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Long-term changes in the sessile epifauna of the Dover Strait pebble community

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ABSTRACT: Dover Strait, a biogeographical cross-road between English Channel and North Sea, supports many economic activities, (e.g., maritime traffic as well as fishing and portuary activities) and has been studied extensively, particularly within the CHARM (Eastern Channel Habitat Atlas for Marine Resource Management) program, a Franco-English collaboration funded by INTERREG III A. The "Modioles 2004" survey was carried out in the frame of the CHARM program, whose principal objectives were i) to map the distribution of the fauna at 46 sites sampled, with a Rallier du Baty dredge, offshore Calais in 2004, ii) to compare the results with those obtained by Cabioch and his collaborators for the period 1972-1976, and iii) to analyze space-time changes that have occurred in sessile epifauna since the earlier survey. In the intervening 30 years, the studied area has sanded up, sessile species distribution has extended eastward and species richness has doubled. Modifications in the sediment cover and assemblage composition can be explained by several factors, such as fluctuating survival rates due to temperature changes and the impact of anthropogenic activities (e.g., fishing, underwater cabling and pollution).

KEY WORDS: sessile epifauna, long-term changes, pebble community, Dover Strait.

ACRONYMS

CHARM: Eastern Channel Habitat Atlas for Marine Resource Management

MABEMONO: MAcroBEnthos de la Manche Oriental et de la mer du Nord (Macrobenthos of the Eastern English Channel and the North Sea)

INTERREG: INTER - REGions (European cooperation project)

AHC : Ascendant Hierarchical Clustering

I- Introduction

Dover Strait is a biogeographical crossroad between English Channel and North Sea. At the Cape Gris-Nez, the tidal currents reach a mean speed of 3 knots during spring tides (Pingree & Maddock, 1977). The strong hydrodynamics of this environment creates a sediment gradient: pebbles and coarse sand in areas with strong currents (offshore), and medium and fine sand in areas with weak currents (along the coasts) (Cabioch & Glaçon, 1975, 1977; Prygiel *et al.*, 1988; Dauvin & Dewarumez, 2002). Many tidal dunes (Dyck Occidental, Out Ruytingen, Ridins de Calais) are very mobile, running parallel to the tidal currents (Le Bot *et al.*, 2000; Idier *et al.*, 2002). Along the French coast, an hydrological structure called the '*fleuve côtier*' and corresponding to low-salinity water mass which integrates continental runoffs and drifts to the North Sea has been described by Brylinski *et al.* (1991) and Dupont *et al.* (1991).

Holme (1961, 1966) conducted the first surveys of benthic communities at mesoscale in English Channel. Later, at the end of the 60's, Cabioch and his collaborators began a synoptic survey of sediments and benthic communities in the Channel as part of the RCP program, *Benthos de la Manche* (Cabioch, 1968; Cabioch & Gentil, 1975; Cabioch & Glaçon, 1975; Souplet *et al.*, 1980; Larsonneur *et al.*, 1982; Sanvicente-Anorve, 1995; Sanvicente-Anorve & Leprêtre, 1995; Sanvicente-Anorve *et al.*, 1996).

Though geographical patterns of the species indicate faunal impoverishment due to a west-east climatic gradient (Gee & Warwick, 1996; Dauvin & Dewarumez, 2002; Desroy *et al.*, 2003), on the scale of English Channel, Dover Strait is a hot spot for biological diversity (Davoult, 1990) and species richness (figure 1). So, the Strait was chosen as the site of this study, which is being conducted as part of CHARM program. Objectives of this program were to map habitats of the main commercial species using physical and biological data.

