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ECOMARG Project:
A multidisciplinary study of Le Danois Bank (Cantabrian Sea, N Spain)

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Abstract

The main objective of the ECOMARG project is the integrated study of the benthic-demersal ecosystem of the singular Asturian marginal shelf (Le Danois Bank), a barely well-known area in spite of belonging to the Spanish EEZ and being subject to fishing activities. The study has a multidisciplinary strategy that includes the abiotic scenario and the benthic and demersal communities. Concerning the abiotic scenario, the morphosedimentary and bathymetric characteristics and also the characteristics of the water column were analysed. Regarding communities, the main compartments of the benthic domain were studied using a multigear system. i) Demersal fish and larger epibenthic communities were sampled using an otter trawl, ii) smaller epibenthos was sampled with a 3.5 m beam trawl, iii) suprabenthos was captured with a sled, iv) a box corer was used to sample endobenthos, and v) a WP2-type plankton net was used to collect near-bottom zooplankton. This methodological approach offers a vision of the biodiversity of the ecosystem and its communities' structure and distribution. The trophic ecology of the dominant species of fish and crustaceans will be used to estimate of the energy flows, the consumption and niche overlap among high level trophic groups. All this information, together with the study of the impact of the fisheries working in the area, will be integrated in a trophodynamic mass-balance model (Ecopath) that will allow us to explain and to synthesize the characteristics of the ecosystem, to compare it with similar ones and to try to predict the consequences of the possible management measures that can be adopted in this remarkable area.

Keywords: Le Danois Bank, benthic communities, trophic ecology, fishery impact, Ecosystem Assessment, Cantabrian Sea.

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1. Introduction

The morphological and structural complexity of the Cantabrian margin is very high. This margin is constituted by a narrow shelf (5 to 40 km wide), a very steep continental break and a few marginal shelves (with a steep 10-12 % slope), and finally, its deepest limits, the Biscay abyssal plain. The most relevant of the Cantabrian marginal shelves is the Asturian shelf, known by the scientific community as 'Le Danois Bank' (Le Danois, 1948) and by the local fishermen as 'El Cachucho'. Le Danois Bank is an almost flat surface, slightly sloped to the coast, but separated of the continental shelf by a deeper marginal basin (850 m).

The main objective of the ECOMARG project is the integrate study of the benthic-demersal ecosystem of Le Danois Bank, barely well-known in spite of belonging to the Spanish EEZ and subject to fishing activities. In summary, the main issues of the ECOMARG project are:

- Morpho-sedimentary and bathymetric study of Le Danois Bank and surrounding area
- Characteristics and dynamics of the water masses
- Description of the benthic and demersal communities
- Fish and crustaceans trophic ecology
- Study of fisheries impacts
- Trophodynamic modelization
- Proposal of sustainable uses of the Bank

In a first stage, the project looked on the description of the physical scenario, through the morpho-sedimentary and bathymetric characteristics, and the study of the dynamic and characteristics of the water masses. In a second phase, the project focused on the fauna, with an integrate study of the three main benthic compartments: endobenthos, epibenthos and suprabenthos.

The trophic ecology of the dominant species of fish and crustaceans will be used to estimate of the energy flows, the consumption and the niche overlap among high level trophic groups. All this information, together with the study of the impact of the fisheries working in the area, will be integrated in a trophodynamic mass-balance model (Ecopath). This methodological approach offers a holistic view of the ecosystem variability, its communities and the distribution of the fishing resources. Finally it can also be an efficient tool in the management of the Bank. The trophodynamic modelization allows us to explain and synthesize the characteristics of the ecosystem, to compare it with similar ones and to try to predict the consequences of possible management measures that can be adopted in this remarkable area.

In the ECOMARG project take part scientists from different institutions: IEO, CSIC, SGPM in Spain, and *Laboratoire de Oceanographie Biologique* of Arcachon in France.

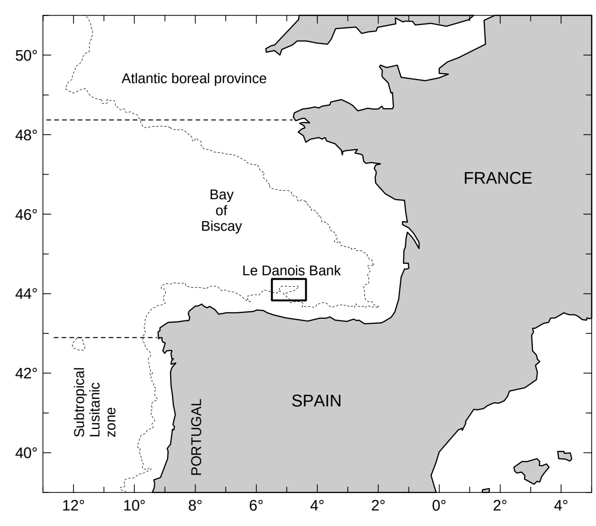

Figure 1. Location of Le Danois Bank in the Bay of Biscay.

2. Methodology

The study area is Le Danois Bank, a marginal shelf located in the Cantabrian Sea (Figure 1), with depths between 450-900 m, including the marginal basin (see introduction). This study included two multidisciplinary surveys, in autumn 2003 and spring 2004, on board the RV *Vizconde de Eza*. The first survey was focused in the description of the physical scenario, including both geophysical and hydrological objectives, and a preliminary biological sampling. The second survey was dedicated mainly to the biological study, using the nighttimes for geophysical works.

2.1. Description of the physical scenario

The Geophysical study was carried out in order to classify the bank grounds in different bottom types, a prerequisite to locate the biological sampling stations. All this information, in combination with the hydrographic data, is being used to explain the faunal variability and distribution.

2.1.1. Geophysical works: included a 100% coverage systematic bathymetric exploration of the area with a multibeam echosounder; seismic profiles following the ship track with Topas system; collecting samples of hard bottoms with a rock dredge, sampling of sediments with Shipek dredge and megabox-corer. All this information has been pooled and processed to obtain a bathymetric map of Le Danois Bank, the marginal basin and the adjacent shelf based on the multibeam data; and also a bottom-quality map based in the direct samples and the bottom reflectivity. Finally complete and detailed morpho-bathymetric and physiographic studies of the area were obtained.

2.1.2. Hydrography: a sample of independent sections on the main slopes of the bank was performed in the 2003 survey, together with a regular grid in the upper surface of the bank. A total of 49 stations were carried out, using a CTD Seabird+rosette at depths between 450 and 3000 m. 150 water samples were obtained in several profiles to obtain nutrients measurements and to calibrate CTD conductivity sensor.

During 2004 survey, CTD Seabird casts were performed following a regular grid of 5 nm NS by 10 nm EW, with the aim to determine mesoscalar structures linked to the bank and its possible influence limit. In this case, hydrographical profiles were carried out to a maximum depth of 650 m, sequentially (respecting as far as possible the sinopticity). A total of 41 stations in the sampling grid and 11 more in the biological sampling stations, were accomplished covering all the water column.

