Temporal evolution over ten years in the macrobenthos of muddy sands in the Bay of Concarneau (France)

Amphiura filiformis
Correspondence analysis
Benthos
Ecological succession

Amphiura filiformis
Analyse des correspondances
Benthos
Succession écologique

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ABSTRACT

The temporal evolution of the *Amphiura filiformis* community of two stations in the Bay of Concarneau was followed during a period of ten years (1970-1979). A concomitance has been found between the demographic fluctuations of the community and the effects of climatic and hydrodynamic factors occurring in the bay throughout the observation period. At the end of the decade a decline of the *Amphiura filiformis* population and some qualitative changes in the community are observed.

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RÉSUMÉ

Évolution temporelle des peuplements des sables envasés de la baie de Concarneau (France)

L'évolution temporelle de la communauté à *Amphiura filiformis* a été suivie durant une période de dix ans (1970-1979) en deux stations de la baie de Concarneau. Une concordance a été trouvée entre les fluctuations au sein de la communauté et les effets des facteurs climatiques et hydrodynamiques dans la baie. A la fin de la décennie, on observe le déclin de la population d'*Amphiura filiformis* et des changements dans la composition qualitative de la communauté.

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INTRODUCTION

The Bay of Concarneau in southern Brittany has been the object of an extended study during a little more than a decade. This study was mainly focused on the descriptive and dynamic ecology of zoobenthos and phytobenthos on soft substrates (Chardy, Glémarec, 1977; Boucher, 1975; Levenez, 1978; Menesguen, 1980).

Throughout the several partial surveys, preliminary results made evident an ecological succession which has been related to variations in climatic factors existing in the bay during the observation periods (Glémarec, 1979; Aldana, 1980; Seaman, 1981).

The purpose of this study was therefore to perform a global analysis of the available data in order to understand community evolution over an intermediate term of time, and to search for a possible distinction between " autogenic " succession and " allogenic " succession induced by external factors to the community (according to Tansley's definitions, *in* Drury, Nisbet, 1973).

METHODS AND MATERIALS

The available numerical information was obtained through a regular Smith-McIntyre sampling program made at two stations : Mousterlin and Concarneau, with respective depths of 17 and 28 m. Both stations have the same type of sediment and are characterized by a community dominated by the Ophiuroid *Amphiura filiformis.* The data analysed came from the 1970-1974 and 1977-1979 periods.

Description of temporal evolution was achieved by correspondence analysis used in previous studies (Chardy *et al.*, 1976 ; Chardy, Glémarec, 1977).

Diversity and density were found to be useful complementary indices. Data processing was done on a CII-IRIS 80 computer at the Centre Océanologique de Bretagne. Programs for statistical analysis were written by Alain Laurec.

Climatic data were compiled, specifically air and water temperatures. In this medium temperate zoogeographical province, spring and summer temperatures broadly influence biological parameters involved in reproductive process. Moreover, in winter, storms can disturb equilibrium at water-sediment interface and disperse populations. Storms are noticed when wind speeds are greater than 100 km/h.

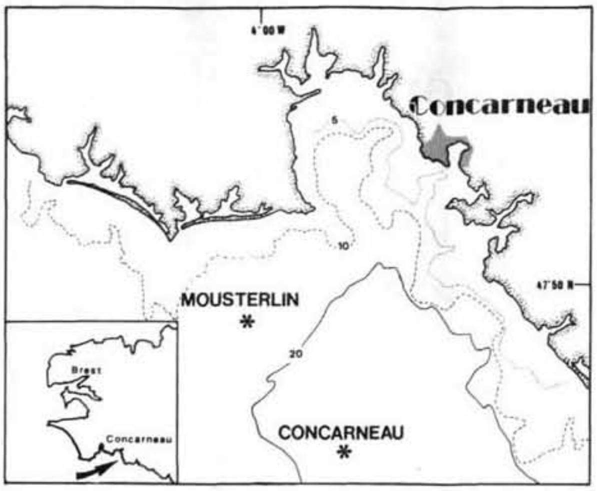

Figure 1

Location of sampling stations in Bay of Concarneau. Isobaths in meters.

Localisation des stations de prélèvements en baie de Concarneau. Isobathes en mètres.