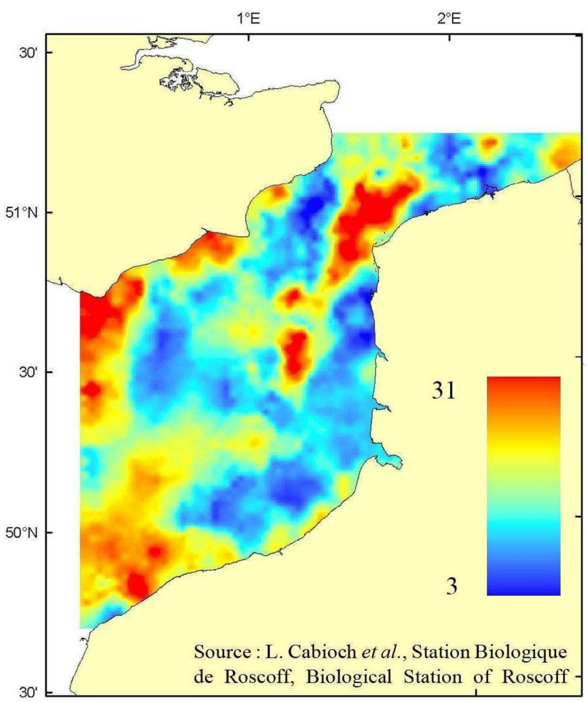

Figure 1 : The Dover strait : a 'hot spot' for species richness (front Carpetier et al., 2005b).

This paper focuses on the temporal changes of sessile epifauna species. These species are part of the benthic compartment, which is considered as a good integrator of the environmental stresses due to sedentarity and long life cycles of species (Dauvin, 1993)

The primary goals of this research were:

(1) to compare the results of the 2004 survey with those obtained by Cabioch and collaborators for the period 1972 –1976, and

to analyze the space-time changes that have occurred in the sessile epifauna since the earlier survey.

Material and method

A total of 46 sites, located offshore Calais, were sampled by Cabioch and his collaborators in 1972-76. These sites were revisited between March and June 2004 with the R/V *Sepia II* (figure 2).

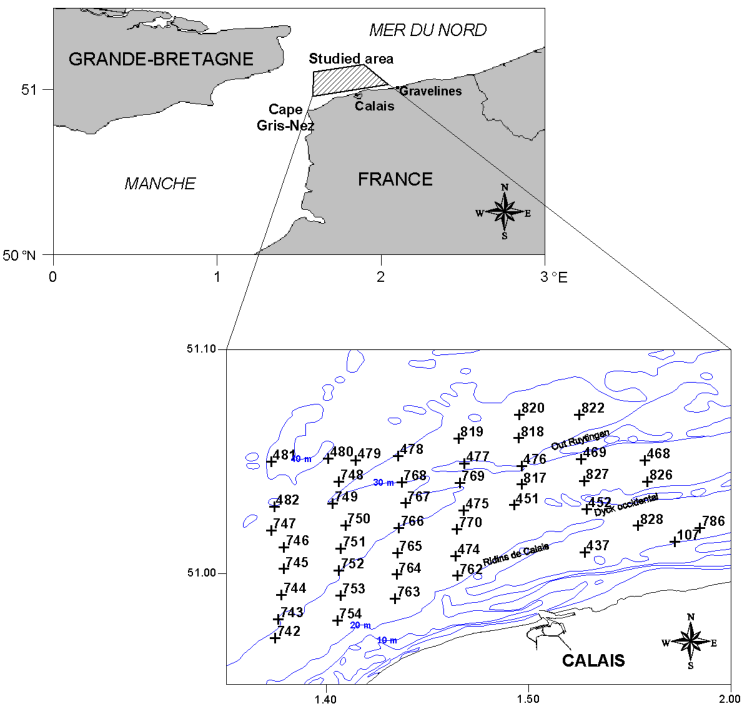

Figure 2 : Location of the area studied and the 46 sampling sites.

Sampling, sorting and identification:

- Gear: Rallier du Baty dredge,
- Sieving: 2-mm circular mesh sieve,
- Fixation: 10% buffered formalin,
- Sorting: at laboratory,
- Identification: to the species level under a dissecting microscope,
- Conservation: 70% ethanol.

When a sub-sampling was necessary at a site, all the pebbles from a station were counted and numbered (as many as 1230). Then, depending sample volume, a 30 to 50 pebble sub-sample was performed using Excel randomization ([function rand × (number of pebbles-1) +1], which returns a random number between 1 and the number of pebbles in the station according to a uniform law), so that the choice would not be subjective. All these steps were taken as soon as possible in order to prevent damage to the organisms. Absence of effects due to this sub-sampling on the species richness was tested with 4 stations: species encountered on more than 5 or 10 % of the pebbles for one station were correctly sub-sampled (88±14 % and 98±4 % respectively; table 1).

