FISH ASSEMBLAGES ASSOCIATED WITH BOTTOM HABITATS ON THE SOUTH COAST OF MADEIRA

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With 4 figures and 2 tables

ABSTRACT. This study reports on a visual census of the ichtyofauna of the sea front of Funchal in order to describe the fish community assemblages associated with the bottom habitats. This is a more quantitative approach following AUGIER'S 1985 work upon the characterization of the benthic communities, including the associated fish species.

Species composition, distribution and relative abundance are discussed and related with the sea shore and the coastal management of the area.

INTRODUCTION

The coast of Madeira is characteristically steep and rapidly attains great depth. The shelf slopes uniformly down, with occasionally peaks to about 50m depth, falling sharply thereafter.

Since the 18th century there has been extensive work on the taxonomy and biology of the Madeiran ichtyofauna (NORONHA & SARMENTO, 1948). However, little is known at a community level. The mapping of the marine benthic biocenosis from the littoral of Funchal by Augier, in 1985, was the first study of the composition, distribution of the fauna and flora communities and their relation with the environment.

The present work was initiated to provide further information on the distribution, abundance and community structure of the fish associated with bottom habitats in a coastal area of south Madeira, namely Clube Naval to Cais do Carvão sea front (Fig. 1). To achieve these aims it was necessary to follow a quantitative approach using standardized procedures. The chosen method was visual census of fish along a line-transect. Used by several authors, it is the simplest and most economical method used in benthic surveys (GAMBLE, 1984). It was thought to be an appropriate way to overcome the problems of sampling the high relief rock bottoms of Madeira. Visual underwater assessment is also a non-destructive

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technique suggested to determine fish abundance and the population structure in coastal protected areas (BUXTON & SMALE, 1989).

This comunication presents the results of a fundamentally preliminary survey. The data has been analysed with an aim towards identifying patterns particularly related with substrate type. Coastal management practises, their impact upon bottom habitats and thus upon fish communities are briefly discussed.

Methods

For *in situ* studies of benthos, methods commonly applied in terrestrial ecology are often used, with the necessary adaptation for that environment (GAMBLE, 1984). The visual census along a line-transect is one of the more commonly used methods, with observations made by underwater cameras (SEDBERRY & VAN DOLAH, 1984) or SCUBA divers (GAMBLE, 1984; SEDBERRY & BEATTY, 1989).

The fish visual census carried out at the Clube Naval - Cais do Carvão sea front was planned after two preliminary dives, seemed necessary in order to establish the exact location of the transects. These had to be parallel to the coastline whenever possible, in order to maintain a constant mean depth for each transect and include a single type of the bottom substrates characteristic of the area: transect 1, for stones and basalt blocks; transect 2, for the transition area of stones and sand; transect 5, for bedrock; transects from 4 to 6 with sand bottoms, these being the only stations at a significantly different depth (Table 1). Unfortunately, only one census along each transect was possible, due to unfavorable maritime conditions.

For each transect a non-bouyant line was laid on the bottom, with weights every 20m. During the survey the divers would follow the line at a constant speed of 20m per minute, controlled at every weight by one of the 3 members of the crew. A diver recorded all the demersal fish and occasionally pelagic fish observed along a 2m path bissected by the line. Meanwhile, a second diver was censusing cryptic fish. Due to the high populated sand bottoms, the visual census was done by $1m^2$ quadrats. Large fish schools were roughly estimated by dozen. Total fish length was estimated by class sizes of 5cm to check the life stage in the literature.

In order to estimate similarity between stations, correlation and a standard algorithm for agglomerative clustering was used, with = - 0.25 (SNEATH & SOKAL, 1973). Inverse cluster analysis was perfomed to elucidate fish species assemblages.

RESULTS

During the visual census a total of 1774 fish was observed, representing 19 families and distributed across 31 species (Table 2). Most of the species belong to the benthic community or are bottom related species with the exception of two carangidae, *Pseudocaranx dentex* BLOCH & SCHNEIDER, 1801 and *Seriola fasciata* BLOCH,1793.