RESULTS

Faunal groupings

Correspondence analysis showed for both Mousterlin and Concarneau, four faunal groupings identified on the first two axes (Fig. 1). These groups are characterized by organisms known to colonize specific substrates representing the spectrum of fine sands to muddy sands. In fact, groups "A" and "B" at both stations contain species associated with fine sands and muddy sands bottoms, species in Groups C and D are much more related to muds, some are ubiquistous.

At Concarneau station for example these groups are :

A : *Divaricella divaricata. Dosinia lupina. Echinocardium cordatum. Lumbrinereis gracilis. Hyalinoecia grubii. Diplocirrus glaucus. Owenia fusiformis.*

B : *Sipunculus nudus. Amphiura filiformis. Clymene modesta. Nepthys hombergii.*

C : *Acrocnida brachiata. Maldane glebifex. Lumbrinereis impatiens.*

D : *Dentalium novemcostatum. Mysella bidentata. Abra alba. Nucula turgida. Eulima subulata. Ampelisca* spp. *Terebellides ströëmi. Clymene oerstedii. Leanira yhleni. Harmothöe* sp. *Pectinaria koreni. Notomastus latericeus.*

Therefore, "A-D" axis may correspond to sedimentological change related to an increase of fine particles. This must be discussed later.

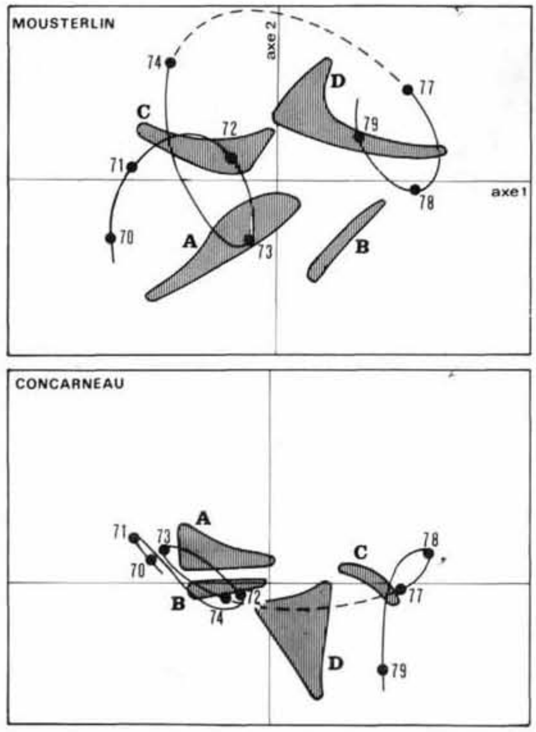

Figure 2

Correspondence analysis : striped envelopes represent species groups. The general trend is shown by the line and summer values (black points). The period without observations (1975-1976) is represented by a dotted line.

Analyse des correspondances : les enveloppes hachurées représentent les groupes d'espèces. La tendance générale est illustrée par la ligne joignant les valeurs estivales (points noirs). La période sans observation est en tiretés.

Temporal evolution

Monthly data are regrouped season by season and the general trend can be shown by a line connecting annual values, of summer, for example (Fig. 2). But it is necessary to consider others parameters to interpret this evolution (Fig. 4). Correspondence analysis places starting point in the negative part of both axes, simultaneously with group "A". This starting point appears just after an important gale and has been interpreted as the beginning of succession (Glémarec, 1979) with low values in specific diversity, general abundance and *Amphiura*

