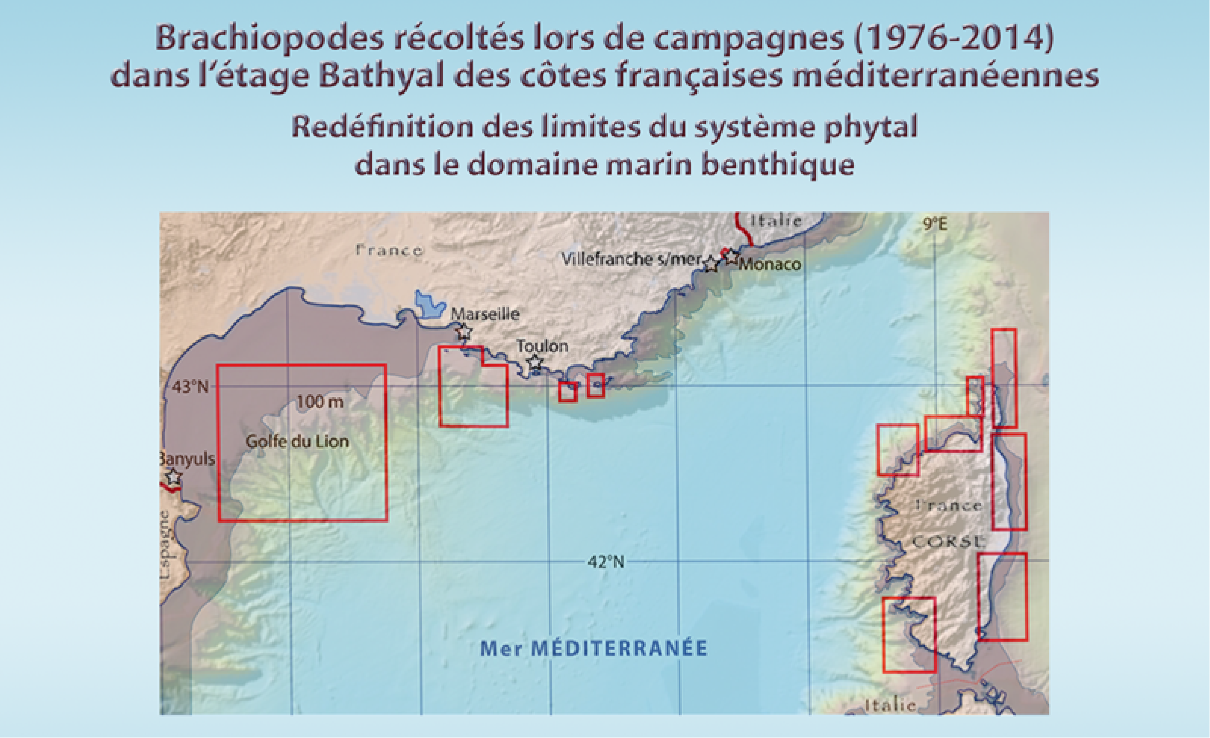
Brachiopodes récoltés lors de campagnes (1976-2014)
dans l'étage Bathyal des côtes françaises méditerranéennes

Redéfinition des limites du système phytal
dans le domaine marin benthique

Christian C. EMIG

BrachNet , 20, Rue Chaix, F-13007 Marseille (France)
brachnet@aliceadsl.fr

Quote

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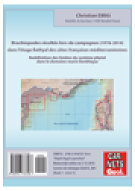

Abstract

Brachiopods sampled during expeditions (1976-2014) in the Bathyal Zone of the French Mediterranean coasts. Redefinition of the boundaries of the phytal system in the marine benthic domain .- The distribution of brachiopods along the French Mediterranean coast, especially in the Bathyal zone, was studied in detail from 1976 to 2014 being one of the main objectives of the RCP-CNRS No 728, that took place during the years 1983 to 1989. The data obtained during these campaigns constitute the main objective of this e-book, which focuses on five brachiopod species *Novocrania anomala, Gryphus vitreus, Terebratulina retusa, Megathiris detruncata, Platidia anomioides* and *Megerlia truncata* that occur in the Upper Bathyal zone. The e-book consists of nine chapters, of which the last two contain the data concerning all the stations studied, the distributional charts of the five species mentioned, included. The presence of these species in the Mediterranean biocoenoses has put in evidence a hiatus in the systematics based mainly in characters of the shell and rarely in phylogenetic analyses. Another important point that is addressed is the discussion of the validity of some species with fossil record, being *Terebratula minor* (= *Gryphus vitreus*), as well as of extant ones, ie, *Terebratula seminulum,* chosen as examples. Finally, the infestation of *G. vitreus* shells by the *Ostreobium* alga led to reconsider the lower limit of the benthic phytal system and its bathymetric variations as far as in the Bathyal.

Keywords : brachiopod; bathyal; Mediterranean; biocoenosis; aphytal; photic.

Foreword

The primary purpose of this book is to make available all the station books of my cruises in the Bathyal stage off the coasts of Provence and Corsica (France), by adding data from some cruises made by the Ifremer (French Research Institute for the Exploitation of the Sea). Indeed, the collected material, and first and foremost the brachiopods, have been deposited in various Museums, the main deposits of which concern the National Museum of Natural History in Paris, the "Museo Nacional de Ciencias Naturales" (CSIC, in Madrid) and the “Instytut Paleobiologii PAN, Warzawa” (Institute of Paleobiology, Polish Academy of Sciences, in Warsaw). All the collection stations were reported on French nautical charts, as well as the geographical distribution for each species in the different prospected areas.

The research was carried out within the framework of the Cooperative Research Program (National Center for

Scientific Research) RCP-CNRS n°728 entitled *Studies of current populations of brachiopods; transposition to fossil forms* (1983-1989), of which I was the instigator and director. The goal was to federate French researchers working on current and fossil brachiopods, and to add those of our other European colleagues who so wished. This RCP brought together researchers from Marseille, Lyon, Dijon, Besançon, Paris, Brest, Pau for France, Catania for Italy, Oviedo for Spain and Glasgow for Great Britain.

This book is also an opportunity to briefly summarize our knowledge of the history of the Mediterranean Sea, as well as the main results on the ecology of brachiopod species collected in the Bathyal stage, recalling that ecology cannot be eluded from the diagnoses of these species, as in general for all current species, as well as fossils on condition that the natural environment can be defined and not the conditions which, in fact, led to their fossilization. A current case is evoked following a siltation of the continental shelf and the upper Bathyal in Corsica.

Finally, new data concerning the distribution of *Gryphus* shells infested by the unicellular green alga *Ostreobium* led to clarify the limit between the phytal (or photic) and aphytal (or aphotic) systems in the benthic domain. A few lines have also been written to encourage the revision of the taxonomy of current species of brachiopods, because the use of a "paleontological systematics" is no longer suitable for their identification.

In the appendix, it seemed to me interesting, even useful, to open the debate on the application of phylogenetic methods in the taxonomy of current species and genera of brachiopods. Two *Terebratula* , *T. minor* and *T. seminulum* , both described by Philippi (1836), are taken as examples.

1. Introduction

In the World Ocean, the bathymetric distribution of brachiopods is the most abundant from the littoral zones to the upper Bathyal stage (Emig, 1988, 2016): for these suspensivorous lophophorates, it is explained by the need to live in biotopes subject to hydrodynamics, favoring the nutritional supply of food particles and plankton. The edge of the continental shelf is particularly favorable due to the particular characteristics of the water masses circulating there, with a predominance of brachiopods, mainly craniiform and rhynchonelliform, throughout the upper Bathyal stage (Emig, 1997a, 2016).

The current distribution of brachiopods extends to all oceans and seas: the latitudinal distribution shows that the linguliforms, mainly littoral, are more abundant in the intertropical zone, while the rhynchonelliforms have a wider distribution in the temperate zones (Emig, 2016).

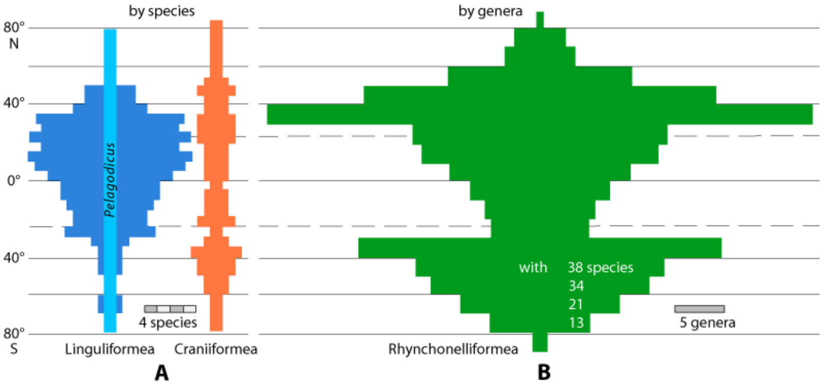

Figure 1-1 : Latitudinal distribution of current taxa of the three brachiopod subphyla: for Linguliformea and Craniiformea (**A**) by species; for the Rhynchonelliformea (**B**) by genera. According to Emig (2016, 2017a).