2.2 Community study

Several samplers were used on each biological station in order to study the different compartments of the benthic fauna. Epibenthos and demersal species were studied using two different gears, a Porcupine baca trawl (ICES, 2003) and a beam trawl. Most of the differences in the catches between the baca and the beam trawl are related with the higher catchability of swimming and large-sized epibenthic species in the baca trawl, compared to the better sampling performance of the beam trawl for flat and slow fish and for sessile and small sized invertebrates. Porcupine baca trawl mesh size was of 90 mm along the net but with a 20 mm liner inside the cod end. Horizontal opening was of 18.5 ± 1.3 m and vertical opening of 3.14 ± 0.20 m. The sampling unit was a 30-minute haul, all carried out at daytime at a speed of 3.5 knots. Beam trawl horizontal opening was of 3.5 m and vertical opening of 0.6 m (mesh size of 10 mm). Beam trawls lasted 15 minutes at a mean speed of 2.5 knots. Both trawl gears were monitored using a Scanmar net sensors. The mean area swept was 57 273 m^2 in otter trawls and 3 258 m^2 in beam trawls. The number of individuals and the weight of each species were obtained from each sample. Area was divided following a bathymetric criterion: the upper part of Le Danois Bank (400-700 m) was identified as Stratum 1, and the marginal basin (700-1000 m) corresponded with Stratum 2.

The endobenthos was collected using a megabox-corer (0.175 m^2 surface area and 15 to 20 cm sediment depth). In every station only one cast was performed, subdividing later the sample in 9 replicates for the faunal study, and other two to sedimenthological studies (grain size, organic matter content, Redox). Sieve size used in endobenthic study was of 0.5 mm. The main sedimentary characteristics determined were: percentage of organic matter, mean particle diameter (Q50, in mm), sorting coefficient (S0), percentage of coarse sands (> 500 µm), fine sands (62-500 µm) and mud (<62 µm).

To study the suprabenthic fauna, a suprabenthic sled was used, fitted with superposed nets of 3 m length and 0.5 mm mesh size, which allowed quantitative sampling of the motile fauna in two water layers: 0-65 and 65-90 cm above the bottom. The sampling surface of the nets was 0.450 m2 in the lower net and 0.225 m^2 in the upper one. Haul time was 2 minutes, always during daytime and at a speed of 2 knots. Sled trawl manoeuvres were also monitored using the Scanmar system.

Benthopelagic plankton was sampled with a plankton net type bongo WP2, with an opening of 1 m^2 and 0.5 mm of mesh size. The net has a double-trip close-open-close allowing to work in a specific depth of the water column, and a fluxmeter to obtain the volume of water filtered. The system obtains horizontal samples of benthopelagic plankton near the bottom (between 8-40 m in this study). Hauls lasted 10-15 minutes, at depths between 458-1125 m. All samples were obtained at the same time of the day (11-13 h), to avoid bias derived of vertical migrations.

In hard bottoms, two different visual techniques were used: a photogrammetric sled and a ROV. The photogram-metric sled has a high resolution digital camera that shoots at set time intervals. It uses four laser pointers to determine the surface covered by each photo and the dimensions of species. It also uses a CTD probe to characterize each photo according to the oceanographic variables (pressure, temperature and salinity). A ROV Swordfish model manufactured by Deep Ocean Engineering was also used up to 600 m deep.

Figure 2 shows the location of the different samplings made with each system during the 2004 survey in Le Danois Bank.

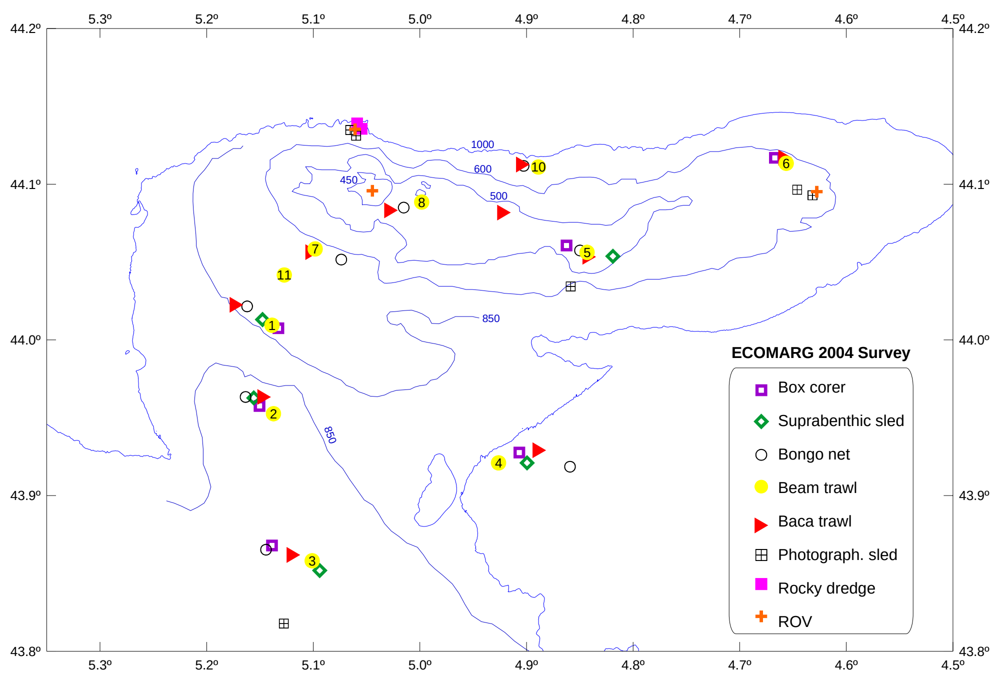

Figure 2. Sampling stations carried out during 2004 spring survey.

2.3. Trophic ecology

Quantitative diet estimation was obtained for the main fish and crustacea decapoda species present in the bank. Stomach content analyses made were based on the volume occupied by every prey, trying to arrive to the lowest taxonomic level possible. Regurgitation was taken in account in fishes, due to the know importance of this factor in species inhabiting high depths. Data will be used to build the trophodinamic model and, moreover, to estimate the trophic levels of the different predators studied. A representative number of individuals per species (15-25) were dissected and their stomach contents analyzed. With this information the mean fullness (expressed as stomach content weight/individual weight) and the diet composition were obtained. The methodology used in fishes has been described in several papers (Velasco & Olaso, 1998; Velasco *et al*. 2001). In some species with a high regurgitation rate, intestinal content was qualitatively analyzed to provide at least some information on diet composition.

In the study of the diet of decapoda crustaceans, the stomach content weight was obtained in the laboratory (wet weight, 0.00001 g precision), and this weight was later allocated between preys applying the dot method (Swynnerton & Worthington, 1951).

Furthermore, the relation between environmental factors and feeding intensity will be studied using multivariate techniques.

2.4. Fisheries

The design of the study of the fisheries working in the area considered two stages. In a first phase all the available information on fisheries activities was compiled using questionaires for the fishermen, aimed to: i) know the history of the fishery in the area; ii) identify and characterize the fleets currently fishing in the bank, and iii) compile all the available information on the catches in the fishery databases.

In a second stage, according to fishermen questionaires, direct information of the fisheries will be obtained. With this objective, quarterly embarkments on commercial vessel will be carried out along a year in every fishing activity. In these embarkments, information on fishery works will be collected and biological samplings will be performed.