The dominant species was by far *Taenioconger longissimus* GUNTHER, 1870 that accounted for about 76% of the total fish observed. It was present in all transects with sand with exception of transect 2.

The second most abundant species was *Pomadasys incisus* BOWDISH, 1825. This species was observed in a school of about 100 juveniles in transect 3 and an individual was sighted in transect 1.

The two pomacentridae *Abudefduf luridus* CUVIER, 1830 and *Chromis chromis* LINNAEUS, 1758 were also abundant. They were only absent on the sand habitats of transects 4, 5 and 6.

Other common species observed were *S. fasciata*, in one school of fish for transects 3 and 6, *Diplodus vulgaris* E. GEOFFROY SAINT-HILAIRE, 1871, in small schools, also the two labrids *Coris julis* LINNAEUS,1758 and *Thalassoma pavo* LINNAEUS, 1758 sharing the same habitat of stones and rocks covered with algae.

Several species were ocasionally seen. That is the case of *Balistes carolinensis* GMELIN, 1789, *Sparisoma cretense* LINNAEUS, 1758 the sparids *Diplodus sargus* LINNAEUS,1758, *Pagrus pagrus* LINNAEUS, 1758 and *Sarpa salpa* LINNAEUS 1758, the endemic labrid *Centrolabrus trutta* LOWE, 1833, the endemic flat fish *Bothus poda maderensis* LOWE, 1834 and finally, *Canthigaster rostrata* BLOCH, 1786 that was present in all transects but 5.

Other fish including *Conger conger* LINNAEUS, 1758, *Dasyatis pastinaca* LINNAEUS, 1758, *Scorpaena scrofa* LINNAEUS, 1758, *Trachinus draco* LINNAEUS, 1758, *Synodus saurus* LINNAEUS, 1758 and the three muraenidae (*Enchelycore anatina* LOWE, 1841; *Gymnothorax unicolor* DELAROCHE, 1809; *Muraena helena* LINNAEUS, 1758) were rarely spotted, probably because of their cryptic habits. Also rare were *Kyphosus sectator* LINNAEUS, 1766, *Xyrichthys novacula* LINNAEUS, 1758, *Mullus surmuletus* LINNAEUS, 1758, *Priacanthus cruentatus* LACEPÈDE, 1801, *Serranus atricauda* GUNTHER, 1874 and *Diplodus annularis* LINNAEUS, 1758.

The abundance of fish was higher on the sand bottoms due to the refered high number of *T. longissimus*. The abundance of fish in transect 3 derives from the high diversity of species found, with a reasonable amount of individuals, including pelagic fish (Table 2). These were carangidae and were excluded from the statistical analysis.

DISCUSSION

AUGIER, 1985, grouped transects 1, 2 and 3 together in his study within a single biocenoses. We found that by grouping these transects, from the present study, very similar results were achieved (Fig. 2). The total number of species for transects 1, 2 and 3 was 26. The lists of species were roughly similar except for several colour cryptic fish that were not registered in this survey, namely three species of gobidae, one blenidae and one gobiesocidae. Species with cryptic habits were rare. This made us believe these fish could be underestimated by the survey.

The composition and abundance of the benthic and bottom related fish species varied during the transects. Normal cluster analysis indicated the substrate as probably the most important parameter determining the distribution of the fauna for the transects surveyed (Fig. 3).

Transects 1 and 2 share the same depth and both have algal cover however, the correlation is weak (r level between 0.7 and 0.8). This substantiates the influence of substrate type upon fish communities. The other group of transects (4, 5 and 6) have the same substrate type situated at different depths and show a high level of correlation. Transect 3 had a distinctly different community compared to the aforementioned groups.

Inverse cluster anaysis resulted in grouping of the different species (Fig. 4). Group A joined two species that are found chiefly over rock and occasionally in mid-water, under wreckage if *B. carolinensis* (TORTONESE, 1986a.) or *Sargassum*, that is the case of *K. sectator* (TORTONESE, 1986b.).