Our knowledge of the geographical distribution of brachiopods along and off the French coast is almost exclusively linked to the results of oceanographic campaigns (Álvarez *et al* ., 2016, 2017). Indeed, on the continental shelf, brachiopods are generally cryptic, therefore not easily accessible from the surface, except by scuba diving, especially since their density is low and their size small, often less than one centimeter. On the other hand, in the deep domain, beyond the edge of the continental shelf (about 100 m), the diversity of brachiopods is maximum with high densities (several hundred individuals per m^2) in the upper Bathyal stage (Emig, 1985a, 1988, 1989a, 1997a) (Figs. 1-1, 1-2). The geographical and bathymetric distributions of brachiopods, as for all species, are directly related to the biotope and therefore to the biocoenosis to which a species of brachiopod is subservient. These current and fossil biocoenoses (thanatocoenoses) have been particularly well studied in the Mediterranean Sea: also the taxonomy of brachiopods cannot be done without taking them into account even, as a character, in a cladistic analysis. This misunderstanding has recently led to questionable descriptions (see Emig, 2014; and Appendices AC).

In the Mediterranean Sea, the proximity of the continental slope, often a few miles from the coast, has facilitated the multiplicity of samples by greatly reducing travel time. The data obtained in the stations surveyed during the sea campaigns carried out between 1976 and 2014 have been gathered in chapters 8 and 9, with the distribution maps of the different species of brachiopods. Some unpublished results are also analyzed and used to discuss the limits of the benthic phytal system in the Mediterranean Sea.

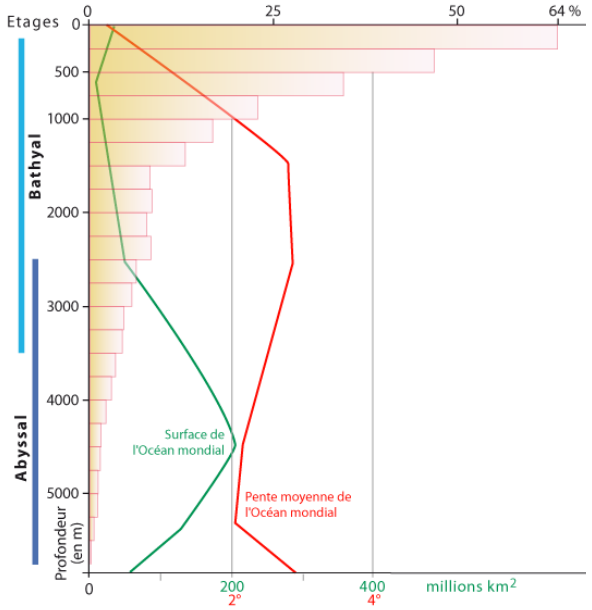

Figure 1-2 : Distribution of current brachiopods according to depth (from Emig, 2016). Curves of the surface and mean slope of the World Ocean according to Costello & Chaudhary (2017): as brachiopods are suspension feeders, they are mainly distributed in sloping or/and hydrodynamic zones from the continental shelf to the the Bathyal stage, according to the local topography.

This document is mainly technical in order to publish all the data collected during the campaigns at sea and allow their subsequent use if necessary or refine those previously published by the various members of the RCP-CNRS 728 and those who have benefited from the material collected. . The latter has been deposited in the collections of the Museo Nacional de Ciencias Naturales (CSIC, Madrid), the National Museum of Natural History in Paris and the Institute of Paleobiology (PAN Warsaw).

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2. Materials and techniques used

A. Campaigns and Ships.

Work within the framework of the Cooperative Research Program (National Center for Scientific Research) RCP-CNRS No. 728 (*Studies of current populations of brachiopods; transposition to fossil forms* , 1983-1989; Director CC Emig), bringing together specialists French, British, Spanish, Italian, were based on the results obtained during the cruises carried out off the coasts of Provence and around Corsica (Table 1, Pl. 1). In this same context, two other campaigns took place: one in Scotland (from Oban) with Gordon Curry (University of Glasgow) and one in Sicily (off Syracuse), organized by Italo Di Geronimo (University of Catania) (Di Geronimo, 1987); they are not dealt with here. The material collected has given rise to numerous publications on various subjects and themes in biology, ecology and paleontology.

Table 1 : List of cruises at sea, the results of which are mentioned in chapter 8 and the maps in chapter 9. French abbreviations for ships: N/O = research vessel; BISM = underwater intervention building; SMI = intervention submarine (Pl. 1).

Campaigns	Dates and Ships		**Provence**
BraProv 0	March 1983 - N/W Antedon	CNRS	Chapter 8: Table 3 and Table 4
BraProv 1	February 28 - March 2, 1985 - N/W Antedon		
BraProv 2	Jan. 27, 1986 - BISM Triton & SMI Griffon	Navy	
Bra Prov 3	11 - 14 December 1986 - N/W Antedon	CNRS	
Bra Prov 4	12 - 16 January 1987 - N/O Catherine-Laurence & ROV Modexa		
Bra Prov 5	4 - 6 March 1987 - N/W Antedon		
Bra Prov 6	March 30 - April 3, 1987 - N/W Catherine-Laurence		
Bra Prov 7	1 - 5 June 1987 - N/W Antedon		
Bra Prov 8	Oct. 22, 1987 - BISM Triton & SMI Griffon	Navy	
Bra Prov 9	16 - 25 November 1987 - N/O Korotneff	CNRS	
Bra Prov 10	Oct. 13, 1989 - BISM Triton & SMI Griffon	Navy	
IsoBra	September 1996 - N/W Catherine-Laurence	CNRS	Chapter 8: Table 5
IsoBra	March 1999 - N/W Catherine-Laurence		
DEPROG	April 1996 - N/W Europe	IFREMER	Chapter 8: Table 5

top

Campaigns	Dates and Ships		**Corsica**
BraCors 1	May 31 - June 9, 1983 - N/W Catherine-Laurence	CNRS	Chapter 8: Table 6 and Table 7
BraCors 2	April 9 - 15, 1984 - N/W Catherine-Laurence		
BraCors 3	2 - 6 July 1984 - N/W Catherine-Laurence		
BraCors 4	4 - 8 July 1985 - N/W Korotneff		
BraCors 5	4 - 22 November 1985 - N/W Catherine-Laurence		
BraCors 6	19 - 23 January 1987 - N/W Catherine-Laurence		
BathyMed	7 - 22 November 1988 - N/O Catherine-Laurence		Chapter 8: Table 8 and Table 9
Meditis 2	May-June 2012 - N/W Europe	IFREMER	Chapter 8: Table 10
Meditis 3	May-June 2013 - N/W Europe		

The station notebooks are available in chapter 8 and the maps of geographical distribution and bathymetric distribution appear in chapter 9. Other counts of *Gryphus vitreus* have taken place during recent CNRS and Ifremer campaigns (Table 1): they have were added to our data.

- The units of measurement used are for distance, nautical mile [= 1852 m], and for speed, knot [= 1852/3600 m/s or 1 nautical mile/h]. These units, although outside the International System of Units, are in use and included in the latter. They are used because one nautical mile on the Earth's surface is one minute of latitude, which is consistent with latitude and longitude being measured in degrees and minutes and seconds – or 1/10th of a second. .
- The geographical coordinates of the stations (latitude, longitude) were obtained by first using the Loran-C positioning system, then replaced by that of the Global Navigation Satellite System type satellite (including GPS) with an accuracy of one meter.

The provision of precise bathymetric maps (with close bathymeric measurements) by the Mediterranean Oceanographic Mission (French Navy, Toulon) made it possible to draw up the profiles of the radials and was of great help in the preparation of the three dives in submersible.

B. Machinery used

Various devices were used depending on the needs of the research and the results to be obtained (see also Emig, 1983; Anastasios, 2013).

Charcot-Picard cruising

It is the main and indispensable machine for harvesting brachiopods on the continental slope. It is the perfectly adapted machine with the best efficiency. There are two assemblies according to the needs:

- a burlap, called underpants, lined with a thick protective net (Fig. 2-1).
- without underpants with a 10 mm mesh net, protected by a thick net (10 mm thread) with a coarse mesh (Fig. 2-2).