Table 1: Accuracy of the sub-sampling for different threshold of species rarefaction.

Station		745	817	749	766	Mean	St dev
Accuracy with species	>=10%	100%	100%	91%	100%	98%	4%
	>=5%	100%	86%	70%	98%	88%	14%

St dev = standard deviation

Accuracy = percentage of non rare species found in the sub-sampling

Analyses were done to determine species richness, coverage percentages and abundances. AHC was used to describe the assemblages. Results were mapped with SURFER 8© (Golden Software) and ArcMap© (ESRI) by using the most adapted interpolation schemes depending on the variables: nearest neighbour for assemblages, kriging for species richness and minimum curvature for sedimentary cover.

Results

Changes in sediment quality

In 1972-76, the bottom substrate was constituted by coarse sediments (gravel and pebbles) at most sampling sites, except for two sites (481 and 826) with sandy bottom. By 2004, the sandy bottoms had expanded considerably (Figure 3).

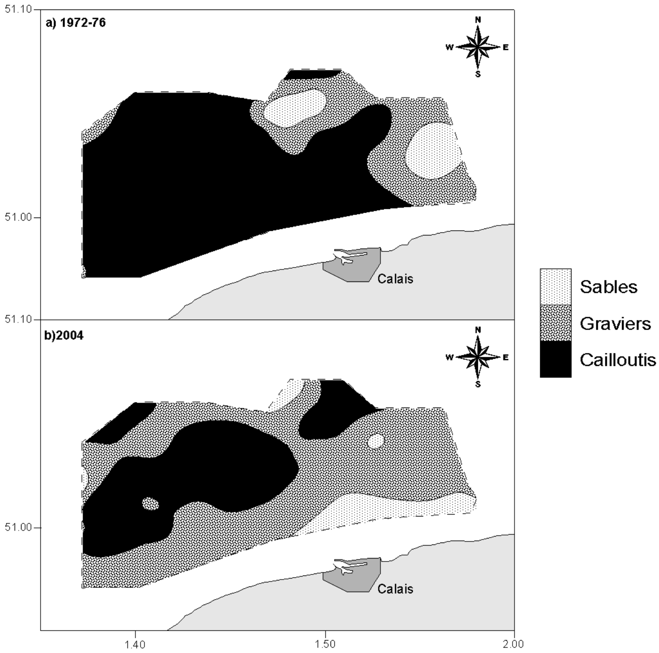

Figure 3: Sedimentary cover of the area in 1972-76 (a) and in 2004 (b). (sable=sand; graviers=gravels; cailloutis = pebbles)

Changes in species assemblages

Species diversity was estimated by the species richness (number of species) due to the use of presence/absence matrix data.

Bryozoa were the most representative phylum in both surveys (30% in 1972-76 and 38% in 2004), followed by Cnidaria (Table 2). Despite the differences in phyla percentages, the total number of phyla recorded for the two periods was similar (7 in 1972-76 and 8 in 2004).

Table 2: Distribution of species in the different zoological groups (a) in 1972-76, and (b) in 2004. The number of species in the zoolgical groups and the corresponding percentage are given.

a) 1972-76		
Zoological group	**Number of species**	**Percentage (%)**
Bryozoa	20	30
Entoprocta	0	0
Cnidaria	20	30
Porifera	8	12
Annelida	6	9
Mollusca	3	4
Tunicata	8	12
Arthropoda	2	3

b) 2004		
Zoological group	**Number of species**	**Percentage (%)**
Bryozoa	46	38
Entoprocta	3	3
Cnidaria	44	37
Porifera	9	8
Annelida	6	5
Mollusca	5	4
Tunicata	4	3
Arthropoda	3	3

The total number of sessile species collected in 2004 was twice as high as in 1972-1976 (respectively 120 and 67). In addition, in 2004, the richest sites were located offshore (Figure 4).