2.5. Trophodinamic modelling

The final and integrating objective of the project is the description of the ecosystem by means of a mass-balance trophodinamic ECOPATH model. This model combines biomass and feeding consumption estimates of the different trophic groups with the flow analysis between the ecosystem elements (Christensen & Pauly, 1992, 1993).

The model uses as input data: biomass estimations, production, consumption and ecotrophic efficiency of every compartment or trophic group described. Diet matrix works as links between groups. The model also includes catches and discards estimations of the different fishery fleets operating in the area. All the components parameterization will follow a *top-down* criteria where lower level values are calculated taking into account the demand of higher levels (usually with better information about biomass, diets and consumptions). Furthermore, this model allows to make spatio-temporal simulations and projections, by means of the Ecosim and Ecospace routines (Walters *et al*., 1997 y 1998), and assuming changes in the present exploitation patterns.

3. Preliminary results

3.1. Description of the physical scenario

Geophysical works main aim was to complete a bathymetric cartography, focused in Le Danois Bank, its marginal basin, and the adjacent continental shelf including the Lastres Canyon (Figure 3). Bottom samples obtained with the megabox-corer, together with the geophysical methods, have allowed the develop of reflectivity and bottom quality maps. These maps, together with the bathymetric and morphologic data of the zone, will allow us to perform a detailed study of the physiographic, geomorphologic and tectonic characteristics of the area (more than 3200 km^2).

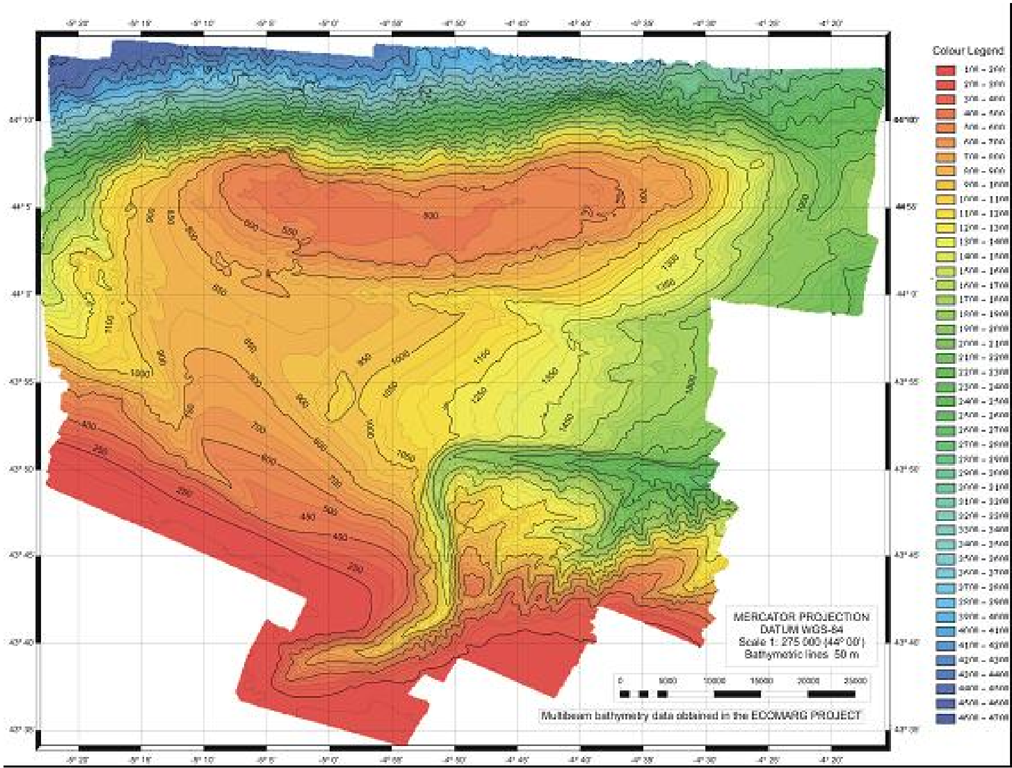

Figure 3. Color codified bathymetric map of the Bank Le Danois and Lastres canyon.

Megabox corer information, obtained in every biological sampling, shows how the sediment of the shallowest stations, between 460 and 682 m depth (Stratum 1, summit of the Bank), is characterized by the presence of sediment types dominated by very fine to fine sand, with a mean diameter between 67.9 and 166.1 µm. Organic matter content was low, ranging from 2.77 to 3.88. In the deepest stations, between 820 and 1028 m depth (Stratum 2, marginal basin), the sediment was mud, with a mean diameter between 8.7 and 28.2 µm. The organic matter content was moderate to high, ranging from 6.26 to 7.00 (% in weight). The selection varied from poor to moderately good.

Hydrographic issues took on included to quantify water masses, and especially, how the Mediterranean water appears in the outer side of the bank and the marginal basin. No circulation cell associated with the bank, as often occurs in seamounts, was detected. The small dimensions and the shape of the bank, together with the surface stratification, could explain in part the absence of these cells. In addition, the data provided by the current meter located at the top of the bank indicated a weak current, contrary to what was expected. A new detailed analysis of the data and some complementary experiments will allow us to confirm or refute these first observations.

3.2. Endobenthic, suprabenthic and benthopelagic communities

The analysis of the endobenthic samples of both surveys is still in process, but as preliminary result it is noteworthy the low abundance in numbers and biomass. This fact has been described in adjacent shelf areas (Tenore *et al.*, 1984). Diversity seems to be high, as is characteristic in deep ecosystems (Carney *et al.*, 1983; Gage *et al.*, 2000; Sanders, 1968). Samples analyzed were clearly dominated by polychaetes (about 76 %), followed by crustaceans (10 %) and mollusks (9%). The polychaetes were characterized by sabellids and terebellids and subsurface deposit-feeders were the dominant infaunal trophic group (26 % of total abundance).

Suprabenthic samples are also in process, but, opposite to endobenthos, suprabenthos of Le Danois Bank is extremely abundant and diverse. The only station finished contained 102 species (56 amphipoda), nine of them probably new to the science: six amphipoda (*Autonoe* sp., *Rhachotropis* sp., Eusiridae indet., *Leucothoe* sp., *Pseudo* sp., *Syrrhoites* sp.), two cumacea (*Paralamprops* sp., *Procampylaspis* sp.) and one isopod (*Arcturopsis* sp.).

Benthopelagic community analyses, in a preliminary stage, suggest a decrease of biomass with depth (between 460 m and the maximum sampled depth, 1125 m). In the upper part of shelf break (460-600 m) copepods and euphausiids (*Meganyctiphanes norvegica* and *Nematobrachion boopis*) dominate in biomass, while decapoda Natantia (*Systellaspis debilis*) and misids (*Eucopia hanseni* and *Gnatophausia zoea*) were the dominant taxa in the deeper stratum (600-1125 m).