Although easy to use, it nevertheless requires a good experience for maximum efficiency according to the desired results in the harvesting of brachiopods, especially in conditions of uneven bottoms as are frequently those of the upper Mediterranean Bathyal, especially on relatively steep slopes and in underwater canyons. Also, hooks [1] are frequent, so to limit the damage or allow the dredge to be raised in the event of a serious hook, the machine is equipped with a breakable line (Fig. 2-1); they sometimes require mending or even repairing the metal structure of the dredge.

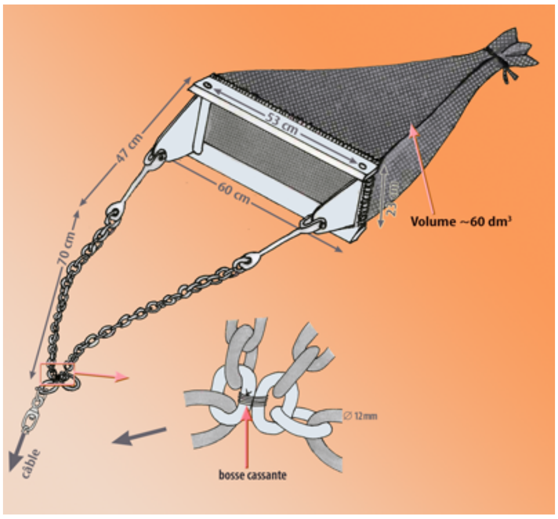

Figure 2-1 : Charcot-Picard dredge, with underpants.

Figure 2-2 : Return to the deck of a Charcot-Picard dredge without underpants (Photos taken from a video).

Dredging at great depths, on often rocky slopes, requires a good estimate of the bottom conditions, in particular the substrate, the slope, the current, which can also have consequences for the safety of the ship and the sailors and scientists working on it. the bridge (Emig, 1983, 1987). One can cite as an example: the length of the cable varies between 2 and 3 times the depth and it depends on the traict going up the slope or along an isobath, the wind at the surface, the interpretation of the sounder data, the substrate, etc. With good practice, the touch of the cable provides information on the work of the dredge on the bottom and also to adapt the speed of the vessel (around 1-1.5 knots) for maximum efficiency.

Small beam trawl (2 m wide)

This trawl was only used occasionally, because it is fragile (Fig. 2-3), it requires a homogeneous soft bottom without major roughness, which is rare in the upper bathyal of the Provençal and Corsican coasts. It resembles the Provençal gangui with a fixed frame, which was used at shallow depths by fishermen (a use today practically prohibited for damage caused in seagrass beds – subject to derogation).

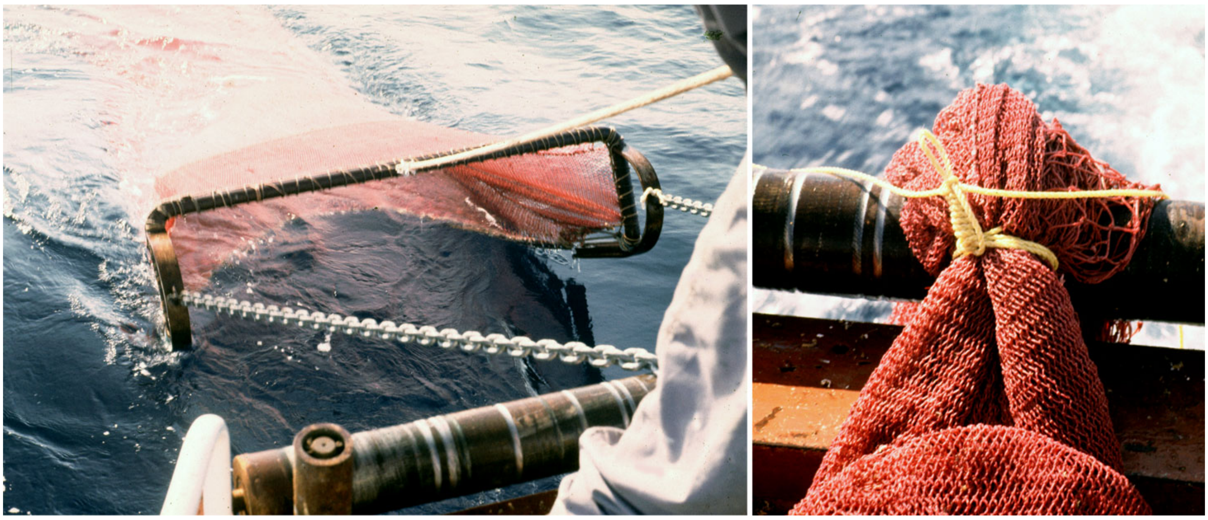

Figure 2-3 : Small beam trawl – left: its launch; right: the knot of raban-de-sac.

Tipper Shipeck

This grab was chosen to take samples of soft sediments for the study of their granulometry, as well as the meiofauna. In English, it is called Shipeck sediment sampler (Fig. 2-4). The bucket with a dimension of approximately 20.5 x 20 cm pivots 180° on touching the bottom and thus performs the sampling. Its launch requires attention so as not to trigger the rotation prematurely.

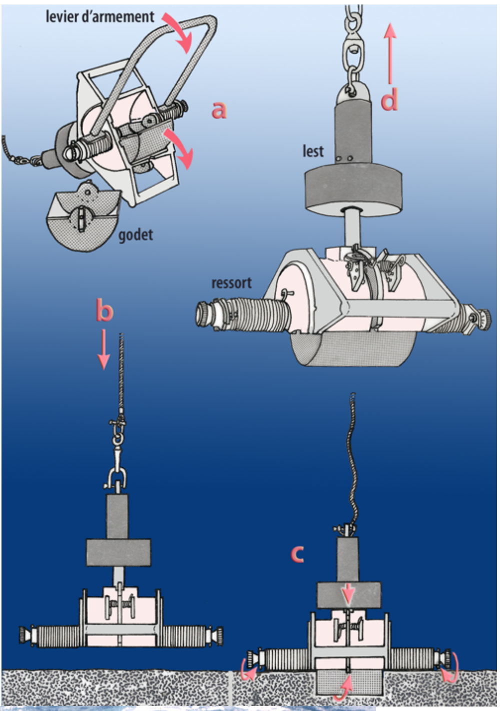

Figure 2-4 : Shipeck grab and its implementation.

Modexa, (remotely guided underwater vehicle)

This ROV (Remotely Operated Vehicle; Pl. 1) was a prototype that appeared at the time of the creations and development of this new type of underwater vehicle, the purpose of which was to replace underwater submersibles. Because the latter require heavy means, both technical and financial, in their implementation and therefore are not easily available. Nevertheless, if an ROV is now easy to use and inexpensive, nothing replaces a human dive for *in situ* observations . This remark was already made in the early 1960s with the first scientific observations and samples taken during scuba diving (Emig, 1966).

Epibenthic luge.

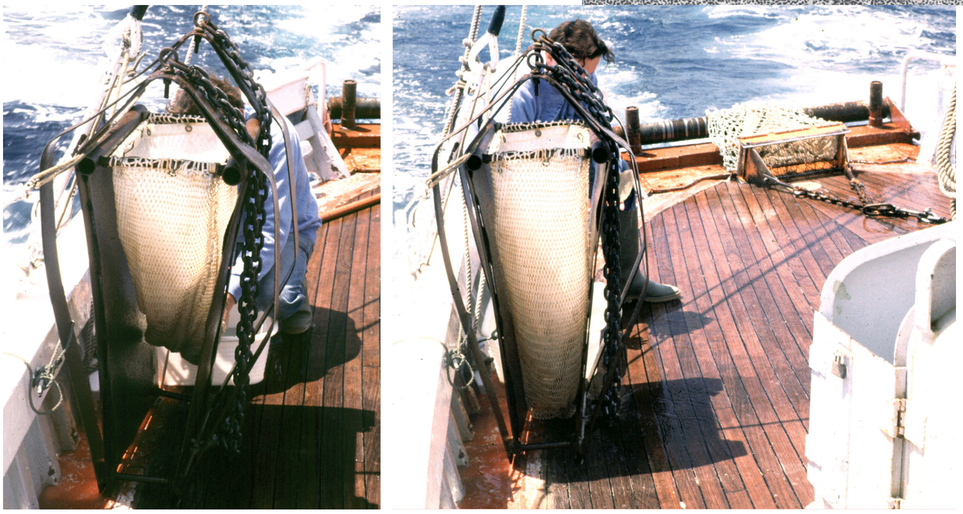

Figure 2-5 : Epibenthic sledge being collected from the sample (left) and ready for the next launch.