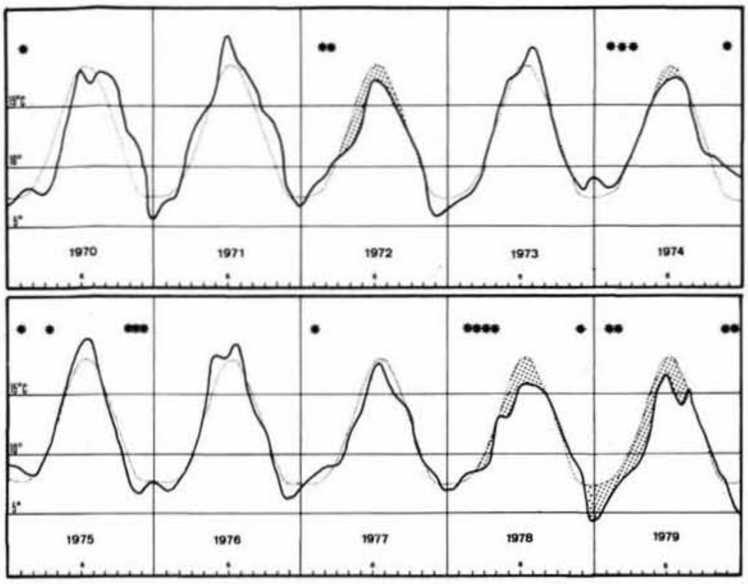

Figure 3

Average monthly air temperature variations from 1970 to 1979 : shadowed zones are anomalies in relation to the 20 years average (dotted line). Asterisks represent important gales (> 100 km/h).

Variations de la température moyenne mensuelle de l'air de 1970 à 1979. Les zones en grisé montrent les principales anomalies par rapport à la moyenne établie sur 20 ans (en pointillés). Les astérisques représentent les tempêtes les plus importantes (> 100 km/h).

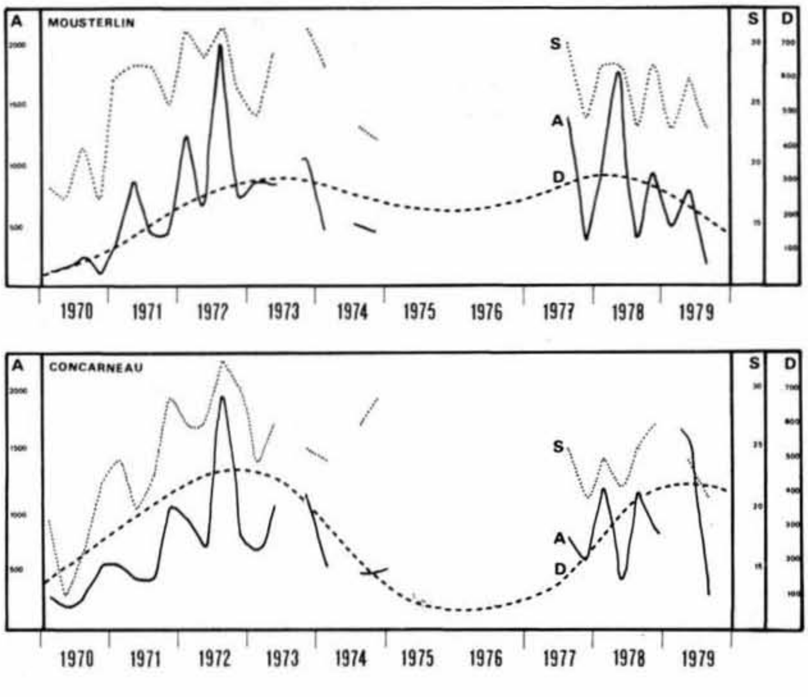

Figure 4

Temporal variations of mean density of the Amphiura filiformis *population in dashed line, compared to total number of species present (S) and to the total abundance (A) represented by dotted line and continuous line respectively.*

Variations temporelles de la densité moyenne de la population d'*Amphiura filiformis* (D) en tiretés, comparées au nombre total d'espèces présentes dans la communauté (S) et à l'abondance totale (A) représentées respectivement par la ligne en pointillés et par la ligne continue.

filiformis density (Fig. 4). Colonisation by group A species indicates a probable trend in sediment stability, which evolves smoothly until 1972, simultaneously with processes of autogenic succession. A reversal takes places after 1972 and it is corroborated by falling of the three parameters D, S and A (Fig. 4). Another critical year, 1978, produces a major regression in the trend after a recuperation period. At the end of the decade the community is desorganized with low densities of *Amphiura*, S and A are falling.

A search for climate anomalies was made as an attempt to explain these major inversions. Indeed the patterns of climate change showed precisely some of the same " abnormal " years (Fig. 3).

The observed ecological disruptions occurred during years having reduced spring and summer temperatures, following severe winter storms in 1972, 1978 and 1979. Since other stormy years (1970, 1975 and 1977) did not lower air temperatures, evolution of the community seems to be more strongly correlated with climatic than with hydrodynamic phenomena.

