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# Analysis of demersal fish assemblages on the Senegalese continental shelf considering fishing impact over the decade 1986-1995

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## Abstract

The assemblages of demersal fish and associated species of the Senegalese continental shelf are analyzed in order to characterize their diversity and evolution during the 1986-1995 period. The biological data come from an historical series of scientific trawling surveys. The analytical process (dominance curves), as well as the interpretation of the results, support an evaluation of the ecosystems effects of fishing, in a zone which has undergone an increasing pressure of commercial exploitation for several decades. The stability observed over the period could be interpreted as an adaptation of the studied community to a relatively strong fishing pressure.

Keywords: Demersal fish; Community structure; Fisheries impact; Dominance curves; West Africa.

## Introduction

The question of the assessment of fishing impacts on ecosystems is nowadays a topic of increasing interest for fisheries management purposes (Pauly *et al.*, 1998, 2000; ICES, 2000). This new approach to the management of fishing fits in a more general context, namely the global evaluation of the human impact on the environment which has led to the obligation of preserving biodiversity (Convention of Biological Diversity, 1992). In this context, methods of measurement of biodiversity making it possible to establish a diagnosis of changes in biodiversity are required (Blanchard, 2000). Among those, dominance curves and derived Abundance Biomass Comparison (ABC) plots (Clarke and Warwick, 1994) are often used.

The present study proposes the application of these methods to the demersal communities of Senegal, which appear to be a convenient case for exploring and discussing its applicability in tropical environments. Indeed:
- The demersal communities of the Senegalese continental shelf are submitted to a strong fishing pressure since several decades (Chauveau, 1985; SIAP, 2002; Chavance, 2002).
- Several scientific trawling surveys have been carried out over several years (Gascuel and Guitton, 2001) on these grounds of great economic interest (La pêche maritime, 1973; Gascuel

and Ménard, 1997). The present study uses one of the most complete and homogeneous dataset collected in the zone (*i.e.* a sampling serie by the RV/Louis Sauger during the 1986-1995 decade).

# Material and method

## *Biological data*

The biological data were collected by bottom-trawl scientific surveys. These data are exhaustively stored in homogeneous format (software First-SIAP, Gascuel and Guitton, 2001) in the Senegalese database of the SIAP project (Ba, 1999), from which the information used here was extracted.

- This sampling concerns 13 surveys between 1986 and 1995 (Table I), each one covering the whole Senegalese continental shelf (about 100 stations/survey).
- The sampling strategy for each campaign followed a stratified-random plan.
- The analyses were made on the standardised abundances and biomasses index (catch in number and kg/30' haul) of the sampled species (see list in Table II).
- The majority of the taxa were determined at the specific level, for a few taxa the determination was generic (genus or group of several species).
- For several sampling stations and some species, only the biomass (kg) is available (the abundance (N) was not recorded). In those cases, the abundance is estimated using the value of the biomass (per 30' haul) divided by the 'mean individual weight' of the concerned species. For each species the mean individual weight was calculated as the total biomass divided by the total abundance, using all the stations where the two informations were simultaneously recorded.

(NB: The consequence of the two last points on the results will be taken into account in the discussion).

Table I. List of the sampling surveys and numbers of fishing trawls (stations)

| Code | Date | Number of stations |
|---|---|---|
| 1 | November 1986 | 92 |
| 2 | May 1987 | 95 |
| 3 | October 1986 | 97 |
| 4 | March-April 1988 | 97 |
| 5 | April 1989 | 100 |
| 6 | November 1989 | 101 |
| 7 | March 1990 | 99 |
| 8 | March-April 1991 | 93 |
| 9 | April-May 1992 | 98 |
| 10 | October 1992 | 102 |
| 11 | April-May 1993 | 98 |
| 12 | March 1994 | 96 |
| 13 | May 1995 | 95 |