The sledge used (Fig. 2-5), derived from that of Ockelmann, was developed by Ledoyer (1987) for epibenthic mobile fauna, in particular crustaceans (cumaceans, amphipods, etc.).

underwater submersible

The dives with the submersible SMS Griffon, from the support ship BSM Triton (Pl. 1) were included in the framework of aid for scientific research by the French Navy, from the home port of Toulon. The observations, made during the three dives carried out in Provence (Table 1), proved essential in the study of the ecology and the distribution of the brachiopods of the Bathyal. In addition, each radial (see chapters 8 and 9) had been preceded by an intensive sampling campaign, then followed by another to sample the areas observed during the dives.

Note

The machines used only allow qualitative sampling without giving the density per m^2. It is in the stations proposed in submersible, where density measurements of *Gryphus vitreus* were carried out visually, that the traicts with the Charcot-Picard dredge were calibrated to obtain an extrapolation according to the number of individuals harvested: each dredging being done at the same constant speed of the ship for the same duration of work on the bottom (the touch of the cable provides perfect information on the arrival on the bottom). In addition, during all dredging, the work of the gear on the bottom is very frequently controlled with one hand on the pulling cable.

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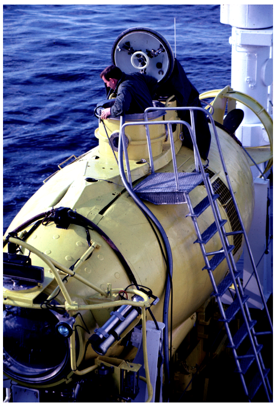
[1] *Fisher term .* Natural submerged obstacle in which the net or gear (trawl, dredge) gets caught.

N/W Alciope (Marseille)

N/O Korotneff (Villefranche s/mer)

N/W Catherine-Laurence (Villefranche s/mer)

BSM Triton (Toulon), SMS Griffon support ship



N/O Antedon (Marseille) ROV Modexa (Marseille) SMS Griffon (Toulon)

Plate 1 : Main oceanographic vessels used during the campaigns in Provence and Corsica.

3. History of exchanges in the deep Mediterranean domain

The edge of the continental shelf constitutes a limit, separating the neritic domain from the deep domain, as important as the coastal line. This rim is defined by geological, physico-chemical and biological characteristics (Emig, 1997a). The deep domain is divided into three stages, whose extension and importance in the Mediterranean Sea differ from those in the World Ocean (Fig. 3-1).

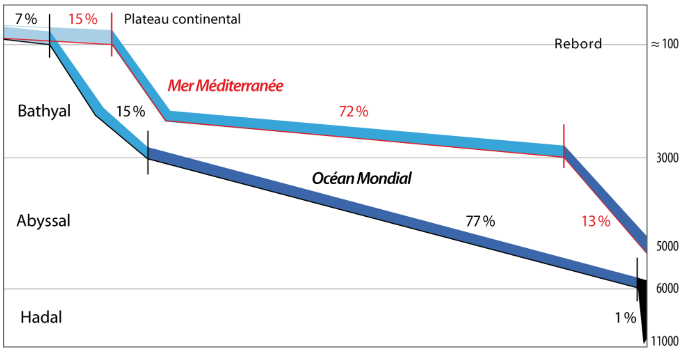


Figure 3-1 : Comparison of the extension, in percentage, of the levels in the World Ocean and in the Mediterranean Sea which represents only 0.82% of the total surface of the World Ocean and 0.35% of its volume. The edge of the continental shelf (whose depth varies according to the ocean or sea considered) marks the border between the neritic (continental shelf) and deep domains: it is located around one hundred, one hundred and ten meters in the Mediterranean Sea. Note that the depth of two hundred meters is an exclusively economic and not scientific limit, and it is only in this context that it should be mentioned.

The deep Mediterranean domain remains poorly known, probably because the deep benthos is characterized by a lack of originality and poverty, the reasons for which are to be found in the recent history of the fauna (Di Geronimo, 1990; Laubier & Emig, 1993; Taviani, 2002; Emig & Geistdoerfer, 2004, 2008). Three main types of exchanges are at the origin of this:

- historical exchanges through changes in fauna since the Pliocene and during climatic fluctuations with successions of glacial and interglacial periods (Fig. 3-2, 3-3);
- bathymetric exchanges within the bathyal and abyssal levels subject to very specific conditions (homothermy, relative oligotrophy, barrier of the Gibraltar sill, circulation of water masses); the deeper the extent of species in the Mediterranean Sea and the wider their distribution outside the Mediterranean (Fig. 3-4);
- geographical exchanges with close affinities between the western and eastern basins of the Mediterranean Sea and between the latter and the nearby Atlantic Ocean. The case of endemic species remains a biogeographical problem. In general, species always have a deeper distribution going east and their size becomes smaller.

These exchanges are all directly subject to the characteristics of the deep Mediterranean domain, mainly to homothermy (around 13°-13.5°C in the western basin and 14°-15°C in the eastern basin), to high salinity (about 38 to 38.5 psu [2]), stratification of water layers and their barotropic circulation, currents in straits (Gibraltar and Siculo-Tunisian) (Fig. 3-3).

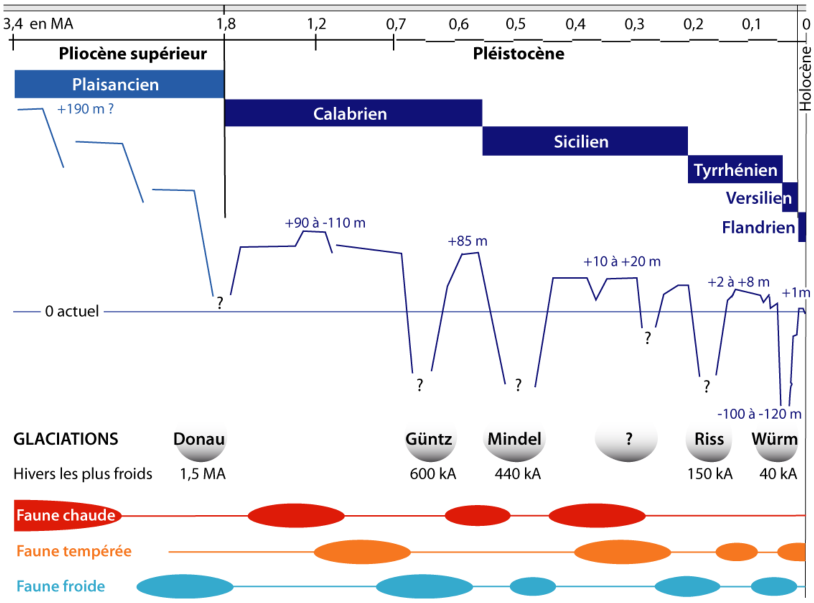


Figure 3-2 : Main phases of faunal succession in the Mediterranean Sea since the Pliocene during the various glacial and interglacial periods (marked by variations in sea level) (modified, after Laubier & Emig, 1993). The actual number of glaciations during the Pleistocene remains to be completed, as it is possible that there were one or two other glaciations between those of Mindel and Riss.

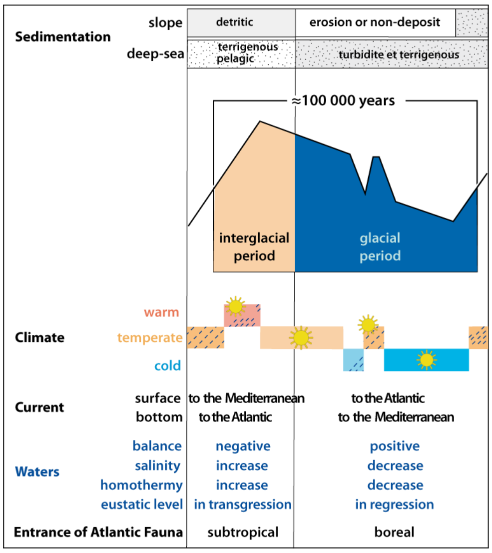


Figure 3-3 : Summary of the main characteristics of a Quaternary glaciation during the glacial and interglacial periods, in the Mediterranean Sea.

