculiarity was not observed by Houston and Haedrich [13] for the Carson canyon (Grand Banks) which was considered as an 'active' canyon where sediment was continually flushed out all along the submarine valley, thus preventing the development of abundant epibenthic populations. Finally, as previously suggested by Rowe [24] and Rowe et al. [25], such dominant epibenthic species may be considered as 'canyon indicator species' mainly observed in canyons which act as depocenter for organic matter. Further investigations on the benthic communities of the Capbreton canyon will provide new insights on the distribution of these species with regard to the extension of the confinement area within the upper portion of this submarine valley.

Acknowledgments

Thanks are due to DGO (Talence) for the loan of the Flusha box-corer, to BIMM-MNHN (Paris) for the loan of the sieving equipment, to the crew of the RV *Côte d'Aquitaine* for their valuable assistance at sea and to A. Urzelai, I. Esteban and I. Zabala (INSUB, San Sebastian) for their helpful contribution to the sorting of Capbreton samples. This French-Spanish co-operative research programme was partly supported by the French CIRMAT-CNRS (1988-89 CAPBRETON cruises).

REFERENCES

- [1] Aguirrezabalaga F., Altuna A., Marruedo J., Miner A., Pena J., Romero A., San Juan R., San Vicente C., Serrano A., Ibañez M., Contribución al conocimiento de la fauna marina de la Costa Vasca. VI, Lurralde 11 (1988) 217-265.
- [2] Barnard J.L., Karaman G.S., The families and genera of marine gammaridean Amphipoda (except marine gammaroids), Rec. Aust. Mus. 13 (Suppl. 1 and 2) (1991) 1-866.
- [3] Bonnier J., Edriophthalmes, in: Koehler R. (Ed.), Résultats scientifiques de la campagne du « Caudan » dans le golfe de Gascogne, août-septembre 1895, Ann. Univ. Lyon 26 (1896) 527-689.
- [4] Chevreux E., Amphipodes provenant des campagnes de l'Hirondelle (1885-1888), Résult. Camp. Scient. Prince Albert I 16 (1900) 1-195.
- [5] Cunha M.R., Sorbe J.C., Bernardes C., On the structure of the neritic suprabenthic communities from the Portuguese continental margin, Mar. Ecol. Prog. Ser. 157 (1997) 119-137.
- [6] Dauvin J.C., Sorbe J.C., Suprabenthic amphipods from the southern margin of the Cap-Ferret canyon (Bay of Biscay, northeastern Atlantic Ocean): abundance and bathymetric distribution, Pol. Arch. Hydrobiol. 42 (1995) 441-460.
- [7] Elizalde M., Les communautés suprabenthiques bathyales de la marge sud du canyon du Cap Ferret (Golfe de Gascogne), Ph.D. thesis, université de Bordeaux-I, France, 1994, 212 p.
- [8] Elizalde M., Sorbe J.C., Dauvin J.C., Las comunidades suprabentónicas batiales del golfo de Vizcaya (margen sur del cañon de Cap-Ferret): composición faunística y estructura, Publ. Espec. Inst. Esp. Oceanogr. 11 (1993) 247-258.