3.3 Epibenthic and demersal communities

The total number of species caught with the beam trawl is 173, and 168 using baca trawl (Figure 4). Epibenthic communities of the marginal basin (Stratum 2), located between continental shelf and Le Danois Bank, are richer and more diverse than the upper part of the bank, in both gears used on epibenthos, and in both seasons (Table 1). Beam trawl catches in biomass and numbers were larger in Stratum 1 in both seasons, while in the baca trawl spring catch of Stratum 2 exceeded Stratum 1 one. A similar pattern has been found in density of individuals.

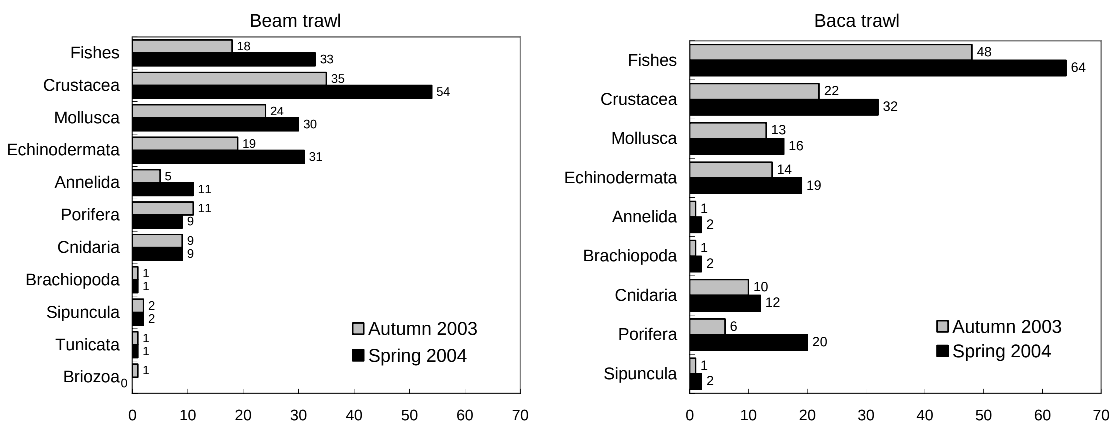

Figure 4. Species richness by taxonomic group and season from beam trawl and baca trawl samples.

Regarding seasonal differences, spring richness was higher in both strata and gears, except in the Stratum 2 samples of baca (Table 1). Beam trawl biomass and density was always higher in spring, while in baca trawl they were always higher in autumn (except density of Stratum 2).

Table 1. Mean values of ecological indices by gear, season and strata on Le Danois Bank. Species richness (S), biomass (B), abundance (N), diversity in biomass (H'_B) and number (H'_N) with their standard deviations (SD).

Beam trawl		S	SD_S	B	SD_B	N	SD_N	H'_B	$SD_{H'B}$	H'_N	$SD_{H'N}$
Autumn	Stratum 1	31.43	11.87	5.08	2.71	4149.0	3439.4	2,58	0.65	2.09	0.84
	Stratum 2	34.00	24.04	2.56	3.48	205.0	243.2	2.58	0.65	4.13	0.74
Spring	Stratum 1	42.80	12.76	11.32	6.70	29504.2	24670.0	2.76	0.87	1.52	1.17
	Stratum 2	55.80	5.76	8.08	4.29	790.4	520.7	2.96	0.70	4.09	0.93

Baca trawl		S	SD_S	B	SD_B	N	SD_N	H'_B	$SD_{H'B}$	H'_N	$SD_{H'N}$
Autumn	Stratum 1	37.33	6.51	828.42	270.25	5108.7	3852.1	2.26	0.63	2.26	1.14
	Stratum 2	71.00	0.00	443.52	174.97	2649.0	1120.1	3.48	0.16	3.88	0.60
Spring	Stratum 1	43.33	5.50	249.63	181.05	1815.3	1528.0	2.73	0.34	2.96	1.00
	Stratum 2	57.75	15.97	336.65	107.41	2720.8	3154.1	3.57	0.17	3.56	0.79

Bigger sized epibenthic and demersal communities, sampled with the baca trawl, are clearly dominated by fishes in both strata, while beam trawl smaller sized communities present a higher number of dominant taxa (Figure 5). Mollusks and brachiopods in Stratum 1 and sponges and echinoderms in Stratum 2 presented higher values of biomass. In the beam trawl samplings. Cnidarians were only important in Stratum 2.

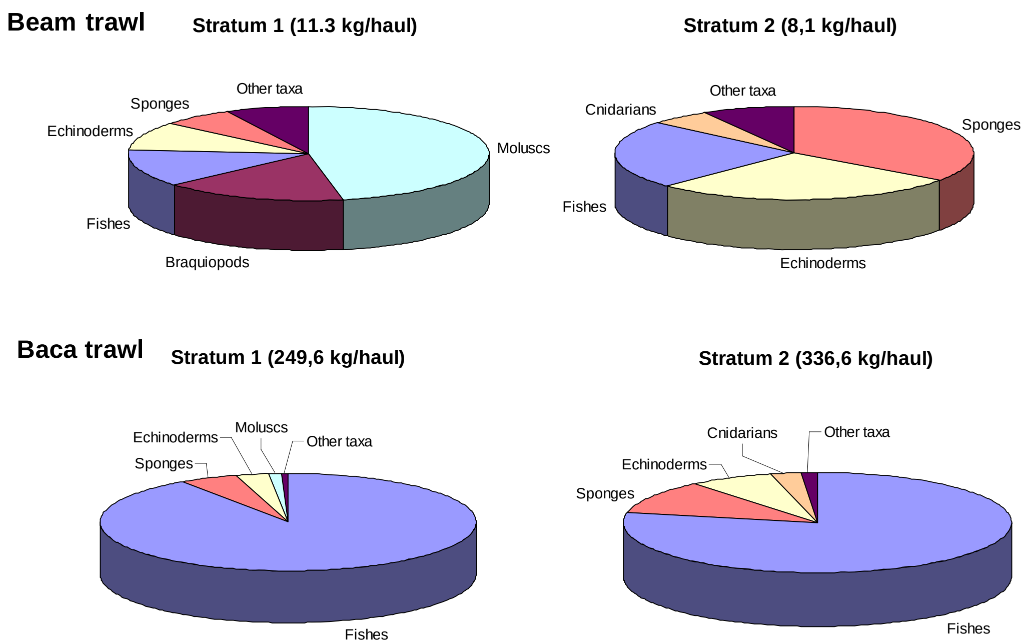

Figure 5. Faunal composition in biomass by gear of epibenthic samples.

Tables 2 and 3 summarize the dominant species in spring 2004, for the beam trawl and baca trawl samplings respectively. One of the first conclusions that can be drawn of these preliminary results is that these abundant species are indicators of a low fisheries impact in the Bank (e.g. sponges, macrourids or deep water sharks).

Table 2. Beam trawl dominant species in biomass and number for the total area and by stratum.