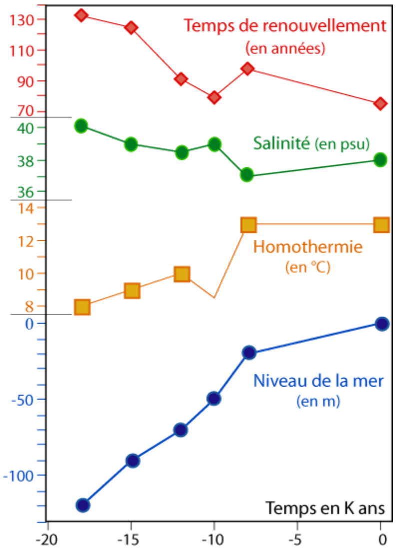


Figure 3-4 : Paleo-oceanographic evolution of the waters of the Western Mediterranean Basin since the last Würm glaciation (from Poutiers, 1987).

The oceanographic history of the Mediterranean Sea has been the subject of numerous publications and sometimes contradictory debates, particularly on the subject of the salinity crisis in the Messinian. The main stages of this story have been summarized by Laubier & Emig (1993), Emig & Geistdoerfer (2004, 2008).

The current deep Mediterranean appears to be a much younger sea than any other part of the deep World Ocean. Its fauna is mainly composed of old (primitive?) groups within the phyla, while a smaller fraction includes the more specialized types of their group. It is at the level of the edge of the continental shelf, acting as a border at around one hundred to one hundred and ten meters in depth, that an important faunal change occurs (Fig. 3-5, and 4-1, 4-2).

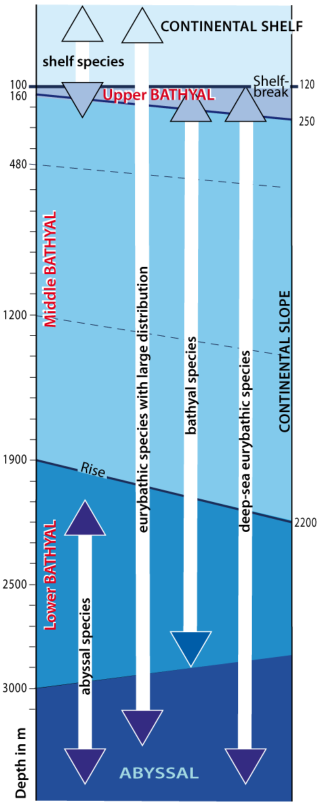


Figure 3-5 : Bathymetric distribution of the various categories of species (modified, according to Carpine, 1970; Reyss, 1970) with the limits of the Bathyal stage (and its sub-stages (in dotted line the sub-limits in the Middle Bathyal) and their variations.

In the vertical distribution of the deep Mediterranean benthos, deep homothermy is the most important factor: there are no temperature variations to limit, at depth, the fauna at various levels as in the Atlantic Ocean. Many species are eurybathic in the Mediterranean Sea only because they are hot eurytherm or stenothermic. Also, distribution limits are governed by other factors, such as salinity, grain size, pressure, available food, hydrodynamics. And, this variety of local conditions leads to a more heterogeneous bathyal level than that of the Atlantic Ocean (Laubier & Emig, 1993; Emig, 1997a; Emig & Geistdoerfer, 2004, 2008) (Fig. 3-5); this is linked to a mainly belt distribution according to isobaths.

This sea is an important center of evolution with future speciations and the creation of new endemic species due to its physical features with strong gradients.

4. Definition of the upper Bathyal stage

The upper limit of the Bathyal stage is located at the level of the edge of the continental shelf: it is defined not only by morpho-geological characteristics, but also physical and biological characteristics of the water masses, the benthos and the pelagos (Fig. 4 -1, 4-2). Despite its paramount importance, this rim being a true boundary due to the strong gradients that occur there, its environment remains little known, as it lies between two distinct areas of interest, the coastal environment and the deep domain (Fig. . 4-2): it is comparable to the limit marine domain – terrestrial domain. It is therefore not surprising that the transition from plateau to slope has remained a biological and physical “no man's land” (Vanney & Stanley, 1983; Vanney & Gennesseaux, 1988; Emig, 1997a).

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[2] According to international conventions (UNESCO, 1985), salinity values have no specific unit, data are expressed in psu (= practical salinity unit).

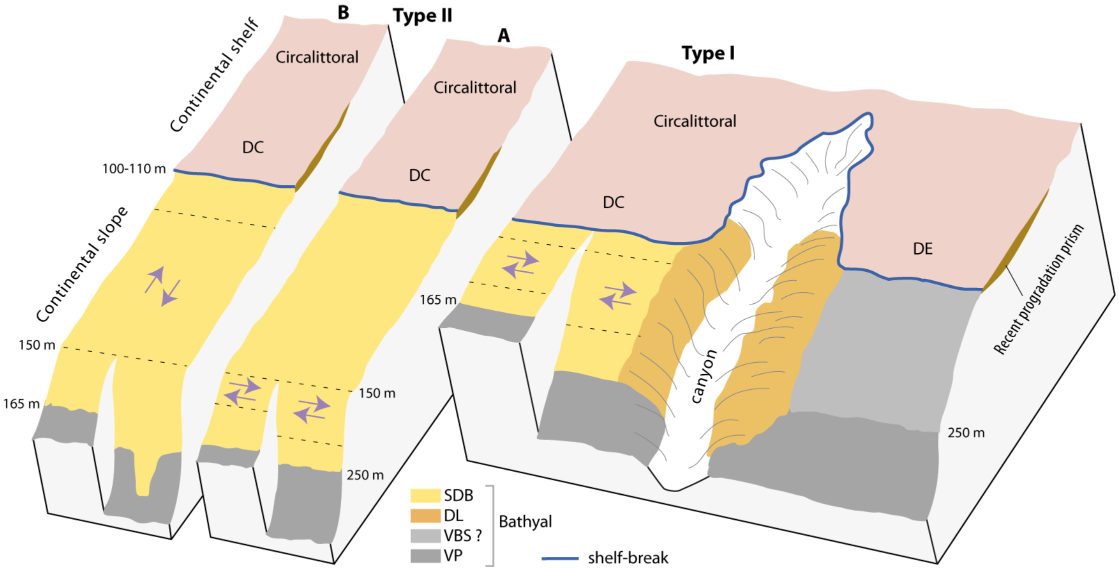


Figure 4-1 : Block diagram of the two main types of profile (I and II) of the upper zone of the Bathyal stage, with the distribution of the biocoenoses, according to the slope and the depth (according to Emig, 1997a). The arrows indicate the direction of the bottom currents in the zones (between dotted lines) of maximum density of brachiopods where the currents are the most intense – see also Fig. 4-3. Bathyal biocoenoses (see also Fig. 4-2): SDB = b. Bathyal Detrital Sands; DL=b. the Large Detrital; VBS = b. of the Upper Bathyal Vase; PV = b. of the Deep Vase. Circilittoral biocoenoses: DC = b. Coastal Detrital; OF = b. Silted Detritus.

A. Morpho-geological characteristics

The morphology of the upper Bathyal zone, generally loose substrates, presents two main types of profiles (Fig. 4-1) on which the slope failure occurs at 100 to 120 m. However, on the Type II profile, the break in the continental shelf was generally considered to be around 150 m depth, which, in fact, corresponds to the edge of a large flat bathyal terrace; because the true continental limit, often missed, is located towards the shore and corresponds to the edge of a short declivity of about 5 to 20 m (Fig. 4-1) (Emig, 1989a, 1989b, 1997a; Savoye & Piper, 1993).

The lower boundary of the upper bathyal zone is marked by the " *mud-line* " following an abrupt change in environmental conditions (Blake & Doyle, 1983) and serves as an energy level marker (Stanley *et al* ., 1983; Emig, 1997a). Generally located between 160 and 300 m depth according to the profile of the slope (Fig. 4-1, 4-2, 4-3), whose morphology governs the influence of the dominant abiotic factors, one can summarize by more the slope is weak, the less the *mud-line* is deep (Emig, 1989a, 1989b). Thus, it is confirmed that the limits of benthic layering cannot be defined by bathymetry alone, but according to a set of factors.

The recent imprint, since the last rise in sea level (Würm glaciation ≈ 17,000 years), clearly appears in the upper Bathyal: the edge of the continental shelf is located at the outer limit of the deposits forming a prograding prism (Fig. 4-1). The shelf edge is in balance with current environmental conditions; its progradation during the late Holocene was negligible and its depth coincides with a level of "deposition equilibrium" (Mougenot *et al* ., 1983; Monaco *et al* ., 1990; Courp & Monaco, 1990; Savoye & Piper, 1993). The relative absence of recent sediments in the Upper Bathyal shows that the sediments are mainly residual sediments (Würmian) reworked with quaternary thanatocoenoses visible by submersibles and generally located between 180 and 200 m deep (Gautier & Picard, 1957; Blanc, 1968; Emig & Arnaud, 1988; Emig & García-Carrascosa, 1991; Emig, 1997a).