- [9] Elizalde M., Weber O., Sorbe J.C., Influence des caractères sédimentologiques sur la distribution des Crustacés benthiques de la pente atlantique (golfe de Gascogne; marge sud du canyon du Cap-Ferret), Actes du III^e Colloque international « Océanographie du Golfe de Gascogne », 1993, pp. 269-273.
- [10] Haedrich R.L., Rowe G.T., Polloni P.T., Zonation and faunal composition of epibenthic populations on the continental slope south of New England, J. Mar. Res. 33 (1975) 191-212.
- [11] Haedrich R.L., Rowe G.T., Polloni P.T., The megabenthic fauna in the deep sea south of New England, USA, Mar. Biol. 57 (1980) 165-179.
- [12] Holdich D.M., Jones J.A., Tanaids. Keys and Notes for the Identification of the Species, Synopses of the British Fauna No. 27, 1983, 98 p.
- [13] Houston K.A., Haedrich R.L., Abundance and biomass of macrobenthos in the vicinity of Carson Submarine Canyon, northwest Atlantic Ocean, Mar. Biol. 82 (1984) 301-305.
- [14] Koehler R., Arcturidés nouveaux provenant des campagnes de la Princesse-Alice ou appartenant au Musée Océanographique de Monaco, Bull. Inst. Océanogr. 214 (1911) 1-65.
- [15] Lagardère J.P., Distribution des décapodes dans le sud du golfe de Gascogne, Rev. Trav. Inst. Pêches Marit. 37 (1973) 77-95.
- [16] Le Danois E., Les profondeurs de la mer. Trente ans de recherches sur la faune sous-marine au large des côtes de France, Payot Édition, Paris, 1948, 303 p.
- [17] Le Floch J., Quelques propriétés des eaux d'origine méditerranéenne dans le golfe de Gascogne, Trav. Centre Rech. Étud. Océanogr. 7 (1968) 25-36.
- [18] Ogawa N., Tauzin P., Contribution à l'étude hydrologique et géochimique du Gouf de Capbreton, Bull. Inst. Géol. Bassin Aquitaine 14 (1973) 19-46.
- [19] Peypouquet J.P., Sur la présence d'espèces méditerranéennes au niveau des étages circalittoral et épibathyal de la zone de Cap-Breton, Bull. Inst. Géol. Bassin Aquitaine 13 (1973) 143-146.
- [20] Rallo A., Estudio biológico de los fondos de la fosa del Capbreton (golfo de Vizcaya, Atlantico Oriental). Campaña preparatoria, Julio (1987). Nota sobre las primeras capturas de fauna de poliquetos, Cuad. Invest. Biol. (Bilbao) 13 (1988) 145-149.
- [21] Rallo A., García-Arberas L., Isasi I., Distribución y asociaciones entre diversos grupos de invertebrados béticos en aguas del cañon del Capbreton (golfo de Vizcaya), Actes du III^e Colloque international « Océanographie du Golfe de Gascogne », 1993, pp. 275-278.
- [22] Rallo A., García-Arberas L., Isasi I., Fauna macrobentónica de los fondos del cañon de Capbreton: análisis faunístico de poliquetos, crustáceos y cnidarios y caracterización de puntos de muestreo según estos descriptores, Cah. Biol. Mar. 35 (1993) 69-90.