Table II. List of the species

| | | | |
|---|---|---|---|
| 1 | *Acanthurus monroviae* | 48 | *Merluccius* spp. |
| 2 | *Alectis alexandrinus* | 49 | *Mustelus mustelus* |
| 3 | *Aluterus punctatus* | 50 | *Mycteroperca rubra* |
| 4 | *Antigonia capros* | 51 | *Octopus vulgaris* |
| 5 | *Argyrosoma regium* | 52 | *Pagellus bellottii* |
| 6 | *Arius heudeloti* | 53 | *Parapristipoma octolineatum* |
| 7 | *Arius latiscutatus* | 54 | *Penaeus notialis* |
| 8 | *Arnoglossus capensis* | 55 | *Plectorhynchus mediterraneus* |
| 9 | *Balistes capriscus* | 56 | *Pomadasys incisus* |
| 10 | *Balistes punctatus* | 57 | *Pomadasys jubelini+peroteti* |
| 11 | *Batrachoides* sp. | 58 | *Pontinus kuhlii* |
| 12 | *Bodianus* spp. | 59 | *Priacanthus arenatus* |
| 13 | *Boops boops* | 60 | *Pseudotolithus senegalensis* |
| 14 | *Bothus podas* | 61 | *Pseudupenaeus prayensis* |
| 15 | *Brachydeuterus auritus* | 62 | *Pteroscion peli* |
| 16 | *Branchiostegus semifasciatus* | 63 | *Pterothrissus belloci* |
| 17 | *Brotula barbata* | 64 | *Raja miraletus* |
| 18 | *Calappa* spp. | 65 | *Raja straeleni* |
| 19 | *Chaetodon hoefleri* | 66 | *Rhinobatos rhinobatos* |
| 20 | *Chelidonichthys gabonensis* | 67 | *Sardinella aurita* |
| 21 | *Chilomycterus antennatus* | 68 | *Sardinella maderensis* |
| 22 | *Chloroscombrus chrysurus* | 69 | *Scomber japonicus* |
| 23 | *Citharus macrolepidotus* | 70 | *Scorpaena angolensis* |
| 24 | *Cybium tritor* | 71 | *Scorpaena* spp. |
| 25 | *Cymbium* spp. | 72 | *Scorpaena stephanica* |
| 26 | *Cynoglossus canariensis* | 73 | *Scyacium micrurum* |
| 27 | *Cynoglossus senegalensis* | 74 | *Selene dorsalis* |
| 28 | *Cynoponticus ferox* | 75 | *Sepia* spp. |
| 29 | *Dactylopterus volitans* | 76 | *Soleidae* |
| 30 | *Dasyatis margarita* | 77 | *Sparus caeruleostictus* |
| 31 | *Decapterus* spp. | 78 | *Sphoeroides* spp. |
| 32 | *Dentex angolensis* | 79 | *Sphyraena guachancho* |
| 33 | *Dentex canariensis* | 80 | *Squids* |
| 34 | *Dentex gibbosus* | 81 | *Stromateus fiatola* |
| 35 | *Dentex macrophthalmus* | 82 | *Synaptura* spp. |
| 36 | *Drepane africana* | 83 | *Torpedo torpedo* |
| 37 | *Epinephelus aeneus* | 84 | *Ttrachinocephalus myops* |
| 38 | *Epinephelus goreensis* | 85 | *Trachinus armatus* |
| 39 | *Eucinostomus melanopterus* | 86 | *Trachurus trecae* |
| 40 | *Fistularia petimba* | 87 | *Trichiurus lepturus* |
| 41 | *Fistularia tabaccaria* | 88 | *Trigla* spp. |
| 42 | *Galeoides decadactylus* | 89 | *Umbrina canariensis* |
| 43 | *Grammoplites gruveli* | 90 | *Uranoscopus cadenati* |
| 44 | *Ilisha africana* | 91 | *Uranoscopus polli* |
| 45 | *Lagocephalus laevigatus* | 92 | *Zanobatus schoenleinii* |
| 46 | *Lepidotrigla cadmani* | 93 | *Zeus faber* |
| 47 | *Lepidotrigla carolae* | | |

## *Data analysis*

The community structure was investigated using Abundance Biomass Comparison (ABC) plots (Clarke and Warwick, 1994) which is an extention of the k-dominance curves theory (Lambshead *et al.*, 1983). The method allows to draw up a diagnosis of the diversity status of the studied community, with a gradual pattern from unstressed to grossly stressed. The analysis is computed using Primer software (Clarke and Warwick, 1994).

## *Results*

The fishing effort is high in the studied area since several decades (Figs 1-2).
According to theory, the diagnosis for the studied community (Fig. 3) is 'stressed' or 'moderately stressed'. This diagnosis remains the same for each of the 13 sampling surveys, suggesting no significant evolution in the diversity status of the Senegalese demersal fish community along the studied period. This result is to be related to the lack of a significant trend in the global cpue (Fig. 4) and also to the lack of drastic change in the species dominances (Fig. 5) between 1986 and 1995.