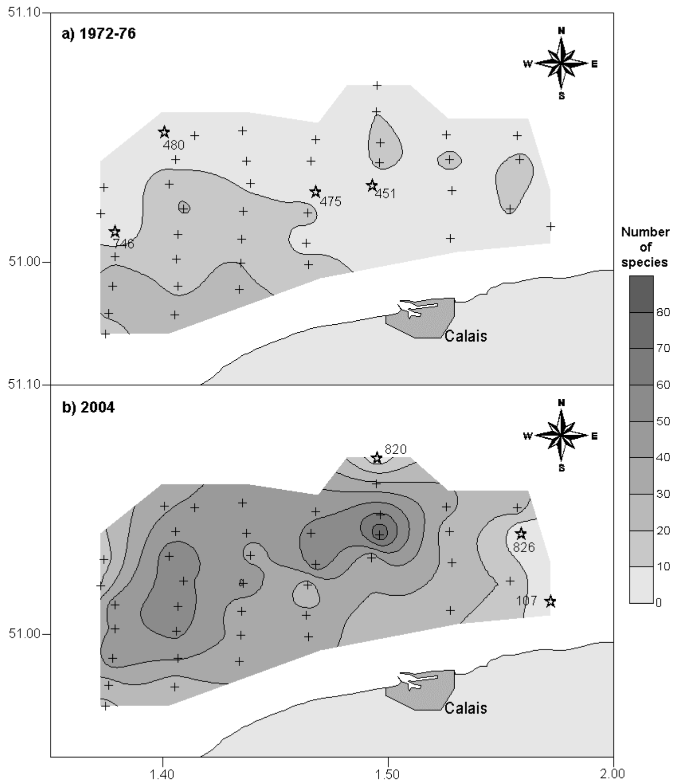

Figure 4 : Spatial distribution of species richness (a) in 1972-76, (b) in 2004. The stars represent the location without sessile epifauna.

A comparison of the surveys shows that 45 species were collected during both surveys and 59 only in 2004 (**table 3**). In addition, 22 species were found only in 1972-76 and 16 appeared since this date on the French coast of the Dover Strait (Wimereux Marine Fauna). They include one Porifera, three Cnidaria, one Annelida, ten Bryozoa and one Entoprocta. Most of these species were previously found along the coasts of British Islands (South and West of the caosts) or in other parts of the North-east Atlantic. The presence of the Entoprocta *Pedicellina hispida*, found once at the Cape Gris-Nez (Davoult *et al.*, 1999), was confirmed.

Table 3: Presence and absence of species in 1972-76 and in 2004, with the new species for the Wimereux Marine Fauna.

Species	1972-76	2004
Bryozoa		
Abietinaria abietina	x	x
Alcyonidium diaphanum		x
Alcyonidium gelatinosum	x	
Alcyonidium mytili	x	x
Bicellariella ciliata		x
Bowerbankia imbricata		x
Bugula flabellata		x
Callopora dumerilii		x
Callopora lineata		x
Cellepora pumicosa	x	x
Chorizopora brongniartii		x
Conopeum reticulum	x	x
Crisia aculeata	x	x
Crisia eburnea	x	
Diplosolen obelia		x *
Disporella hispida	x	x
Electra pilosa	x	x
Escharella immersa		x
Escharella spp.	x	x
Escharella variolosa	x	x
Escharella ventricosa		x *
Escharoides coccinea		x
Flustra foliacea	x	x
Hagiosynodos latus		x
Hippothoa divaricata		x *
Hippothoa flagellum		x *
Lepralia spp.	x	
Membranipora membranacea		x
Microporella ciliata		x
Omalosecosa ramulosa	x	x
Parasmittina trispinosa		x
Plagioecia patina	x	x
Plagioecia sarniensis		x *
Plagioecia spp.	x	
Porella concinna		x
Puellina venusta		x *
Reptadeonella violacea	x	x
Schizomavella auriculata		x
Schizomavella cornuta		x *
Schizomavella linearis	x	x
Schizoporella cornualis		x
Schizoporella hesperia		x *
Schizoporella patula		x *
Schizoporella spp.		x
Schizoporella unicornis	x	x
Scruparia ambigua		x
Smittoidea reticulata		x *
Tubulipora liliacea		x
Tubulipora phalangea		x
Tubulipora spp.	x	x
Turbicellepora avicularis		x