Group B gathers two species that were found feeding on infaunal sand benthos. *P. pagrus* was not spotted in the sand transect by accident. Juveniles of this species are refered to live in sea grass beds (BAUCHOT & HUREAU, 1986).

Group C is a cluster of most of the cryptic fish observed. Some of these species hide in crevices such as, *C. conger, S. scrofa, P. canthigaster, M. helena* and *E. anatina*. *C. conger* was observed in the only rock crevice found in sand transect 4. Other species present are predators also associated with rock substrate. *S. saurus* and *T. draco* are colour cryptic fish that were seen on sand, but in the vacinity of rock substrate, where potential prey is more abundant.

Again in group D there are two species that hide in rock, that is the case of *G. unicolor*, or burrows in the sand, such as *T. longissimus*. The latter is abundant in all the transects with sand, apart the transition area with stones, which is more exposed and thus has less substrate stability. *T. longissimus* occured from 9 down to 22m depth. The population density was higher on the outer sampling area, transect 6 (3 fish m^{-2}), than the transects close to the coast (2 fish m^{-2}), as well as that refered by Saldanha (1980) for colonies at 50m depth (1-2 fish m^{-2}).

Group E of species includes *C. rostrata, C. trutta* and *S. salpa*. They were found near rocks and algae. It is possibly a group of herbivorous fish. Although, no data on *C. trutta* food habits was found.

Group F contains omnivorous species like *D. sargus* (NUNES, 1974), with fish that feed on small crustaceans and briozoa associated with algae, that is *T. pavo* e and juveniles of *S. cretense* and *S. atricauda*.

In group G there are two species, *C. julis* and *D. vulgaris*, that shift from rock to sandy bottoms to feed on small crutaceans, molluscs and worms. *C. julis* is reported to burrow into sand at night (QUINARD & PRAS, 1986a).

In Group H, the two pomacentridae *A. luridus* and *C. chromis* are territorial species, living over rocky bottoms (SALDANHA, 1980), the former beeing an omnivorous fish and the latter a plankton feeder (QUIGNARD & PRAS, 1986b).

Because several species were rare and there was only a single census by transect the interpretation of the cluster dendograms requires a careful approach.

In recent years, several amateur divers suggested that the border of the stone - sand habitats was moving towards the pebble beach of Clube naval (Albuquerque, pers. com.). This was confirmed with the layout of transects 1 and 2, which showed this line at an approximate distance of 85m, when compared with about 160m registered by AUGIER (1985).

During the preliminary dives, in June this year, a layer of mud was observed on the top of the sand bottom. This was after the rainy season, when the rivers, heavily loaded with sediments discharge into the coastal waters of Funchal. Water currents spread the sediments along the coast. Recently, the sea front of Clube Naval to Cais do Carvão has been under significant pressure from construction. Some building practices involving the dumping of earth and construction materials at coastal sites. It is believed that these processes can lead to a drastic change of the habitat for several species, some of them of economical importance (eg. *S. cretense*, the sparids) and can also lead to a strong negative impact on the nursery grounds of the area.

CONCLUSION

Following a quantitative study of marine coastal benthos of Madeira it was possible to gather information on the composition and abundance of the fish species plus population structure, relating these factors to habitat preference.

The data indicated that the bottom habitats support different fish assemblages according to substrate type. A higher diversity of species and similarity was noticed for the transects of mixed sand and rock, as a logical result of the presence of fish characteristic of both of these habitats. The rock and sand habitat seems to present its own association of fish. The sand bottoms were poor in species diversity, but the high density of *T. longissimus* contributed to higher abundances estimated.

The line-transect method is a useful tool in the study of marine benthos. It is a simple way to overcome the problems of sampling the sea shore of Madeira. The procedures used in the present study for the assessment of the fish assemblages need to be properly tested in the future through repeated transect counts. The difficulty in assessing cryptic fish species is possibly the main weakness of the method, necessitating further improvements.