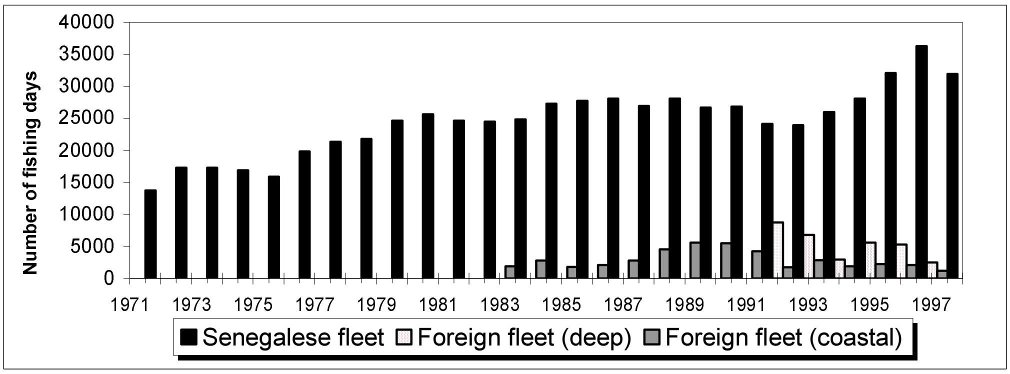


*Fig. 1. Fishing effort of the industrial fishery during the last decades (from 1971 to 1998).*

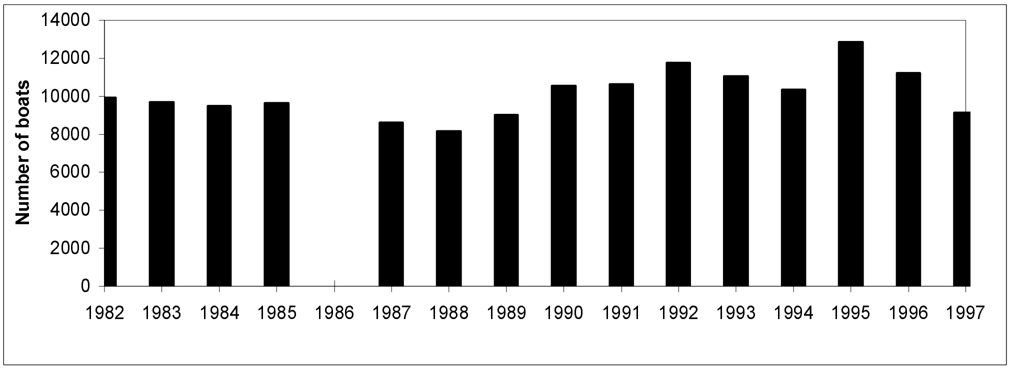


*Fig. 2 : Fishing effort of the small scale fishery during the last decades (from 1982 to 1997).*