Therefore, during the years not studied (1975-1976) there were probably transitory stabilizing populations, since no serious climatic disturbances have been detected. This period should be located in the positive half of axis II for Mousterlin (Fig. 2). In spite of its less obvious fluctuations at Concarneau the same period probably runs through the negative half of the second axis.

Evolution of the *Amphiura filiformis* community

Because *A. filiformis* is the most dominant species of the community, its demographic evolution was closely studied and correlated with that of the other members of the community (Fig. 4). The object of this analysis was to look for general trends in numerical density (abundance) of this species.

According to complementary data on this population (Menesguen, 1980) we can say that a periodic fluctuation clearly occurred over the decade. This species — without mention of several variations — shows two peaks of abundance in ten years in 1972 and 1978, corresponding respectively to average densities of 300/m^2 at Mousterlin and 400/m^2 at Concarneau. For the whole community fluctuations in number of species and the total abundance generally follow the average density of *Amphiura*. Concomitance was found between these three parameters. The climatic data showed once again the coincidence of the population's decline and the immediate aftermath of the critical years, 1972 and 1978.

Along this decade qualitative composition of this community changes and among numeric fluctuations of different species, some interesting patterns can be identified illustrated Figure 5.

a) *Hyalinoecia grubii* is most abundant during the first half of the decade, at the two stations. Others species are inversely more numerous in the second half of the decade, *Notomastus latericeus* at Mousterlin, *Halcampa* sp. at Concarneau.

b) *Cirolana borealis* is very abundant during the first half at Concarneau, during the second half at Mousterlin.

c) Some species show weak fluctuations throughout the decade, *Nephtys hombergii* by example, and it is interesting to note that this worm is omnivorous.

d) *Abra alba* illustrate a special example of interspecific competition. At the beginning of the decade, *Abra alba* is a pioneer species well represented, then it is largely dominated by its predator *Amphiura filiformis*. Similar fluctuations appeared in 1977 and 1978 and we waited for the declination of *Amphiura filiformis* after 1978 to observe abundant return of *Abra alba* : this was observed at the two stations.

These qualitatives changes within community can be related in correspondence analysis with the migration from negative to positive values on the first axis. At beginning of succession, preponderance of grouping A species associated with fine sands and muddy sands, is replaced by mud species as *Maldane glebifex*, *Lumbrinereis impatiens*, *Leanira yhleni* or by ubiquistous or