B. Physical Characteristics

The upper bathyal zone is a high-energy sector characterized by gradient variations of the dominant abiotic factors, namely hydrodynamics, salinity, temperature, oxygen, sediments (Fig. 4-2). Throughout the northwest basin there is a main current, the Liguro-Provençal-Catalan current, which follows the break-up of the continental shelf and coincides with a permanent shelf/slope density front; this flow is intensified by the prevailing winds and separates the continental water masses on the shelf from those deep on the continental slope (Salat & Font, 1987; Millot, 1987; Wang *et al* ., 1988; Emig, 1989b; Monaco *et al* . , 1990; Font, 1990; Emig & García-Carrascosa, 1991; Huthnance, 1992).

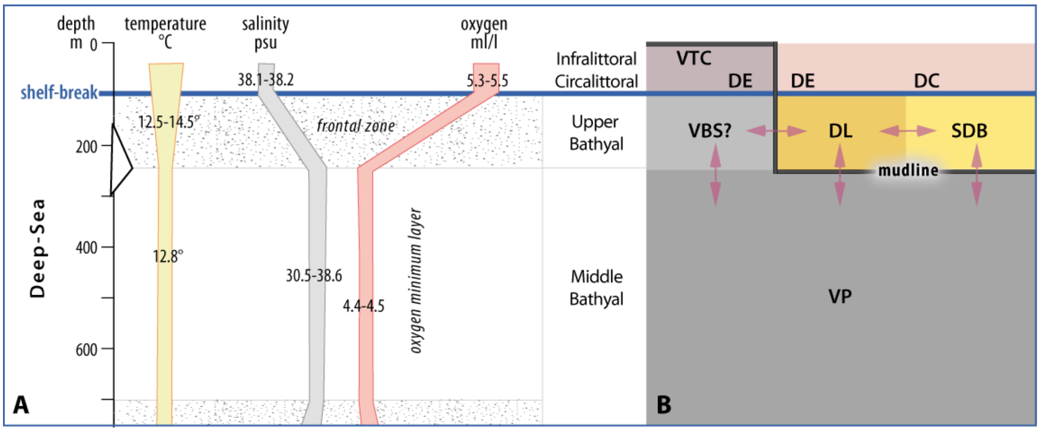


Figure 4-2 : A. Diagram of the different parameters of the water column in the Bathyal stage (from Emig, 1997a). B. Distribution of circalittoral and bathyal biocoenoses along the continental slope with the limits and relationships of the benthic fauna. Biocoenosis: DC - Coastal Detrital, DE - Silted Detrital, DL - Offshore Detrital, SDB - Bathyal Detrital Sands, VBS - Upper Bathyal Mud, VP - Deep Mud, VTC - Coastal Terrigenic Mud .

The current near the bottom, weak or absent on the lower part of the continental shelf, increases in several tens of meters from the edge of the shelf; its bathymetric extent, velocity and direction are directly related to the physiography of the slope (Fig. 4-1). The speed shows a vertical gradient and varies from about 0.5 to 2 knots or more, sometimes causing large ripples or undulations on the bottom (Emig, 1987). Consequently, sedimentation is absent or weak in the Upper Bathyal, which appears to be a resuspension zone with minor particle accumulation and in which the fauna is characterized by high densities of suspension feeders. At the lower limit of this zone, the speed of the bottom current stops over several tens of meters while the substrate becomes muddy (Emig, 1997a): this is the *mudline* (Fig. 4-1 to 4-3) .

The water column above the Upper Bathyal in the northwestern Mediterranean Sea is characterized by several gradients (Fig. 4-2): low annual temperature variation (about 2°C) which becomes constant (deep homothermy) beyond about 200 m depth, increase in salinity and sharp decrease in oxygen, the content of which is however higher than the biological consumption. From the lower limit of the frontal structure, the hydrological properties change strongly (Huang & Su, 1991), in particular by the minimum oxygen layer linked to the Levantine intermediate water mass, a maximum of salinity and homothermy (Fig. 4-2). The C/N ratio in the sediments decreases from 12 to 10 (Carpine, 1970; Emig, 1997a).

C. Biological characteristics

The Circalittoral stage extends to the lower limit of multicellular algae (Pérès & Picard, 1964; Picard, 1971; Bellan-Santini *et al* ., 1994): from submersible observations on the biocoenosis of the Coastal Detrital (DC), the calcareous red algae do not exceed the threshold and, after a short transitional period of to a few tens of meters, the biocoenosis of the Bathyal Detrital Sands (SDB) begins, or on the sides of the submarine canyons, the biocoenosis of the Large Detrital (DL) (Fig. 4-1, 4-3). DL has traditionally been considered a circalittoral biocoenosis, sometimes confused with SDB, but both undoubtedly belong to the Upper Bathyal (Laubier & Emig, 1993). The edge of the continental shelf corresponds to the upper limit of the distribution of at least two exclusive upper bathyal species, the brachiopod *Gryphus vitreus* in the SDB and the crinoid *Leptometra phalangium* (Müller, 1841) in the DL, while the *mudline* marks the limit of their extension in depth.

The substrate of the SDB is a well-sorted fine to coarse sandy sediment, clogged with a fine fraction of up to 60% and containing a large detrital proportion of small hard substrates of endogenous origin (fragments of shells of molluscs and brachiopods, sponges, bryozoans, corals) and gravels, pebbles; this detrital fraction is a characteristic of SDB (Falconetti, 1980; Emig, 1989a, 1989b).

The substrate of the DL is a sandy mud (gravel, sand, mud) (Picard, 1965; Emig, unpublished data).

The benthic fauna of these biocoenoses has been described by Pérès & Picard (1964), Picard (1965), Falconetti (1980), Pérès (1982, 1985) and recently by Grinyó *et al* . (2018).

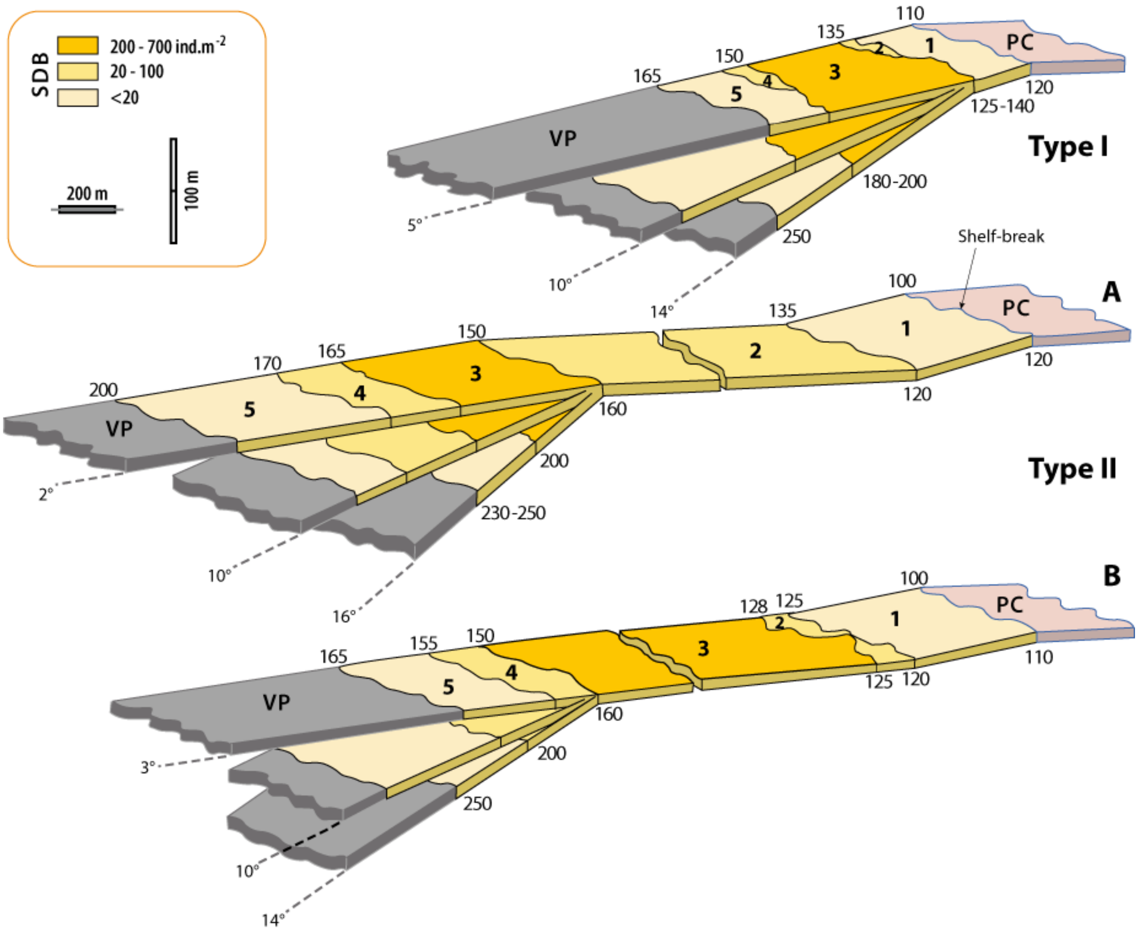


Figure 4-3 : Density zones (1-5) of *Gryphus vitreus* according to the two types of profile (I and II) encountered during cruises at sea. PC: continental shelf (Circalittoral); VP: Deep Vase biocoenosis; SDB: Biocoenosis of Detrital Bathyal Sands (from Emig, 1989b).