Species	1972-76	2004
Cnidaria		
Actinaria spp.	x	x
Actinia equina		x
Adamsia carciniopados		x
Alcyonium digitatum	x	x
Alcyonium glomeratum		x *
Aureliana heterocera		x *
Bougainvillia ramosa		x
Calycella syringa		x
Campanularia hincksii	x	x
Campanularia spp.	x	
Campanularia volubilis		x *
Cereus pedunculatus		x
Cerianthus lloydii	x	
Clytia gracilis		x
Clytia hemisphaerica		x
Coryne pusilla		x
Diphasia attenuata	x	
Dynamena pumila		x
Eirene viridula		x
Eudendrium capillare		x
Eudendrium ramosum		x
Filellum serpens	x	
Halecium halecinum	x	x
Halecium spp.	x	x
Hydractinia echinata	x	x
Hydrallmania falcata	x	x
Hydranthea margarica		x
Kirchenpaueria pinnata	x	x
Leuckartia octona		x
Merona cornucopiae		x
Metridium senile		x
Nemertesia antennina	x	x
Nemertesia ramosa	x	
Obelia dichotoma		x
Orthopyxis integra		x
Phialella quadrata		x
Plumularia setacea		x
Podocoryne carnea		x
Sagartia elegans	x	x
Sagartia troglodytes	x	x
Sagartiogeton undatus		x
Sarsia loveni		x
Sarsia tubulosa		x
Sertularella gaudichaudi		x
Sertularia argentea	x	x
Sertularia cupressina	x	x
Tubularia indivisa	x	x
Tubularia spp.	x	
Urticina felina	x	x

Species	1972-76	2004
Annelida		
Filograna implexa		x
Megalomma vesiculosum	x	
Pomatoceros lamarckii		x *
Pomatoceros triqueter	x	x
Sabellaria spinulosa	x	x
Serpula vermicularis	x	x
Spirorbis pagenstecheri	x	
Spirorbis spirillum	x	
Spirorbis tridentatus	x	
Spirorbis spp.	x	x
Arthropoda		
Acasta spongites	x	
Balanus balanus		x
Balanus crenatus	x	x
Verruca stroemia	x	x
Mollusca		
Modiolus modiolus	x	x
Musculus discors	x	x
Mytilus edulis	x	x
Pododesmus patelliformis		x
Pododesmus squama		x
Entoprocta		
Barentsia gracilis		x
Pedicellina hispida		x
Pedicellina nutans		x *
Porifera		
Cliona celata	x	
Cliona spp.	x	
Dysidea fragilis	x	x
Haliclona cinerea		x
Haliclona oculata		x
Halisarca dujardini		x
Leuconia fistulosa	x	
Poecillastra compressa		x *
Porifera spp.	x	x
Suberites spp.		x
Sycon ciliatum		x
Tethya aurantium		x
Tunicata		
Ascidie spp.	x	x
Ascidiella mentula	x	
Ascidiella spp.	x	
Ciona intestinalis	x	x
Dendrodoa glossularia	x	x
Didemnum spp.	x	
Molgula spp.		x
Pyuridae spp.	x	

The AHC was performed on data without rare species (e.g. found in 1 or 2 stations) and by using the Cosine index (**figure 5**). The level of cut was chosen in order to have 50 % similarity between the stations. It revealed 8 faunal assemblages in 1972-76 and only 4 in 2004 (**figure 6**). In both surveys, the assemblage numbered VIII is constituted by stations with few or no species. In 1972-76, the assemblage VI, that covers the biggest area, was not characterized. It was only tolerant species which occupied it. However, in 2004, the main assemblage (XI), which spreads over a wider area than in 1972-1976, is characterized by *Hagiosynodos latus*, *Omalosecosa ramulosa*, *Reptadeonella violacea*, *Tubulipora liliacea*, *Sertularia cupressina*, *Urticina felina*, *Verruca stroemia*, *Sycon ciliatum*, *Dendrodoa grossularia* and undetermined Porifera (**table 4**).