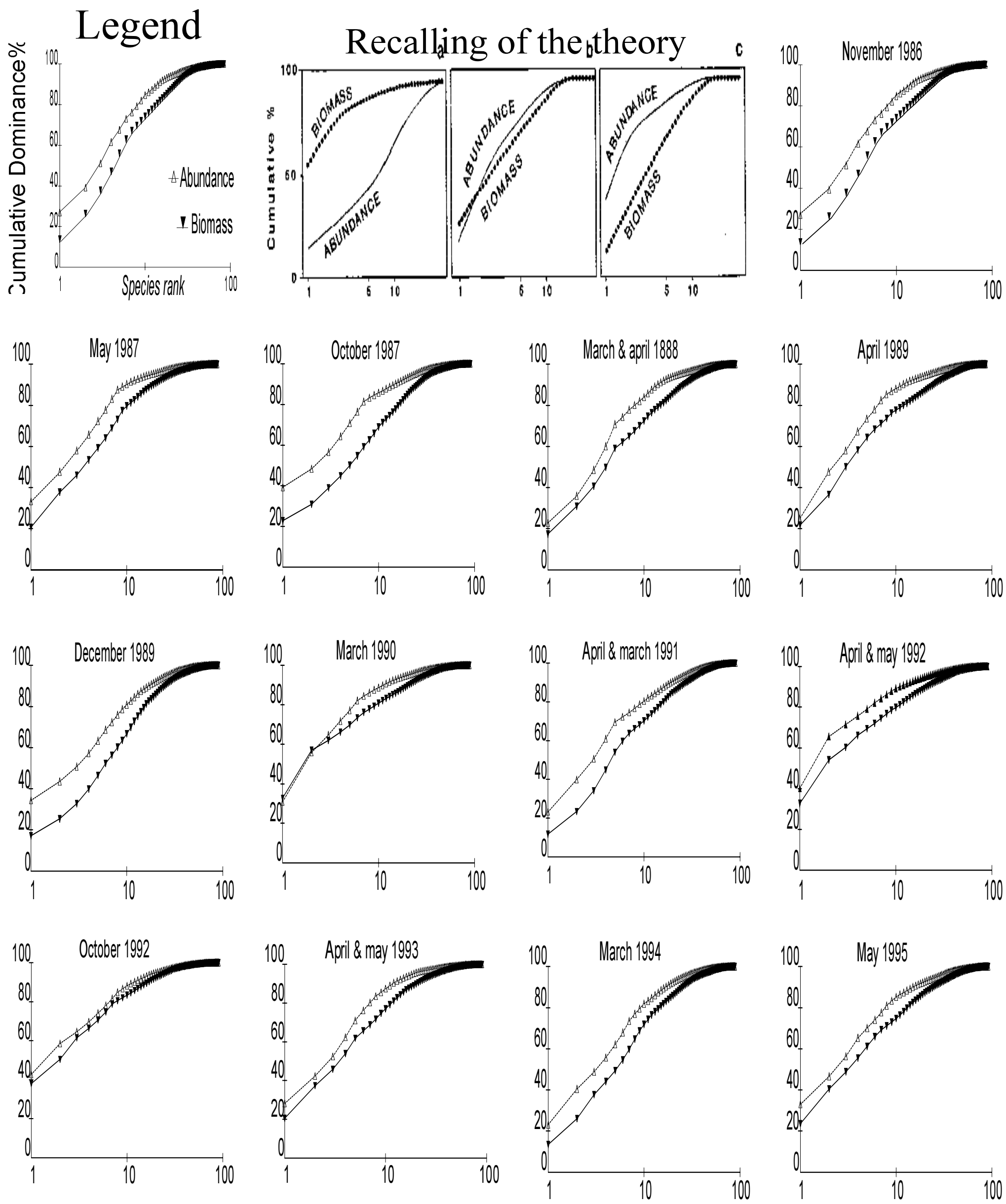


*Fig. 3. ABC plot computed for the 13 surveys from 1986 to 1995.*

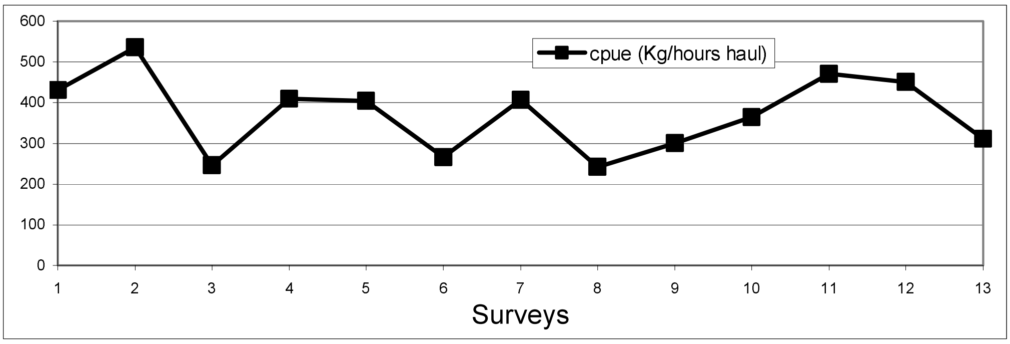


*Fig. 4. Global abundance index (kg/hour haul).*

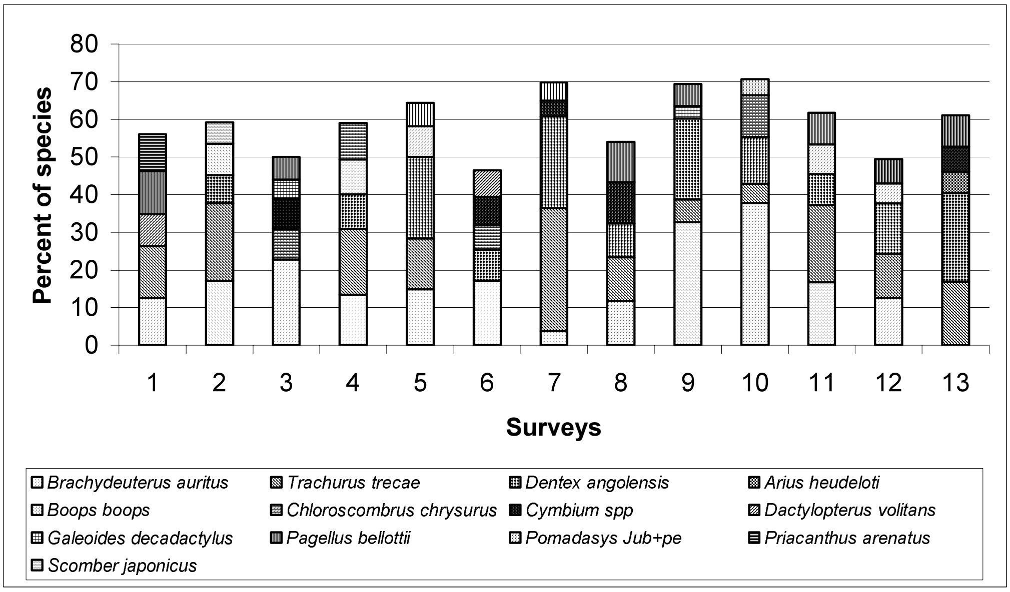


*Fig. 5. Proportions of the dominant species.*

## Discussion

Concerning the adequacy of the data and the methodology two aspects must be pointed out:

- The first one concerns the lack of specific determination of the fauna. The theory of the method states that the determination level must be homogeneous for all the taxa. This is not the case here, some taxa representing a group of species. Fortunately this problem concerns only relatively rare taxa, that do not occur in the first rank of abundance or biomass. So, we can consider that these taxa have a minor influence on the shape of the curves and finally that they do not interfere on the related diagnosis. Considering this, there is an alternative with eliminating them from the analysis. We choose to keep them in, in order to fit the analysis to the biological information 'as it is recorded', without eliminating any taxa that could represent an halieutic interest.

- The second point is related to the estimation of abundance, when they have not been recorded (see methodology). This problem concerns only a few samples in the beginning of the sampling series but a greater proportion for the last surveys. Considering this problem, we choose to keep the related samples in the analysis, in order to compute the diagnosis on the most complete dataset possible. Doing this we consider the fact that the relative position of the biomass and the abundance curves (and consequently the related diagnosis) are more influenced by changes of the species occurring in the first rank than by changes of individual mean weight within these species.

The results can be summarized in the two folowing points: (1) the general diagnosis is 'stressed' (moderately or not) and (2) there is no significant evolution of this diagnosis (no apparent increase in this observed stress). We can notice that both of them are consistent with what was known or expected. Indeed:

- Concerning the first aspect, the result is not really surprising considering the fact that the community has been submitted to a strong fishing pressure for such a long time (see Figs 1 and 2). It is also coherent with many halieutic evaluation studies and models, even if they are generally based on monospecific studies (Caverivière and Thiam, 1992, 1994, 1996; Caverivière, 1994; Gascuel et Thiam, 1994).