Biomass (g/haul)

	Total		Stratum 1		Stratum 2
Limopsis aurita	2398.3	*Limopsis aurita*	4790.0	*Pheronema grayi*	2774.4
Pheronema grayi	1387.2	*Griphus vitreus*	1825.8	*Stichopus tremulus*	1311.0
Griphus vitreus	922.8	*Phormosoma placenta*	630.2	*Phormosoma placenta*	672.3
Stichopus tremulus	864.7	Porífero sp 1	511.0	*Trachyscorpia cristulata*	582.5
Phormosoma placenta	651.3	*Turridae sp*	445.3	*Lepidion eques*	316.9
Turridae sp	367.0	*Stichopus tremulus*	418.4	*Trachyrhynchus scabrus*	309.7
Trachyscorpia cristulata	291.3	*Galeus melastomus*	392.0	*Turridae sp*	288.8
Galeus melastomus	260.3	*Laetmonice filicornis*	322.5	Antozoa sp 1	208.9

Abundance (number/haul)

Total		Stratum 1		Stratum 2	
Limopsis aurita	11933.3	*Limopsis aurita*	23843.8	*Turridae sp*	188.2
Porífera sp 1	1337.9	Porífera sp 1	2675.8	*Antalis agilis*	52.4
Griphus vitreus	807.0	*Griphus vitreus*	1598.0	*Gnathophausia zoea*	45.6
Turridae sp	250.6	*Turridae sp*	313.0	*Laetmonice filicornis*	44.0
Pagurus alatus	82.8	*Pagurus alatus*	148.8	*Pontophilus norvegicus*	30.8
Laetmonice filicornis	78.3	*Laetmonice filicornis*	112.6	*Munida tenuimana*	30.2
Gnathophausia zoea	70.0	*Gnathophausia zoea*	94.4	*Phormosoma placenta*	26.2
Coral indet.	39.9	White sponge	78.8	*Limopsis aurita*	22.8

Table 3. Baca trawl dominant species in biomass and number for total area and by stratum.

Biomass (kg/haul)

Total		Stratum 1		Stratum 2	
Chimaera monstrosa	51.8	*Chimaera monstrosa*	81.2	*Trachyrhynchus scabrus*	76.3
Galeus melastomus	50.3	*Galeus melastomus*	61.1	*Deania calceus*	40.0
Trachyrhynchus scabrus	40.9	*Micromesistius poutassou*	21.5	*Pheronema grayi*	36.0
Deania calceus	16.4	*Trachyrhynchus scabrus*	17.4	*Galeus melastomus*	34.0
Pheronema grayi	14.4	*Etmopterus spinax*	12.5	*Alepocephalus rostratus*	24.8
Micromesistius poutassou	13.0	*Xenodermichthys copei*	7.2	*Alepocephalus bairdii*	15.9
Alepocephalus rostratus	9.9	*Phycis blennoides*	7.0	*Trachyscorpia cristulata*	13.0
Etmopterus spinax	7.5	*Geodia megastrella*	5.7	*Phormosoma placenta*	13.0

Abundance (number/haul)

Total		Stratum 1		Stratum 2	
Pheronema grayi	481.4	*Xenodermichthys copei*	479.7	*Pheronema grayi*	1203.5
Xenodermichthys copei	290.1	*Caryophyllia smithii*	260.2	*Phormosoma placenta*	253.0
Caryophyllia smithii	156.2	*Micromesistius poutassou*	193.2	*Trachyrhynchus scabrus*	244.0
Phormosoma placenta	154.9	*Galeus melastomus*	162.2	*Parapagurus pilosimanus*	149.3
Trachyrhynchus scabrus	130.0	*Etmopterus spinax*	152.0	Antozoa sp. 1	136.5
Micromesistius poutassou	116.9	*Chimaera monstrosa*	117.8	*Alepocephalus bairdii*	95.8
Galeus melastomus	111.5	*Phormosoma placenta*	89.5	*Lepidion eques*	87.0
Etmopterus spinax	91.3	*Trachyrhynchus scabrus*	54.0	*Nymphaster arenatus*	50.8

Multivariate analyses are still in progress, but two preliminary studies approach the analysis of decapod crustaceans communities and the whole taxocoenosis are available:

3.3.1. Decapod crustaceans: MDS (Multidimensional Scaling analysis) results, based on smaller epibenthic-infaunal decapods (captured with beam trawls), separated two (three) groups of hauls, basically as a function of depth (Figure 6). The shallowest group comprises those hauls performed between 458-544 m, the second one those performed between 576-728 m, and the third those carried out between 803-1022 m.

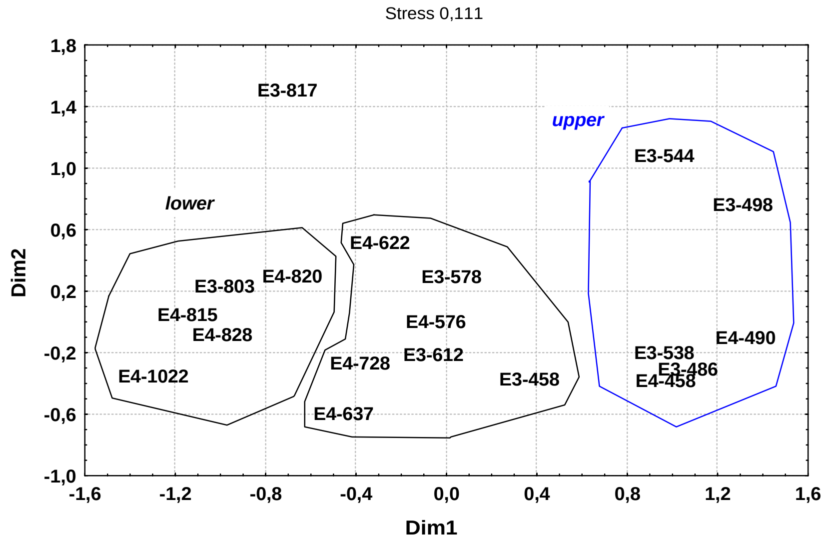

Figure 6. MDS based on decapod crustaceans sampled with the beam trawl

The MDS based on the nektobenthic-large epibenthic decapods (baca trawl) splits two groups of hauls (Figure 7), the first comprising hauls performed between 454-586 m depth and the second comprising hauls between 628-1048 m.

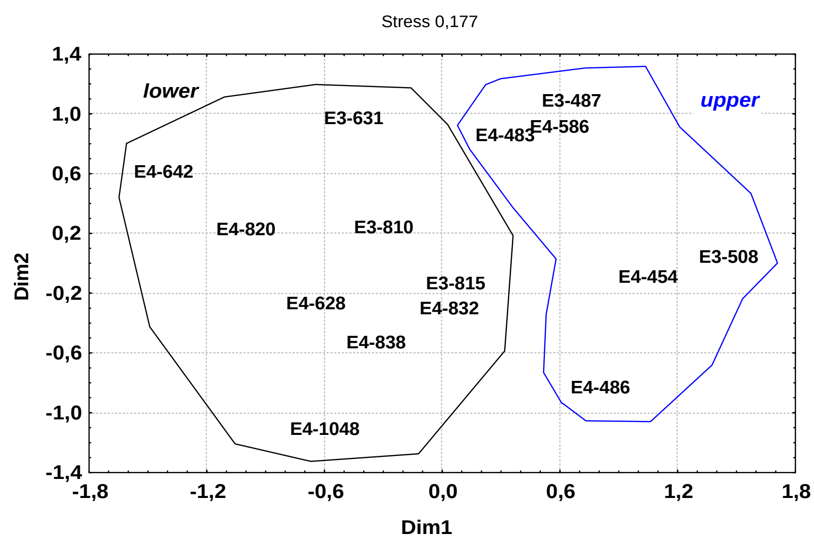

Figure 7. MDS based on decapod crustaceans sampled with the baca trawl.