The visual census technique could be of great use applied in future studies in order to assess seasonal variability of the fish fauna related with bottom habitats and to perform regular monitoring of coastal protected areas.

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TABLE 1 - Physical characterisctics of each transect.

Transect n°	Mean Depth (m)	Relief (m)	Substrate % sand: rock	Algal cover	Temperature °C
1	6.0	0 - 0.5	0: 100	80	21
2	7.0	0 - 0.5	40: 60	40	21
3	16.0	0 - 2.0	10: 90	10	21
4	10.0	0	0: 100	0	21
5	10.0	0	0: 100	80	21
6	22.5	0	0: 100	0	20

REFERENCES

AUGIER, H.:

1985. Primière Contribution a l' Étude et la Cartographie des Biocenoses Marine Benthiques de l' Ile de Madère. *Boletim do Museu Municipal do Funchal*, **37** (168): 86-129.

BAUCHOT, M.-L. & J. C. HUREAU:

1986. Sparidae. *In* Fishes of the North-eastern Atlantic and the Mediterranean. Vol. II. Ed. J. P. Whitehead, M.-L. Bauchot, J. C. Hureau, J. Nielsen, E. Tortonese. UNESCO. Paris. pp. 883- 907.

BUXTON, C. D. & M. J. SMALE:

1989. Abundance and distribution patterns of three temperate marine reef fish (Pisces: Sparidae) in exploited and unexploited areas off the southern Cape coast. *Journal of Applied Ecology*, **26**: 441-451.

GAMBLE, J. C.:

1984. Diving. *In* Methods for the study of Marine Benthos. Ed. N. A. Holme and A. D. McIntyre (2nd edn.). IBP Handbook 16. Blackwell Scientific Publicatins. Oxford. pp. 99-139.

NORONHA, A. C. & SARMENTO, A. A.:

1949. Vertebrados da Madeira. Vol II Peixes. 2nd edn. Junta Geral do Distrito Autónomo do Funchal. 181 pp.

NUNES, A. A.:

1974. Peixes da Madeira. 2nd edn. Junta Geral do Distrito Autónomo do Funchal. 248 pp.

QUINARD, J. P. & A. PRAS:

1986a. Labridae. *In* Fishes of the North-eastern Atlantic and the Mediterranean. Vol. II. Ed. J. P. Whitehead, M.-L. Bauchot, J. C. Hureau, J. Nielsen, E. Tortonese. UNESCO. Paris. pp. 919-942.

1986b. Pomacentridae. *In* Fishes of the North-eastern Atlantic and the

Mediterranean. Vol. II. Ed. J. P. Whitehead, M.-L. Bauchot, J. C. Hureau, J. Nielsen, E. Tortonese. UNESCO. Paris. pp. 916- 918.

SALDANHA, L.:

1980. Fauna Submarina Atlântica - Portugal continental, Açores, Madeira. Publicações Europa América. Lisboa. 179 pp.

SEDBERRY, G. R. & R. F. VAN DOLAH:

1984. Demersal fish assemblages associated with hard bottom habitat in the South Atlantic Bight of the U.S.A. *Environmental Biology of Fishes*, 11 (4): 241-258.

SEDBERRY, G. R. & H. R. BEATTY:

1989. A visual census of fishes on a jetty at Murrells Inlet, South Carolina. *The Journal of the Elisha Mitchell Scientific Society*, 105 (29): 59-74.

SNEATH, P. H. A. & R. R. SOKAL:

1973. Numerical Taxonomy. Freeman. San Francisco. 573 pp.

TORTONESE, E.:

1986a. Balistidae. *In* Fishes of the North-eastern Atlantic and the Mediterranean. Vol. III. Ed. J. P. Whitehead, M.-L. Bauchot, J. C. Hureau, J. Nielsen, E. Tortonese. UNESCO. Paris. pp. 1335-1337.