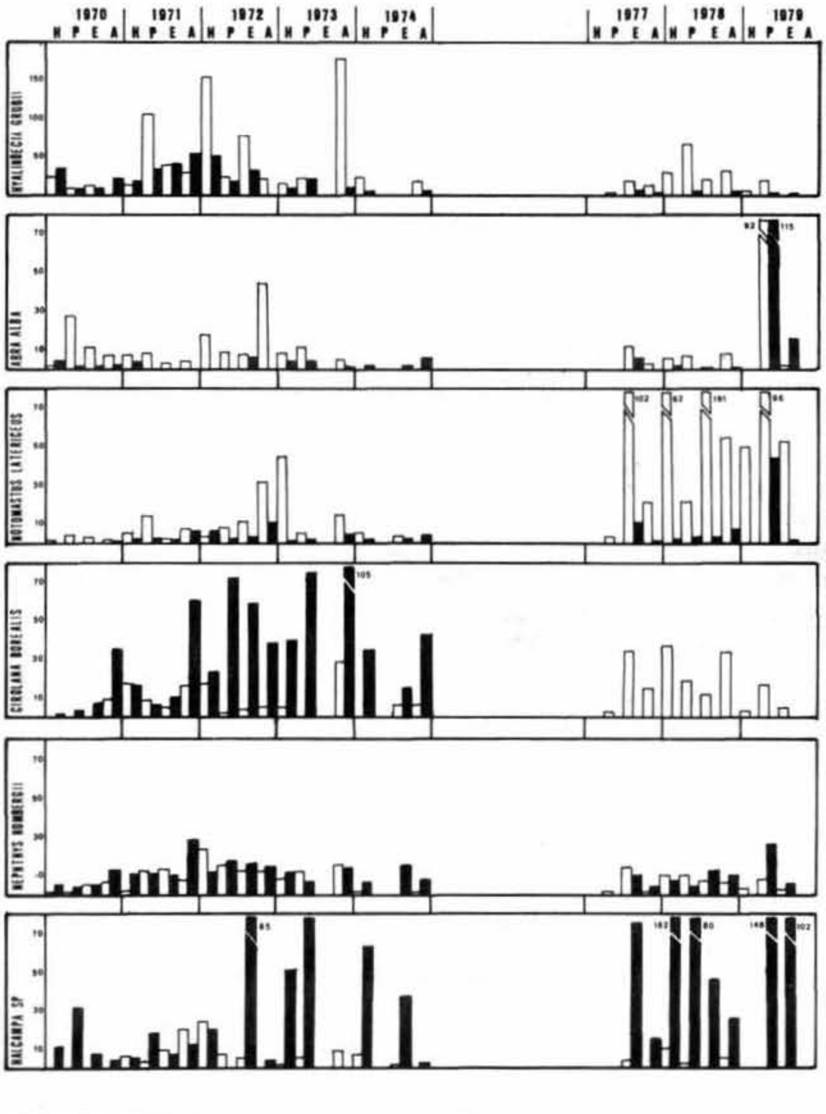

Figure 5

Numerical fluctuations (densities/m^2) of six different species at two stations : Mousterlin in white, Concarneau in black.

Fluctuations numériques (densités/m^2) de six espèces différentes aux deux stations : Mousterlin en blanc, Concarneau en noir.

tolerant species related to edaphic factors *Notomastus latericeus, Dentalium novemcostatum, Terebellides stroemi, Pectinaria koreni, Owenia fusiformis*, ... Since granulometric analysis do not show any significant modifications these last species can indicate a desequilibrium in the community. This is confirmed by low values of S and A, specially at Mousterlin.

DISCUSSION

The hypothesis proposed by previous authors (Chardy, Glémarec, 1977; Glémarec, 1978; Aldana, 1980; Seaman 1981) in which benthic populations in the bay of Concarneau are seriously affected by climatic anomalies is enhanced in this study. Each year cold conditions in winter are responsable for seasonal fluctuations in this temperate biogeographic area (Glémarec, 1979). Independently of phenomenon, low values of spring temperatures associated with winter and spring gales are partly responsible for the observed fluctuations especially in 1972 and 1978. Can a periodical pattern be expected in this case ?

These physical stresses or allogenic factors disturb the normal course of autogenic ecological succession. Climatic events, leading to air and water temperatures colder than the average in spring and in summer, as in 1972 and 1978, over ten years of observations, induced perturbations in the autogenic processes of succession : increasing densities, diversities, regular recrutments in populations, ... Hydrodynamic consequences after rough winter gales apparently disturb sediment stability, lowering diversity and inducing a disorganisation of the benthic community. In the same way calm years, without important gales, allow increased bottom sedimentation favorable to enhanced density and diversity of the community. The effect of these sedimentological (meteorological) disturbances on benthic organisms of the bay has been detected from the primary level of the trophic pyramid. Boucher (1975) found an enhancement in microfloral productivity in relation to increasinf stability. A close correlation has been found between the decreasing hydrodynamism in Mousterlin, an increase of microphytobenthic populations and its positive influence on microfaunal densities (Levenez, 1978). Macrobenthic numerical fluctuations proved to be strongly related to sediment grain size, and in the correspondence analysis displacement from negative to positive values on the I axis can be interpreted as allogenic succession influenced by an increase of fine particles or a general desorganisation. This is suggested by faunal group D distant from group A in the correspondence analysis (Fig. 2). We can not confirme hypothesis of changes in the granulometric parameters. Meanwhile Delanoë and Pinot (1979) suspected periodic sedimentological changes of more than ten years in the same area.

CONCLUSION

In the temporal evolution of the *Amphiura filiformis* community at two stations, fluctuations reveal the importance of external factors (climatic, meteorological) in succession. Despite of these allogenic disturbances, autogenic phenomena — succession in the ecological acceptance of the word — can be followed, but it is always difficult to distinct between fluctuations induced by external factors and real succession corresponding to changes indexed by internal factors. During the decade correspondence analysis reveals an important displacement in the first projection plane. Seasonal and interannual perturbations are added to general trend of community, in this autogenic succession it is difficult to eliminate influence of an external factor, of fine particules by example, because sediment and community are always in interaction.

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