- [23] Rowe G.T., Observations on bottom currents and epibenthic populations in Hatteras Submarine Canyon, *Deep-Sea Res.* 18 (1971) 569–581.
- [24] Rowe G.T., The exploration of submarine canyons and their benthic faunal assemblages, *Proc. Roy. Soc. Edinburgh (B)* 73 (1972) 159–169.
- [25] Rowe G.T., Polloni P.T., Haedrich R.L., The deep-sea macrobenthos on the continental margin of the northwest Atlantic Ocean, *Deep-Sea Res.* 29 (1982) 257–278.
- [26] San Martín G., Ceberio A., Aguirrezabalaga F., *Exogone* species (Polychaeta: Syllidae: Exogoninae) from the Capbreton Canyon (Bay of Biscay, NE Atlantic), *Cah. Biol. Mar.* 37 (1996) 249–258.
- [27] Scherrer B., *Biostatistique*, Gaëtan Morin Edition, Paris, 1984, 850 p.
- [28] Schoener T.W., Resource partitioning in ecological communities, *Science* 185 (1974) 27–39.
- [29] Shepard F.P., Dill R.F., *Submarine Canyons and Other Sea Valleys*, Rand McNally & Company, Chicago, 1966, 381 p.
- [30] Sorbe J.C., Contribution à la connaissance des peuplements suprabenthiques néritiques sud-Gascogne, Ph.D. thesis, université de Bordeaux-I, France, 1984, 225 p.
- [31] Sorbe J.C., Structural evolution of two suprabenthic soft-bottom communities of the south Gascogne continental shelf, *Sci. Mar.* 53 (1989) 335–342.
- [32] Sorbe J.C., Le canyon de Capbreton : état des connaissances sur ce site exceptionnel de la marge atlantique européenne, in: Urrutia J., Rallo A. (Eds.), *Oceanografía del golfo de Vizcaya*, Servicio Editorial UPV-EHU, Bilbao, 1990, pp. 93–140.
- [33] Sorbe J.C., Weber O., Influence de la profondeur et des sédiments superficiels sur la structure des communautés suprabenthiques bathyales sud-Gascogne, *Actas del IV Coloquio Internacional sobre Oceanografía del Golfo de Vizcaya*, 1995, pp. 183–194.
- [34] Tauzin P., Étude des relations entre les caractéristiques physico-chimiques et chimiques des milieux de dépôt et la distribution de quelques éléments métalliques dans les sédiments de divers environnements du golfe de Gascogne, Ph.D. thesis, université de Bordeaux-I, France, 1974, 117 p.
- [35] Teixeira Gomes A.A., Análise morfológica dos canhões submarinos da Nazaré e de Setúbal, *Mestre em Ciências das Zonas Costeiras*, Universidade de Aveiro, Portugal, 1996, 152 p.
- [36] Urzelai A., Elizalde M., Arana B., Capellan T., Esteban I., San Vicente C., Ibañez M., Estudio de las comunidades de los fondos batiales de la fosa de Capbreton (golfo de Vizcaya): metodología y resultados preliminares, *Bentos* 6 (1990) 345–353.
- [37] Urzelai A., Elizalde M., Capellan T., Esteban I., Quiroga A., Zabala I., Ibañez M., Estudio preliminar de las comunidades de *Pagurus alatus* Fabricius, 1775 y *Parapagurus pilosimanus* S. I. Smith, 1879 (Crustacea Decapoda) y *Epizoanthus paguriphilus* Verril, 1883 (Anthozoa Zoantaria) de la fosa de Capbreton (golfo de Vizcaya), *Lurralde* 13 (1990) 193–206.
- [38] Vanney J.R., Mougénot D., Un canyon sous-marin de type « gouf ». Le canhão de Nazaré (Portugal), *Oceanol. Acta* 13 (1990) 1–14.