The Bathyal stage outcrops in fossil deposits in Italy, notably in Calabria and Sicily; they have been described by various authors, but we will retain here only a few works concerning brachiopods at the same time: Seguenza (1871), Di Geronimo (1979, 1984, 1987), Barrier (1984), Gaetani & Saccà (1984), Saccà (1986, 1992), Taviani (2002), Taddei Ruggiero & Taddei (2006), Ruggiero & Raia (2010).

On muddy substrates (Fig. 4-2B, 4-4, 4-5), the transition between the circalittoral biocoenoses of the Silted Detrital (DE) and the Coastal Terrigenous Mud (CTV) and those of the Bathyal stage, could be done by the biocoenosis of the

Upper Bathyal Vase (VBS) which nevertheless remains hypothetical due to the lack of investigations. However, according to data from Guille (1970), Picard (1971), Salen-Picard (1982), Albertelli *et al* . (1991) and Albertelli & Fraschetti (1992), there is indeed a faunal change at the edge of the plateau with the appearance of dominant species (Fig. 4-4), in particular the ophiurid *Amphiura filiformis* (Müller, 1776), reaching 8-34% of the fauna according to Salen-Picard (1982) and Albertelli *et al* . (1991), and the polychaete *Maldane glebifex* Grube, 1860, while species characteristic of circalittoral biocoenoses DE and VTC are absent in the Upper Bathyal; certain species can reach high densities there in certain regions, such as the echinoderm *Brissopsis lyrifera* Forbes, 1841, the pennatular *Funicula quadrangularis* (Pallas, 1766), the sponge *Thenea muricata* (Bowerbank, 1858).

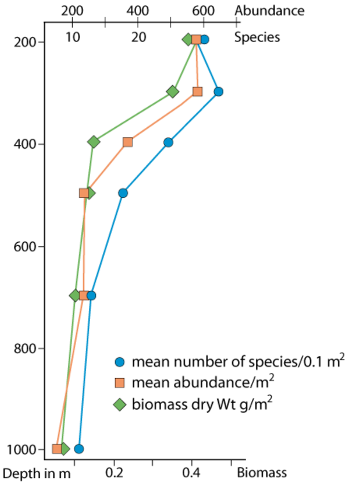
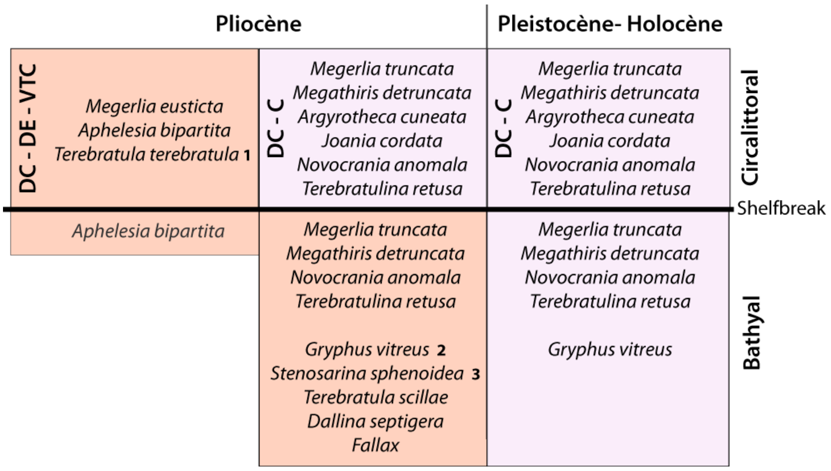


Figure 4-4 : Species richness, abundance and biomass of macrofauna along a radial on the continental slope in Crete (after Tselepides & Eleftheriou, 1992).

Let us remember to close this chapter that the biological characteristics are only one of the aspects making it possible to define a biocoenosis [3] , the other being the biotope [4] whose abiotic factors are also governed by geomorphology (and physiography). It is therefore necessary to take into consideration data from physical, chemical and geological oceanography, including geomorphology, which biological oceanographers have too often neglected, or even ignored. Because it is only with concomitant multidisciplinary results that benthic layering can or must be defined. In addition, when entering the deep domain, it is essential to precisely locate its upper limit, and therefore the "true" edge of the continental shelf. Ignorance of this limit and of the underlying zone with its strong gradient characteristics had led some authors to consider the upper Bathyal as a transition zone (Ercegovic, 1957; see chapter 7). The analysis of the results obtained in this zone requires precise sampling, because the passage to the deep domain from the plateau can be done in just a few tens of meters. For brachiopods (Emig, 1988, 2016, 2017a), as for other suspension feeders, hydrodynamics in the Upper Bathyal is particularly conducive to high-density distribution.

Evolution of the presence of brachiopods in biocoenoses

It was towards the end of the Pliocene that some changes gradually took place within the brachiopods.



Pliocène		Pleistocène- Holocène	
DC - DE - VTC *Megerlia eusticta* *Aphelesia bipartita* *Terebratula terebratula* 1	DC - C *Megerlia truncata* *Megathiris detruncata* *Argyrotheca cuneata* *Joania cordata* *Novocrania anomala* *Terebratulina retusa*	DC - C *Megerlia truncata* *Megathiris detruncata* *Argyrotheca cuneata* *Joania cordata* *Novocrania anomala* *Terebratulina retusa*	Circalittoral
			Shelfbreak
Aphelesia bipartita	*Megerlia truncata* *Megathiris detruncata* *Novocrania anomala* *Terebratulina retusa* *Gryphus vitreus* 2 *Stenosarina sphenoidea* 3 *Terebratula scillae* *Dallina septigera* *Fallax*	*Megerlia truncata* *Megathiris detruncata* *Novocrania anomala* *Terebratulina retusa* *Gryphus vitreus*	Bathyal

Figure 4-5 : Presence of brachiopods in the biocoenoses of the Circalittoral (continental shelf) and Bathyal levels, from the Pliocene to the present day, in the Western Mediterranean Basin. 1.- Synonym: *Terebratula calabra* Seguenza, 1871 ; 2.- Including *G. minor* Philippi, 1836; 3.- *Stenosarina sphenoidea* (Philippi, 1844) (= form *Stenosarina davidsoni* Logan, 1998) - see Emig (2017a). Abbreviations of Mediterranean biocoenoses: DC = Coastal Detrital; DE = Silted Detrital; VTC = Coastal Terrigenous Mud; C = Coralligenous. Fossil species are those cited in paleoecology work, while there is a long list of varieties and species that can be referred to them in systematic work (see Appendix B).

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[3] **Biocoenosis** : set of **populations** linked by mutual dependence and maintaining themselves permanently and reproducing in a **biotope** (see Arnaud & Emig, 1987).
Population : set of individuals of the same species living in the same place.

[4] **Biotope** : living space of a biocoenosis, defined and delimited by the relative constancy of its abiotic factors or the predictability of its fluctuations.

5. The brachiopod species of the French Mediterranean Bathyal

In the Mediterranean Sea, with the creation of university marine stations at the end of the 19th century , the proximity of the continental slope to the coast facilitated deep dredging from the Arago Laboratory [5] (Banyuls), from the Station Marine d'Endoume [6] (Marseille), the Biological Station of Villefranche-sur-mer [7] and the Oceanographic Museum of Monaco [8] (Fig. 5-1, 5-2), as well as dives in submersible on brachiopod bottoms from Toulon [9] . With the exception of the Gulf of Lion, the width of the continental shelf is between a few hundred meters and a few nautical miles, while the limit of territorial waters is 12 miles in the Mediterranean Sea, beyond which are international waters. For more than two centuries, extant and fossil Mediterranean brachiopods have been widely sampled and studied perhaps more than in other equivalent surface areas (Table 2).