Other factors than depth might have an influence on the aggregation of hauls. Therefore, both in the analyses of baca and beam trawls, hauls performed on stations 3 and 7 with depths comprised between 622-642 m were associated to the deepest assemblage, because their species composition is more similar to hauls performed at 728-1048 m depth range, than those performed at 450-600 m. St3 is situated in the N of Le Danois Bank, characterized by a steep slope, while St7, though located on the western part is also in steep bottoms.

3.3.2. All taxa: Cluster analyses show the existence of a faunal boundary between Le Danois Bank and the marginal basin (Figure 8). This limit is located around 820 m depth for the smaller communities (beam trawl) and around 640 for the bigger ones (baca trawl). The upper part of the bank is typified by the brachiopod *Griphus vitreus*, the bivalve *Limopsis aurita*, and the urchin

Phormosoma placenta, in beam trawls, and by the fishes *Chimaera monstrosa, Galeus melastomus, Micromesistius poutassou* in baca trawls. Marginal basin is characterised by the large sponge *Pheronema grayi*, an unidentified antozoan and the fish *Lepidion eques* in beam trawls, and the sharks *Deania calceus* and *G. melastomus*, also together with *L. eques* in baca trawls.

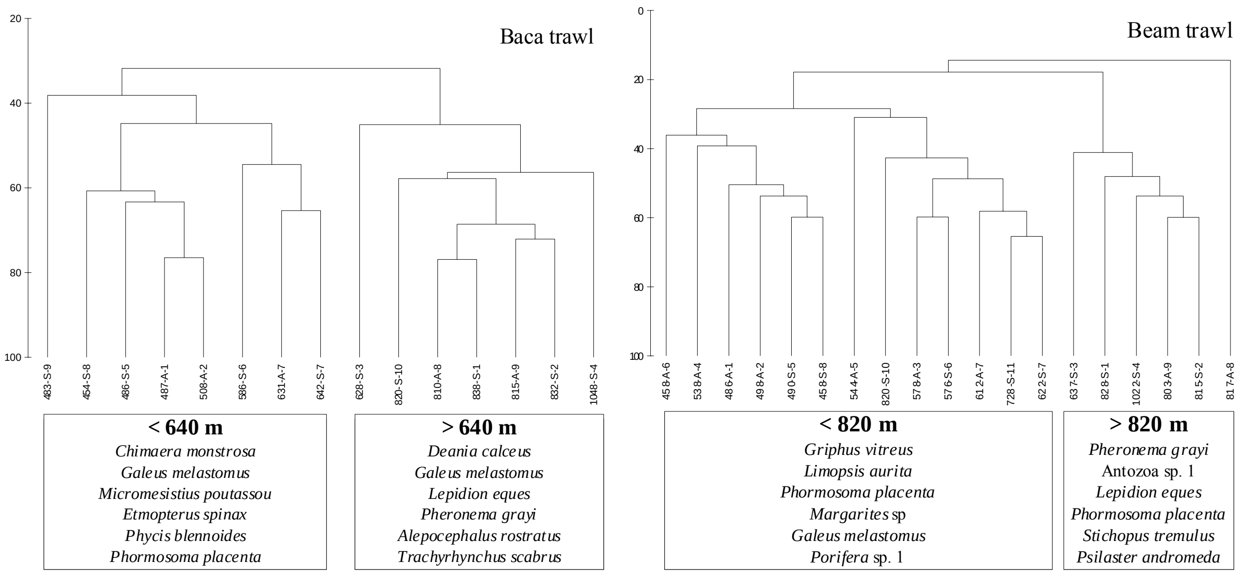

Figure 8. Cluster (Bray-Curtis) of beam and baca trawls. Labels indicate depth-season (A-autumn, S-spring) and station number. Boxes below contain species typifying group according to SIMPER analysis).

3.4. Faunal differences of Le Danois ecosystem and the continental shelf

There aren't historical data series on beam trawl, box corer and suprabenthic sledge samplings in the continental shelf. Regarding baca trawl, the IEO has been sampling epibenthic and demersal communities in the Cantabrian shelf since 1983. Gears used in these surveys and in Le Danois Bank are similar but with some differences in the groundrope (Porcupine baca is more suited to harder bottoms) and in the vertical opening (also larger in the former gear).

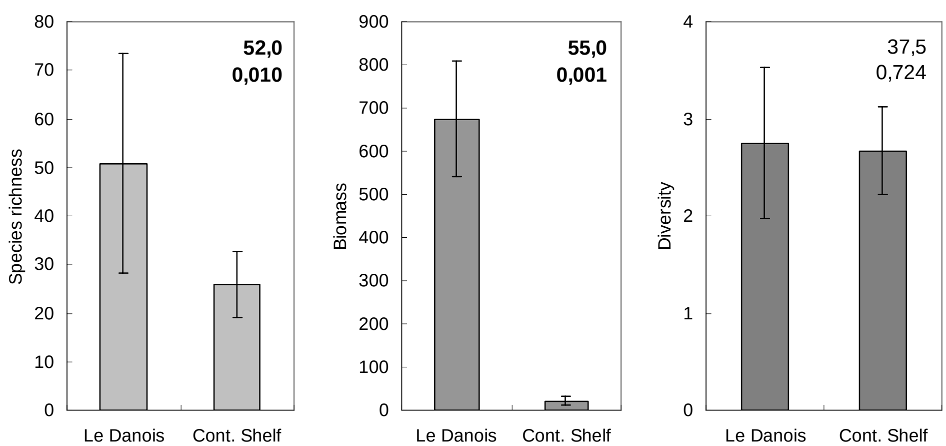

Figure 9. Differences in ecological indices between Le Danois Bank and the Cantabrian continental shelf next to the bank. Numbers inside the boxes represent T (above) and p (below) of the Mann-Whitney test between zones (significant differences in bold).

When comparing Le Danois Bank samples with their equivalents in depth on continental shelf samples (autumn 2003, deeper of 450 m), it is noteworthy the large differences in biomass with the Le Danois Bank mean catch, which is three times higher than the continental shelf catches (Figure 9). The differences in species richness are also remarkable, with 50.8 species/haul in Le Danois Bank and 25.9 in the shelf. Nevertheless, Le Danois Bank samples aren't significantly more diverse than continental shelf ones (Figure 9). Nevertheless, it has to be borne in mind that part of the differences could be attributed to the differences in sample gear.

The taxonomic composition of the catches also presents clear differences (Figure 10). Although both zones are dominated by fishes, in Le Danois Bank crustaceans have a low biomass importance, opposite to continental shelf. On the other hand, sponges and echinoderms are dominant groups in Le Danois Bank and have low presence in the adjacent shelf. This fact could be a result of the different trawling effort applied in both areas (high in the continental shelf and almost null in Le Danois Bank). Both groups, especially big sponges, are considered as vulnerable by trawlers (ICES, 2005).