1986b. Kyphosidae. *In* Fishes of the North-eastern Atlantic and the Mediterranean. Vol. II. Ed. J. P. Whitehead, M.-L. Bauchot, J. C. Hureau, J. Nielsen, E. Tortonese. UNESCO. Paris. pp. 912-913.

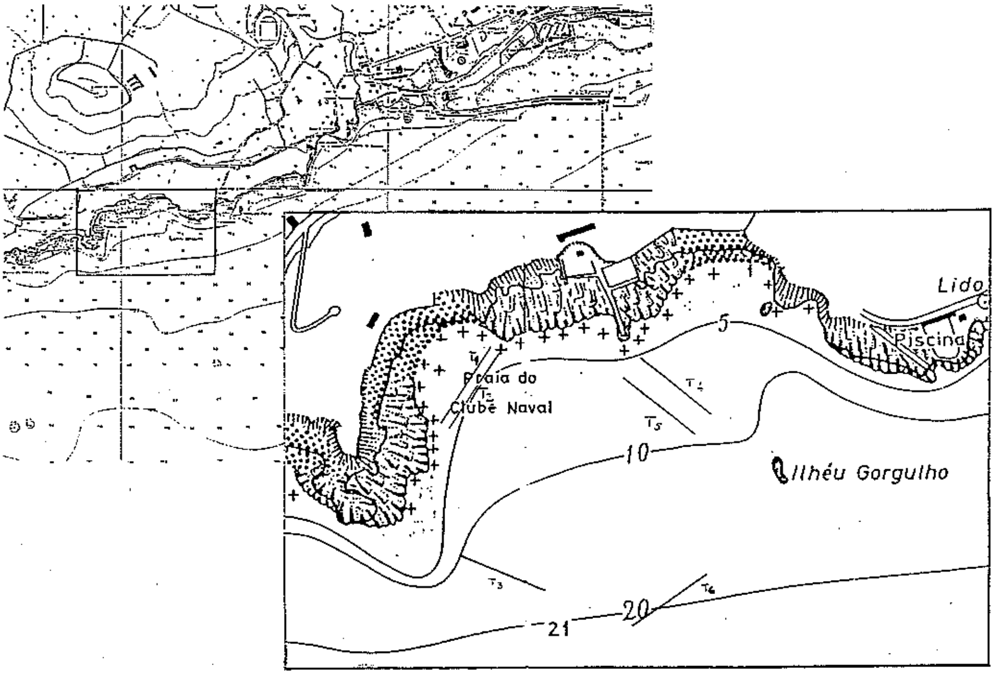

Figure 1 - Map of the sampling area with the location of line-transects.