- Concerning the second aspect, it is consistent with previous results on the same faunistic assemblages (Jouffre *et al.*, 1999) which suggests that the multipecies level of the biological structures doesn't show the same sensitiveness to fishing impacts as the monospecific one. A study at the regional scale from Mauritania to Guinea (Jouffre *et al.*, submitted) has also suggested that it is essentially during the launching phase of the fisheries that the fishing impact on the composition of the demersal assemblage is the most perceptible.

Going further, the present results, compared to the general and theorical frame of the method, suggest that the targeted community is 'moderately stressed' (rather than 'grossly stressed'). However, the question of the calibration of the method to refine the diagnosis based on this kind of data and for this objective remains largely open. Moreover, the data do not cover the initial state of the community (*i.e.* virgin state before fishing). That remains an essential question in order to reach a really operational diagnosis (in other words, to distinguish moderately stressed communities from strongly stressed ones).

## Conclusion

On the practical level, the method of k-dominance curves/ABC plots seems applicable for a general assesment of multispecific halieutic resources in tropical areas, since one obtains a diagnosis which is coherent with expectations.

This method seems to be relatively robust, e.g. by tolerating deviation from theory, namely by tolerating to some extent taxa with levels of different determination provided they do not belong to the first ranks of abundance. However, for truly calibrating and validating the method considering this kind of data and objective (directed towards the halieutic impact), it would be necessary to apply it to a series of older surveys from Senegal, making it possible to include the launching phase of the fisheries. Applying this to similar regional data (such as available in Guinea and Mauritania) should also be interesting according to this objective.

Lastly, considering the ecological plan, the stability observed over the period (1986-1995) could be interpreted as an adaptation of the studied community to a relatively strong fishing pressure.

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