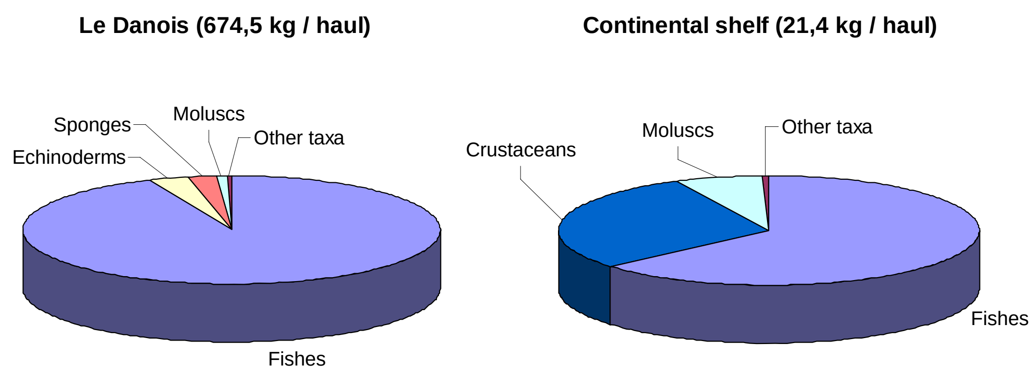

Figure 10. Faunal composition of mean catch (biomass) in Le Danois Bank and on the continental shelf.

Differences between Le Danois Bank and the Cantabrian Sea continental shelf, according to a SIMPER analysis, are explained mainly by the fishes. Dominant species of fishes in Le Danois Bank (see above) presented higher catches in this zone than in the continental shelf (Table 4). Likewise, some species vulnerable to trawling, as big sponge *Pheronema grayi*, were absent on the continental shelf, or presented very low biomass (the urchin *Phormosoma placenta* and the holothurid *Stichopus tremulus*). Only the crustacean *Munida sarsi* was more abundant in the continental shelf (replaced in Le Danois Bank by *Munida tenuimana*).

Table 4. Species explaining 90 % of dissimilarity between Le Danois Bank (LD) and the Cantabrian Sea continental shelf (CS) in autumn 2003. W= kg/haul in each group; δ= average dissimilarity; δi (%)= cumulative dissimilarity of indicator i. *= < 0.1 kg/haul.

Le Danois vs. Cantabrian shelf, δ= 95.81	Taxa	W LD	W CS	δ_i (%)
Galeus melastomus	Fishes	129.7	2.2	19.80
Chimaera monstrosa	Fishes	141.7	1.8	38.93
Trachyrhynchus scabrus	Fishes	98.0	*	55.77
Micromesistius poutassou	Fishes	154.8	3.7	71.73
Deania calceus	Fishes	16.8	*	75.60
Etmopterus spinax	Fishes	26.5	2.0	79.24
Pheronema grayi	Sponges	14.4	0.0	81.79

Trachyscorpia cristulata echinata	Fishes	10.5	0.0	83.75
Phormosoma placenta	Echinoderms	11.5	*	85.57
Phycis blennoides	Fishes	11.7	1.8	87.09
Lepidion eques	Fishes	5.6	*	88.42
Munida sarsi	Crustaceans	0.0	7.1	89.59
Stichopus tremulus	Echinoderms	6.5	*	90.62

Besides these faunal differences, and from the fishery resources point of view, it is noteworthy the presence in Le Danois Bank of reproductive adults of some species (e.g. *Micromesistius poutassou, Phycis blennoides, Helicolenus dactylopterus*) very scarce on the shelf. Also is worth mentioning the presence of juveniles of four-spot megrim (*Lepidorrhombus boscii*) in the upper plain of the Bank.

3.5. Trophic ecology

3.5.1. Decapod crustaceans.

The diet of eleven species of decapod crustaceans revealed how bathypelagic shrimps *Acanthephyra pelagica*, *Sergia robusta*, and *Pasiphaea tarda* based their diets in makroplankton taxa. Euphausiids, cnidarians and chaetognaths were common prey. Each species consume other prey as a function of different niche dimensions (e.g. size),. *Acanthephyra pelagica* was the largest species and consumed larger prey (the mysid *Gnathopahusia zoea*, and the own *Pasiphaea tarda*) than the other two. The smallest species, *Sergia robusta*, consumed calanoid copepods and ostracods, as did also *Pasiphaea tarda*, which in turn preyed (the largest specimens) on *S. robusta*. In some cases consumption of some amount of detritus (e.g. *Acanthephyra pelagica* at 820 m) has been reported.

Crangonid shrimps prey on polychetes (only some Eunicida identified). The opistobranch *Phyline* sp. was also important in the diet of *Pontophilus norvegicus* in October 2003. Also, in both species, peracarid crustaceans (e.g. Gammaridea, Cumaceans, the isopod *Eurydice grimaldii*) were more important in October, while in April the polychaetes increased their dominance in the diet. The large crab *Geryon trispinosus* had a varied diet mainly based on infauna (polychaetes, sipunculans) and on larger non-swimmng epifauna (echinoderms, other crabs: e.g. *Bathynectes*), though also consumed some bathypelagic shrimps or suprabenthic crustaceans.

MDS analyses provided a gradient along which the species (diet per sample) were ordered (Figure 11). There was, further, some aggregation of these species in four trophic groups, attributable to functional guilds. Since most species have very diversified diets, some of them in part occurred, however, in two of the established. Shrimp *Acanthephyra pelagica* was in the group of plankton feeders (G1, also comprising other bathypelagic shrimps such as *Sergia robusta*, and *Pasiphaea tarda*). *Munida tenuimana*, and *Parapagurus pilosimanus* were comprised in G2 group. These species, furthermore than infauna-epifauna, consumed a high quantity of detritus, including detritus of phytoplanktonic origin (phytodetritus) as evidenced by parallel analyses of HPLC performed on individuals collected in the same sample.

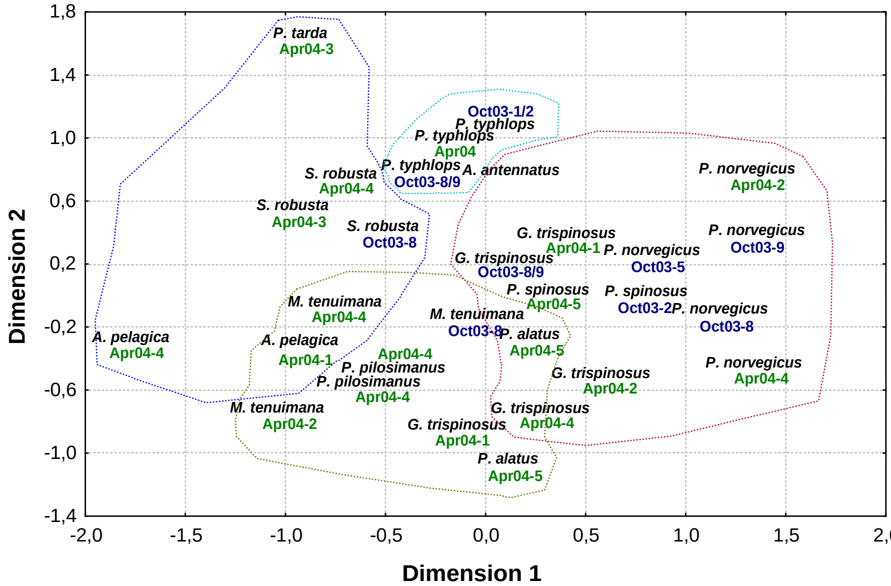

Figure 11. MDS based on decapod crustaceans diets.