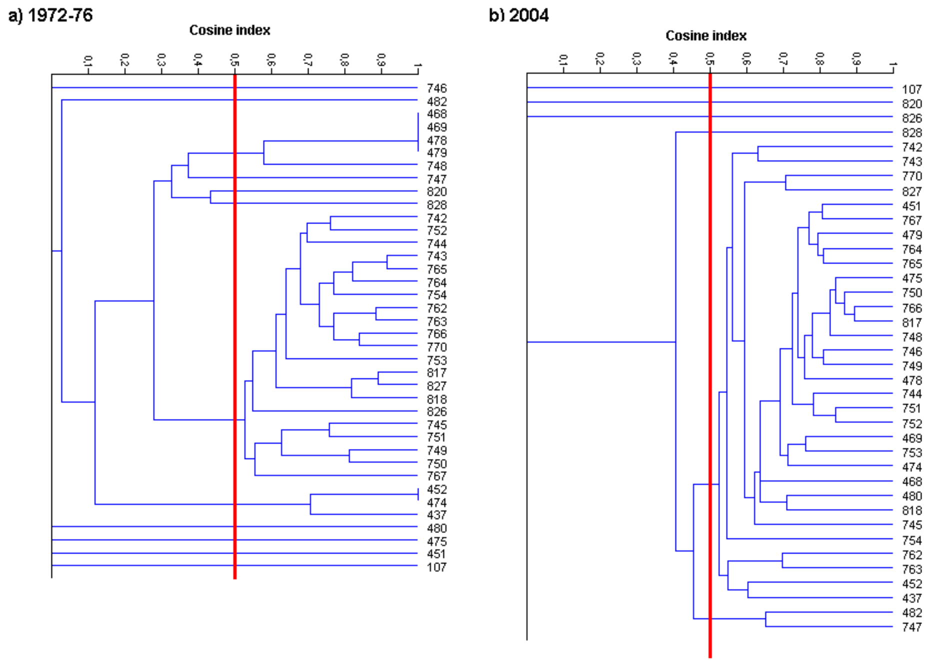

Figure 5 Dendrogramms calculated with the Cosine index and level cut (0.5)

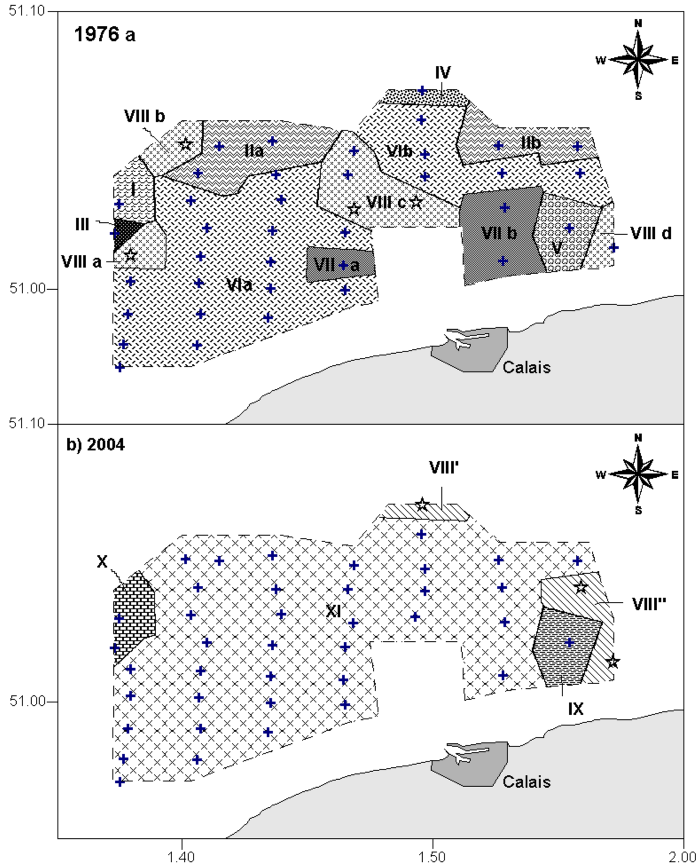

Figure 6: Faunal assemblages determined by AHC (a) in 1972-76, ans (b) in 2004.

Table 1: Characteristic species of the assemblages in 1972-76 and in 2004.