Appendix I. Abundance and percentage contribution of the macrobenthic crustaceans sampled with an epibenthic sled within sites A and B of the Capbreton canyon. * Damaged specimens; unid.: unidentified specimens; juv.: juveniles; MYS: Mysidacea; AMP: Amphipoda; CUM: Cumacea; ISO: Isopoda; TAN: Tanaidacea; EUP: Euphausiacea; DEC: Decapoda.

Site/Station	A/DI19		B/DI66		Site/Station	A/DI19		B/DI66	
Depth (m)	923		1 009		Depth (m)	923		1 009	
Species	No. ind.	%	No. ind.	%	Species	No. ind.	%	No. ind.	%
MYS <i>Amblyops spinifera</i>	1	0.02	–	0.00	<i>Stegocephaloides auratus</i>	1	0.02	–	0.00
<i>Paramblyops rostrata</i>	22	0.48	–	0.00	<i>Bruzelia typica</i>	9	0.20	–	0.00
<i>Parapseudomma calloplura</i>	2	0.04	–	0.00	<i>Gammaridea unid.*</i>	50	1.09	17	2.37
<i>Parerythrobes obesa</i>	1	0.02	–	0.00	<i>Parvipalpus major</i>	15	0.33	–	0.00
Erythropini unid.*	2	0.04	–	0.00	Caprelliacea unid.	–	0.00	17	2.37
<i>Bathymysis helgae</i>	1	0.02	–	0.00	CUM <i>Bathycuma brevivirostre</i>	–	0.00	13	1.81
Mysidacea unid.	2	0.04	–	0.00	<i>Cyclaspis longicaudata</i>	–	0.00	6	0.84
AMP <i>Iphimedia obesa</i>	1	0.02	–	0.00	<i>Diastrylis serrata</i>	12	0.26	2	0.28
<i>Ampelisca declivitatis</i>	1	0.02	–	0.00	<i>Leptostylis villosa</i>	–	0.00	7	0.98
<i>Ampelisca pusilla</i>	8	0.17	60	8.37	<i>Makrokyllindrus longicaudatus</i>	–	0.00	10	1.39
<i>Ampelisca uncinata</i>	10	0.22	–	0.00	<i>Makrokyllindrus longipes</i>	112	2.44	20	2.79
<i>Byblis gernei</i>	5	0.11	–	0.00	<i>Vemakylindrus hastatus</i>	5	0.11	15	2.09
<i>Haploops cf. proxima</i>	–	0.00	1	0.14	<i>Hemilamprops normani</i>	–	0.00	2	0.28
<i>Gitana abyssicola</i>	–	0.00	1	0.14	<i>Eudorella truncatula</i>	1	0.02	21	2.93
Amphilochidae unid.	–	0.00	1	0.14	<i>Epileucon pusillus</i>	–	0.00	20	2.79
Aoridae unid.	1	0.02	9	1.25	<i>Leucon (Crymoleucon) tener</i>	9	0.20	28	3.90
<i>Argissa hamatipes</i>	–	0.00	5	0.70	<i>Leucon (Crymoleucon) sp.A</i>	3	0.07	–	0.00
<i>Chevreuxius grandimanus</i>	–	0.00	76	10.60	<i>Leucon (Crymoleucon) sp.B</i>	–	0.00	5	0.70
<i>Erichthonius cf. fasciatus</i>	18	0.39	–	0.00	<i>Leucon (Leucon) serratus</i>	43	0.94	50	6.97
<i>Cleonardopsis carinata</i>	22	0.48	–	0.00	<i>Leucon (Macrauloleucon)</i>	2	0.04	10	1.39
<i>Eusirus longipes</i>	5	0.11	–	0.00	<i>siphonatus</i>	–	0.00	–	–
<i>Rhachotropis caeca</i>	10	0.22	–	0.00	<i>Leucon spp.*</i>	1	0.02	–	0.00
<i>Rhachotropis gracilis</i>	5	0.11	–	0.00	<i>Campylaspis glabra</i>	–	0.00	1	0.14
<i>Rhachotropis grimaldii</i>	2	0.04	6	0.84	<i>Campylaspis squamifera</i>	–	0.00	1	0.14
<i>Rachotropis rostrata</i>	–	0.00	1	0.14	<i>Cumella gracillima</i>	–	0.00	1	0.14
<i>Rhachotropis spp.*</i>	5	0.11	–	0.00	<i>Procampylaspis armata</i>	–	0.00	24	3.35
<i>Carangoliopsis spinulosa</i>	94	2.05	7	0.97	ISO <i>Chelator insignis</i>	439	9.56	4	0.56
<i>Eriopisa elongata</i>	3	0.07	–	0.00	<i>Desmosoma elongatum</i>	14	0.30	1	0.14
<i>Maera sp.*</i>	–	0.00	1	0.14	<i>Eugerda filipes</i>	2	0.04	–	0.00