The group G2, composed by both Paguridae and *Munida tenuimana*, exploited a variety of resources, basically from the benthic compartment (infauna and epifauna), for instance polychaetes. Fish remains, and particularly detritus were especially important in this group. Detritus represented 20% of diet (wet weight) in *Parapagurus pilosimanus* and in *Munida tenuimana* in April, whereas they were not represented in October in the diet of the later species. The analysis at the optical microscope (x100-x400) of these detritus evidenced an amorphous-greenish unidentified mass of a granular texture, rarely containing some thecae of diatoms.

3.4.2. Fishes

Special ecological characteristic of Le Danois bank in relation to habitat and depth, forced us to increase the number of predator stomachs analyzed. Even though, in several cases a minimum sample size to analyze the trophic spectrum was not reached, the scarce information on the diet of these species and the high interest on using the predators as samplers providing extra-information on the distribution of their preys, drove us to continue with the study. During 2004 survey, 908 stomach contents of 43 species (Table 5) were analyzed, highlighting the importance of wide bathimetric range species (*G. melastomus*, *L. boscii*, *M. poutassou*), and deep water species (*C. monstrosa*, *N. sclerorhynchus*, *H. mirabilis*, *D. calcea*, *H. mediterraneus*, etc.). All this outstanding quantity of information is being analyzed currently.

Table 5. Number of stomachs analyzed by predator species and size range. (*) Species in which the intestinal contents instead of stomach were analyzed

SPECIE	Empty	Full	Regurg.	Total	Range
Galeus melastomus	17	92	1	110	24-76
Micromesistius poutassou	48	42	0	90	17-41
Trachyscorpia cristulata	35	23	5	63	17-47
Deania calcea	37	24	0	61	27-110
Alepocephalus rostratus	37	16	2	55	20-58
Lepidorhombus boscii	8	46	0	54	10-28
Alepocephalus bairdii	44	8	0	52	14-65

SPECIE	Empty	Full	Regurg.	Total	Range
Hoplostetus mediterraneus	21	23	1	45	17-27
Etmopterus spinax	15	21	1	37	14-47
Nezumia sclerorhynchus	5	29	0	34	5- 7
Chimaera monstrosa (*)	0	33	0	33	30-68
Xenodermichthys copei	18	9	0	27	11-16
Hydrolagus mirabilis (*)	0	26	0	26	28-47
Coryphaenoides rupestris	1	19	1	21	6-71
Trachyrincus scabrus (*)	0	19	0	19	38-53
Synaphobranchus kaupii	8	10	0	18	18-38
Bathysolea profundicola	12	5	0	17	16-20
Chlorophthalmus agassizii	0	17	0	17	17-23
Scymnodon ringens	12	5	0	17	37-88
Melanonus zugmayeri	6	9	0	15	5-24
Lepidion eques (*)	6	8	0	14	15-23
Beryx decadactylus	2	8	0	10	25-28
Mora moro (*)	1	9	0	10	26-60
Helicolenus dactylopterus	6	3	0	9	10-38
Lophius piscatorius	5	1	1	7	63-84
Notacanthus bonaparte	4	3	0	7	23-45
Phycis blennoides (*)	0	7	0	7	19-69
Raja circularis	1	4	0	5	44-77
Etmopterus pusillus	4	0	0	4	36-43
Beryx splendens	2	1	0	3	23-43
Halargyreus johnsonii	0	2	1	3	19-42
Centroscymnus coelolepis	0	1	1	2	103-104
Epigonus telescopus	1	1	0	2	30-37
Merluccius merluccius	0	0	2	2	41-49
Raja batis	0	2	0	2	66-91
Raja clavata	0	2	0	2	22-30
Aphanopus carbo	1	0	0	1	66-66
Centroscymnus crepidater	0	1	0	1	59-59
Coelorhynchus coelorhynchus	0	1	0	1	9- 9
Conger conger	0	1	0	1	82-82
Dalatias licha	0	1	0	1	87-87
Hoplostetus atlanticus	0	1	0	1	36-36
Malacocephalus laevis	0	1	0	1	7- 7
Molva macrophthalma	0	1	0	1	56-56
TOTAL	357	535	16	908	

3.5. Fisheries

According to our results, currently no constant fishery is taking place in Le Danois Bank. Only few vessels work sporadically using gillnets and targeting monkfish (*Lophius* spp), or long lines targeting *Beryx* spp., forkbeard (*Phycis blennoides*) and red sea-bream (*Pagellus bogaraveo*). The fleet developing these activities is constituted by 6 vessels operating from Avilés (3-4), San Vicente de la Barquera (2) and Bustio (1) fishing harbours. Up to now it has been impossible to embark in these vessels, nor to perform effort estimates.

In the past, a high fishing pressure existed, mainly by fisheries targeting red sea-bream in the decade of the 70s and the 80s, and also by gillnets up to year 2002, although in the latter only four or five vessels worked on the bank. At present, it has been impossible to obtain a historical record of the landings coming from the bank, due to the absence of geographically referenced information with enough precision to estimate the catches from such a relatively small area.

According to the available information at the moment, no stable trawl fishery works in the bank, except some exploratory hauls or sporadically activities.

3.6. Trophodinamic modelization

The taxonomic-bathymetric boundary found in the epibenthic communities studies match with the zone of shift of communities in benthopelagic crustacea, suggesting a different structure of the trophic webs above and below 600 m. This pattern could be corroborated by the trophodinamic model (under construction currently).

Likewise, these preliminary results show the high importance of suprabenthic organisms in Le Danois Bank in comparison with the adjacent continental shelf. On the contrary, endobenthic compartment is very poor in the Bank, due to the thinness of sediment layer and the low level of organic content. Thereby, the huge biomass of epibenthic filter-feeders has to be supported by sea snow. Due to this fact, it’s necessary to know the influence of transport dynamics in the Cantabrian Sea (*Navidad* and shelf break currents), on the input of particulate organic matter from high production zones located westward the bank. All this important questions have to be solved in the final stage of the study.

It’s now evident the noteworthy differences between Le Danois bank ecosystem structure and the Cantabrian Sea continental shelf, probably due to different environmental characteristics. Nevertheless, fishing activity plays a significant role, disturbing ecosystems through top-down effects. Due to the existence of a trophodynamic model of the Cantabrian Sea that includes fisheries impacts (Sánchez & Olaso, 2004; Sánchez *et al*., 2005), comparisons between both models will be possible, helping us to obtain useful conclusions. For example, it will be possible to determine the importance of the environmental conditions, production and fishing activities in the differences between both ecosystems. All this information and conclusions will allow us to draw up an integrated ecosystem assessment proposal or, depending on the conclusions, to define Le Danois Bank as a Marine Protected Area (MPA).

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