Characteristic species (1972-1976)			
III	IV	V	VII
Kirchenpaueria pinnata	*Nemertesia antennina*	*Nemertesia ramosa*	*Alcyonium digitatum* *Cellepora pumicosa* *Dendrodoa grossularia* *Lichenopora hispida* *Schizomavella linearis* *Sertularia sp* *Tubulipora sp*

Characteristic species (2004)		
IX	X	XI
Conopeum reticulum *Coryne pusilla* *Sagartia elegans* *Barentsia gracilis* *Modiolus modiolus*	*Callopora dumerilii* *Alcyonidium diaphanum*	*Hagiosynodos latus* *Omalosecosa ramulosa* *Reptadeonella violacea* *Tubulipora liliacea* *Sertularia cupressina* *Urticina felina* *Verruca stroemia* *Spongiaire sp* *Sycon ciliatum* *Dendrodoa glossularia*

Discussion

The following hypotheses can explain changes in number of species: changes in methods, changes in primary pelagic production and sanding up of the Dover Strait between 1972-76 and 2004.

1) Changes in methods

This study highlights that species richness of sessile fauna has doubled as species richness of the vagile epifauna

and endofauna (Alizier, comm. pers.); and that species frequency among the different phyla appears to have remained fairly stable. Because the same kind of gear (Rallier du Baty dredge) was used in both periods, the hypothesis of damages by gear on the erect sessile epifauna (Jennings & Kaiser, 1998, Jennings *et al.*, 2001) can be eliminated. The employment of two sorting procedures could explain this doubling. Indeed, in 1972-76, the sorting procedure was partly done on board; the rare species which were not determined on board where brought to the laboratory. In 2004, all samples were brought to the laboratory where determination was done. So, a more scrupulous examination of pebbles may have been done. But 22 species were only found in 1972-76 and some species were not difficult to distinguish (ascidians for example). So, if retained, this explanation has its limits.

Fifteen species, and perhaps sixteen (to confirm), were new for the Wimereux Marine Fauna. All of them are already known along English coasts. This addition could be explained either by the scrupulous pebble examinations of the “Modioles 2004” cruise or by a faunal change between the surveys. Three of these species are very difficult to distinguish because there are very small and sometimes translucent. The other species can be considered as indicators of ecological change presumably related to climat variations.

2) Changes in primary pelagic production

Sessile epifauna in the Dover Strait is composed mainly of Lophochotrozoa, Cnidaria and Porifera, all passive suspension-feeders. In this type of community, organic enrichment can have an impact on species richness and diversity (Pearson & Rosenberg, 1978, Pearson *et al.*, 1985). However, a change in primary pelagic productivity in 2000 and 2002 may have affected food availability, with some impact on the trophic group. But no significant differences in this primary pelagic productivity were found between chlorophyll "a" concentrations during the period 73-77 (USTL, comm. pers.) and the period 2001-2002 (IFREMER, comm. pers.) at Gravelines site, near the area studied here.

3) Sediment changes

The sanding up of the studied area, especially on the north-eastern and eastern boundaries, may be due to movements of tidal dunes (several meters per year) (Le Bot *et al.*, 2000). Such modifications of the sedimentary cover have been known to disturb benthic communities by creating a homogeneous bottom. In spite of the increased amount of sand, and thus the increased area of the sandy bottoms, sessile species richness doubled from the first survey to the second.

Modifications of sediment cover and assemblage composition between the two surveys can also be explained by such factors as fluctuating survival rates due to temperature changes and the impact of anthropogenic activities (e.g., fishing, underwater cabling and pollution). Despite such factors, the pebbles community as described by Cabioch & Glaçon (1977) and Souplet *et al.* (1980) persists in this area.

Our research emphasizes the importance of studying sessile epifauna as a proxy for macrobenthic change. Sadly, such fauna is often neglected due to the difficulty of species identification.

These results appear in the CHARM atlas (Carpentier *et al.*, 2005 a, b), where they contribute to improving fish habitat maps by taking into account biological factors such as trophic availability, in addition to physical factors. This research is the first phase of a larger study encompassing the entire eastern English Channel (MABEMONO), which began in February 2006. The main objective of the MABEMONO program is to identify the macrobenthic community changes between 1972-1976 and 2006-2007.

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For more information on the CHARM program and to download the atlas and the final report, you can go on http://charm.canterbury.ac.uk/.

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