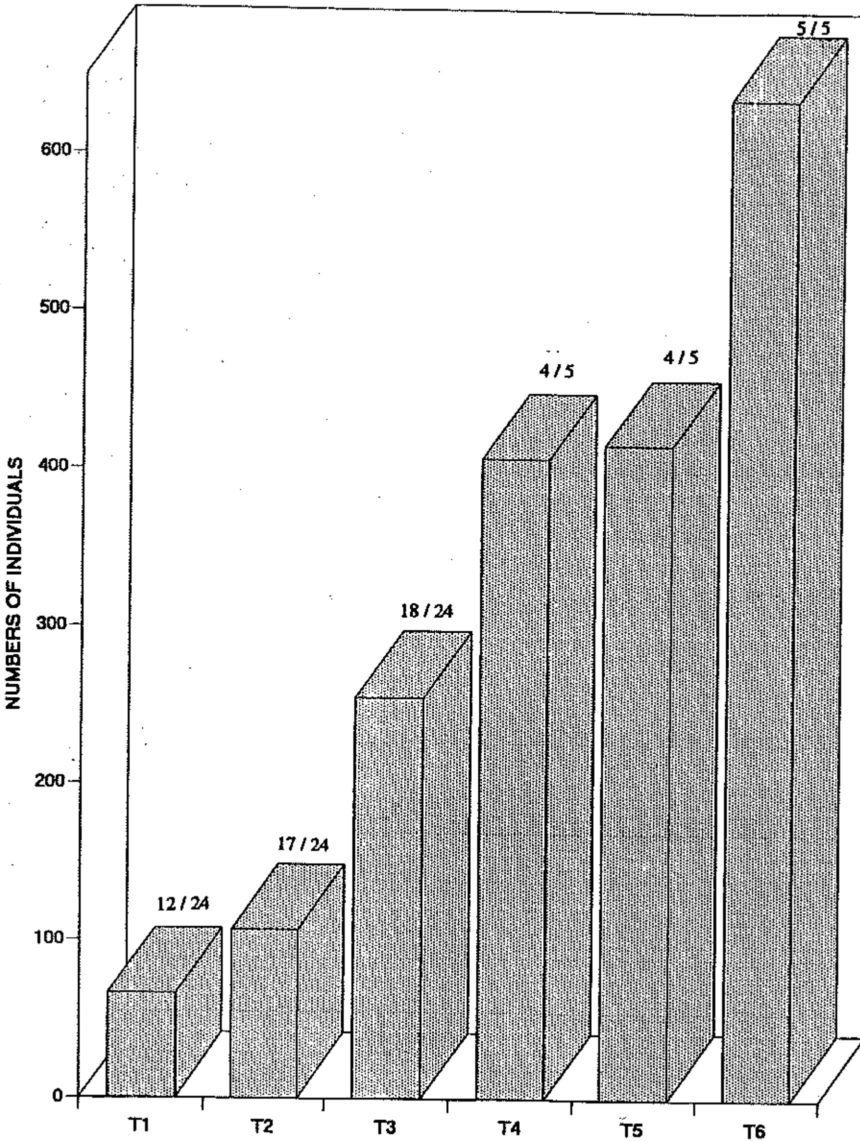

Figure 2 - Abundance and diversity of fish in visual counts by transect sampled.
Number of fish observed versus total registered by AUGIER (1985), on the top of each bar.

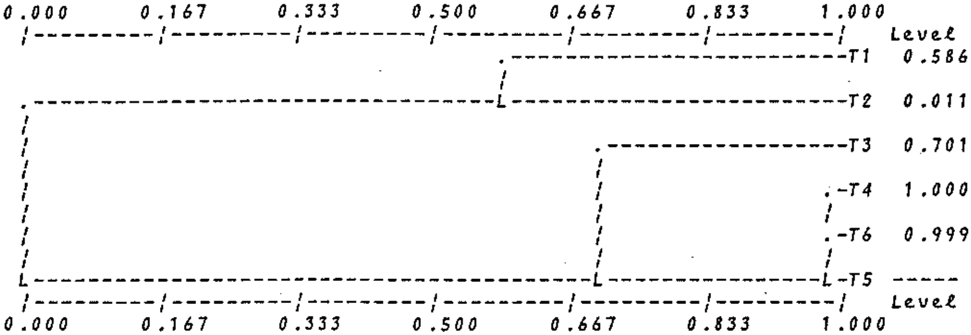

Figure 3 - Normal clustering dendrogam of visual observations by transect.