<i>Bonnierella abyssorum</i>	1 218	26.51	20	2.79	<i>Desmosomatidae*</i>	–	0.00	7	0.98
<i>Listriella sp. A</i>	4	0.09	–	0.00	<i>Haplomesus sp.A</i>	–	0.00	2	0.28
<i>Liljeborgia cf. macronyx</i>	4	0.09	–	0.00	<i>Macrostylis spinifera</i>	–	0.00	9	1.25
<i>Orchomene humilis</i>	3	0.07	–	0.00	<i>Macrostylis sp.A</i>	–	0.00	1	0.14
<i>Scopelocheirus hopei</i>	8	0.17	–	0.00	<i>Belonectes parvus</i>	2	0.04	–	0.00
<i>Tryphosella insignis</i>	13	0.28	2	0.28	<i>Eurycope complanata</i>	–	0.00	13	1.81
<i>Arrhis mediterraneus</i>	5	0.11	29	4.04	<i>Ilyarachna longicornis</i>	–	0.00	17	2.37
<i>Bathymedon longimanus</i>	1	0.02	9	1.25	<i>Ilyarachna polita</i>	22	0.48	6	0.84
<i>Monoculodes packardii</i>	–	0.00	5	0.70	<i>Pseudarachna hirsuta</i>	5	0.11	–	0.00
<i>Synchelidium maculatum</i>	1	0.02	1	0.14	<i>Janirella nansenii</i>	11	0.24	–	0.00
Oedicerotidae sp.A	–	0.00	3	0.42	<i>Bullowanthura aquitanica</i>	5	0.11	4	0.56
Oedicerotidae unid.*	–	0.00	25	3.49	<i>Leptanthura tenuis</i>	–	0.00	14	1.95
<i>Epimeria cornigera</i>	9	0.20	–	0.00	<i>Gnathia sp.</i>	–	0.00	3	0.42
<i>Halice abyssii</i>	–	0.00	1	0.14	<i>Arcturopsis giardi</i>	997	21.70	–	0.00
<i>Pardaliscia mediterranea</i>	1	0.02	1	0.14	TAN <i>Apseudes spinosus</i>	1 097	23.88	10	1.39
<i>Pardaliscella sp.A</i>	2	0.04	–	0.00	<i>Sphyrapus malleolus</i>	–	0.00	5	0.70
<i>Harpinia antennaria</i>	9	0.20	–	0.00	unid.	4	0.09	41	5.72
<i>Harpinia crenulata</i>	11	0.24	–	0.00	EUP <i>Meganocyphanes norvegica</i>	12	0.26	–	0.00
<i>Harpinia latipes</i>	85	1.85	20	2.79	Euphausiacea unid.*	–	0.00	1	0.14
<i>Harpinia sp.D</i>	–	0.00	5	0.70	DEC <i>Metacrangon jacqueti jacqueti</i>	1	0.02	–	0.00
<i>Harpinia sp.E</i>	–	0.00	4	0.56	<i>Pontophilus norvegicus</i>	1	0.02	1	0.14
<i>Harpinia spp.*</i>	5	0.11	–	0.00	<i>Calocaris macandreae</i>	18	0.39	–	0.00
<i>Leptophoxus falcatus</i>	6	0.13	4	0.56	<i>Geryon sp.</i>	–	0.00	1	0.14
<i>Metaphoxus simplex</i>	–	0.00	7	0.97	Brachyura unid. (juv.)	–	0.00	1	0.14
<i>Pseudharpinia excavata</i>	–	0.00	1	0.14	Total	4 594	100.00	717	100.00
Phoxocephalidae unid.*	–	0.00	1	0.14					
<i>Laetmatophilus tuberculatus</i>	95	2.07	–	0.00					

Appendix II. Abundance, density (ind·100 m⁻²) and percentage contribution of the macrobenthic crustaceans sampled with a box-corer within sites A and B of the Capbreton canyon. * Damaged specimens; unid.: unidentified specimens; ?; total number of individuals; x: mean value; s: standard deviation; MYS: Mysidacea; AMP: Amphipoda; CUM: Cumacea; ISO: Isopoda; TAN: Tanataceae; EUP: Euphausiacea; DEC: Decapoda.

Site	A											B											
	KF50	KF51	KF52	KF53	KF57	KF58	KF60	Density		%		B											
Station																							
Depth (m)	1 000	995	997	994	995	1 002	995	Density		%		1 003	KF39	KF40	KF41	KF42	KF43	KF44	KF45	Density		%	
Group/Species																							
MYS																							
AMP																							
ISO																							
TAN																							
EUP																							
DEC																							
Total																							