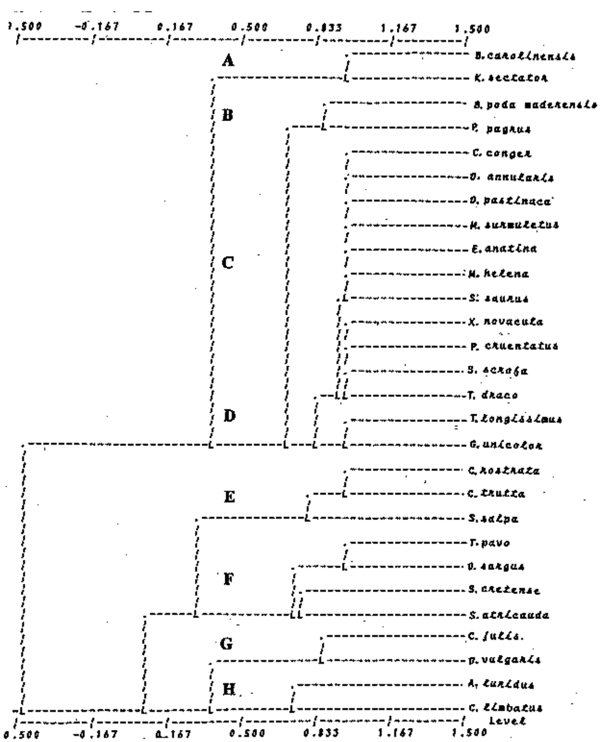

Figure 4 - Inverse clustering dendrogram of the fish observed.

TABLE 2 - Listing of fish observed during diver transects (T1 to T6).

Fish species	Transects T1	T2	T3	T4	T5	T6	total n	% of total N
Balistes carolinensis GMELIN, 1789	0	1	0	0	5	0	6	0,32
Bothus poda maderensis LOWE, 1834	0	3	0	1	0	3	7	0,37
Canthigaster rostrata BLOCH, 1786	2	4	0	5	1	1	13	0,69
Pseudocaranx dentex BLOCH & SCHNEIDER, 1801	0	1	0	0	0	0	1	0,05
Seriola fasciata BLOCH, 1793	0	0	0	0	25	30	55	2,91
Conger conger LINNAEUS, 1758	0	0	0	1	0	0	1	0,05
Taenioconger longissimus GUNTHER, 1870	0	0	400	400	40	600	1440	76,11
Dasyatis pastinaca LINNAEUS, 1758	0	0	0	0	0	2	2	0,11
Pomadasys incisu s BOWDISH, 1825	1*	0	0	0	100*	0	101	5,34
Kyphosus sectator LINNAEUS, 1766	0	0	0	0	6	0	6	0,32
Centrolabrus trutta LOWE, 1833	2	4	0	0	0	0	6	0,32
Coris julis LINNAEUS, 1758	8	0	0	0	15	0	23	1,22
Thalassoma pavo LINNAEUS, 1758	17	8	0	0	0	0	25	1,32
Xyrichthys novacula LINNAEUS, 1758	0	1	0	0	0	0	1	0,05
Mullus surmuletus LINNAEUS, 1758	0	0	3	0	0	0	3	0,16
Enchelycore anatina LOWE, 1841	0	0	0	0	1	0	1	0,05
Gymnothorax unicolor DELAROCHE, 1809	0	0	0	0	2	0	2	0,11
Muraena helena LINNAEUS, 1758	0	0	0	0	1	0	1	0,05
Abudefduf luridus CUVIER, 1830	12	27	0	0	10	0	49	2,59
Chromis chromis LINNAEUS, 1758	7	36	0	0	33	0	76	4,02
Priacanthus cruentatus LACEPÈDE, 1801	0	1	0	0	0	0	1	0,05
Sparisoma cretense LINNAEUS, 1758	2*	2*	0	0	1	0	5	0,26
Scorpaena scrofa LINNAEUS, 1758	0	1*	0	0	0	0	1	0,05
Serranus atricauda GUNTHER, 1874	3	0	0	0	1	0	4	0,21
Diplodus annularis LINNAEUS, 1758	0	0	1	0	0	0	1	0,05
Diplodus sargus LINNAEUS, 1758	6	5	0	0	1	0	12	0,63
Diplodus vulgaris E. GEOFFROY SAINT-HILAIRE, 1	5	5	0	0	12	0	22	1,16
Pagrus pagrus LINNAEUS, 1758	0	2	12*	0	0	0	14	0,74
Sarpa salpa LINNAEUS, 1758	1	5	0	0	0	0	6	0,32
Synodus saurus LINNAEUS, 1758	0	4	0	0	1	0	5	0,26
Trachinus draco LINNAEUS, 1758	0	1	0	0	1	0	2	0,11
total n	66	111	416	407	256	636	1892	100,00
% of total N	3,49	5,87	21,99	21,51	13,53	33,62	100,00	

* Juveniles fish