It should be noted that a number of marine species present in the Mediterranean Sea also live in the Atlantic Ocean or have vicarious forms there, generally with a shallower bathymetric distribution (Laubier & Emig, 1993; Emig & Geistdoerfer, 2004, 2008).

Table 2 : List of brachiopods from the French Mediterranean coasts (in systematic order, collected in the Bathyal, with the known bathymetric interval for each species and their presence in the English Channel and in the Atlantic Ocean (see Emig, 2016, 2017a; and chapter 9).R- = Rhynchonellata. * Number of references for each of these species in the Mediterranean Sea out of all the references citing the species (according to my bibliographic database); these references were used to establish the distribution maps in the Mediterranean Sea (see Figs. 5-3 to 5-9; and Emig, 2018; Emig *et al* ., 2018).

Mediterranean	Sleeve	Atlantic	Known bathymetry (in m)	known since	Classification	References *

Novocrania anomala	🟨	🟨	a few m - 1478	Oligocene	Craniida	131 / 285
Gryphus vitreus		🟨	78 - 2678	Miocene	R-Terebratulidina	132 / 232
Terebratulina retusa	🟨	🟨	9 - 3614	Miocene	R-Terebratulidina	109 / 335
Megathiris detruncata		🟨	5 - 896	Eocene	R-Terebratellidine	90 / 164
Platidia anomioides		🟨	8 - 2190	Miocene	R-Terebratellidine	60 / 159
Megerlia truncata	🟨	🟨	10 - 1970	Miocene	R-Terebratellidine	120 / 236

The classification, proposed below, is the one up to date in the *Brachiopoda Database* [http://paleopolis.rediris.es/brachiopoda_database/index.html], see also Emig *et al* . (2013). The bathyal species of brachiopods, known in the Mediterranean Sea and cited in Table 2, are today all well described by their characters (see Logan, 1979; Boullier *et al* ., 1986; Álvarez & Emig, 2005, Emig, 2010, 2013, 2014, 2016). Nevertheless, the only exclusively bathyal species, at least in the Mediterranean Sea, is *Gryphus vitreus* , while the others also live in biocoenoses of the continental shelf, but with maximum densities in the Bathyal stage. All are known in fossil form (Table 2). Many authors, in particular paleontologists, mainly Italian, French and German, have sometimes described them under various varieties or species, mainly on differences of and in the shell, which are not all taxonomic characters, but are only variations, this way of doing systematics still in use today deserves an explanation (see Appendix A).

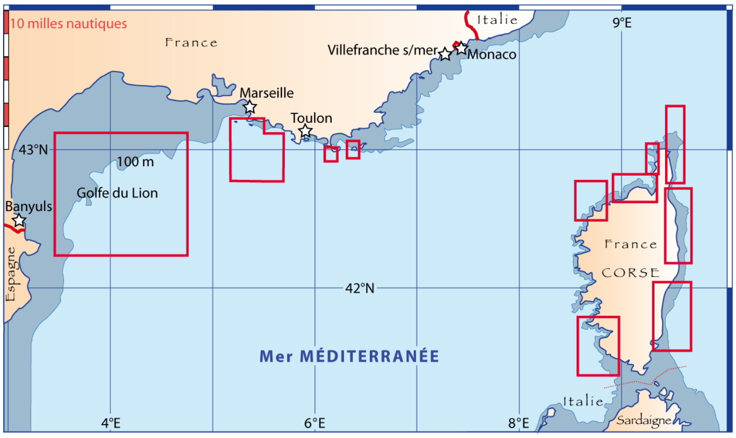

Figure 5-1 : General map of the areas of the cruises at sea to study the distribution of brachiopods along the French coasts (for more details see Material and Appendices). The stars locate the marine laboratories, including three from the CNRS-University, and the Toulon Arsenal for submersible dives (see text and notes).

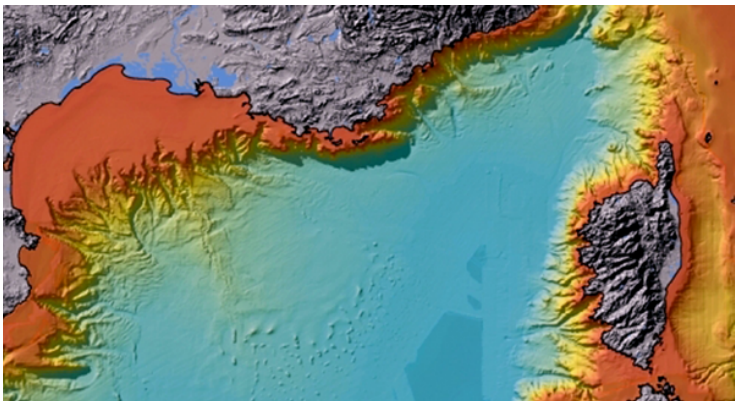

Figure 5-2 : Map from the Commission de la Carte Geologique du Monde (Paris), showing the underwater relief (reproduced with the authorization of the CCGM - http://www.ccgm.org).

In addition, the systematics and biocoenotic distribution of fossil and current brachiopods in the Mediterranean Sea must be studied taking into account the particular and complex geological history of this sea, mainly since the beginning of the Neogene. However, it is often misunderstood, as are the concepts of Mediterranean benthic bionomics. It is because of not having taken it into consideration that certain recent authors, such as Cohen *et al* . (2014) or Robinson (2014, 2017), came to conclusions that are inconsistent with the ecology of Mediterranean brachiopods and their Atlantic vicariant species. Shell characters alone are insufficient to describe a new species when their variations have not been studied and formally identified, just like failure to take into account the biocoenotic distribution of a population [3] , [4] , which is fundamental in Mediterranean benthic bionomy for both current and fossil species.

In addition, the bibliography of these species, which is nevertheless very important (Table 2), mainly includes authors from around the Mediterranean; as for English-speaking authors, they often "forget" to read and quote the works of these authors who, of course, do not write in English. This situation has lasted since the 18th century, as mentioned by Emig (2012) on the descriptions of brachiopods by the Nissart Giuseppe Antonio Risso (1777-1845).

The Brachiopods are not the subject of a redescription here, because during the samplings, their identification is easy to do. Nevertheless, *Gryphus vitreus* has been intensively studied for variations in certain characters, variations that are sometimes considered by paleontologists themselves to be valid characters. The results were then used to reconsider the status of other fossil species, notably from the Mesozoic, as well as stratigraphic systematics. Despite special attention to other small species, such as *Argyrotheca* and *Lacazella* , no individuals were collected during the campaigns listed in Table 1 (see also chapter 8).

Finally, with the exception of *Gryphus vitreus* which lives on a soft substrate, all the other species of brachiopods are fixed on a hard substrate, generally rocky or biological.

Phylum Brachiopoda
Subphylum Craniiformea
Class Craniata
Order Craniida
Superfamily Cranioidea
Family Craniidae
Novocrania Lee and Brunton, 2001

Synonyms: *Criopus* Poli, 1791; *Criopoderma* Poli, 1795; *Orbicula* Cuvier, 1798; *Orbicularius Dumeril* , 1805; *Cryopus* Deshayes, 1836; *Criopododerma* Agassiz, 1846; *Neocrania* Lee and Brunton, 1986; see also Álvarez *et al* . (2005, p. 216), Emig (2018), Emig *et al* . (2018).

Novocrania anomala (Müller, 1776) [*Patella anomala* Müller, 1776]

Synonyms: *Anomia turbinata* Poli, 1795; *Orbicula anomala* : Cuvier (1798); *Orbicula norwegica* Lamarck, 1801; *Criopus anomalus* : Fleming (1822); *Anomia norwegica* : Wood (1828); *Crania anomala* : Lovén (1846); *Neocrania anomala* : Lee and Brunton (1986).

Type-locality: Hår-Krøllen (Denmark).

Cast: Fig. 4-5, 5-3, Plate 2; see chapters 8 and 9.

Novocrania turbinata (Poli, 1795), described in the Bathyal stage of the waters of the Kingdom of the Two Sicilies (Italy), is synonymous with *N. anomala* , as recently demonstrated by Emig (2014). In fact, this species has always been considered by authors as the Mediterranean or vicariant variety of *N. anomala* , with the exception of rare paleontologists, including Brunton (1989), Logan & Long (2001) or Robinson (2017). This is how this last author suggests that the ‟ *turbinata* variety ” be raised to the rank of species, but without providing phylogenetic proof of this through a cladistic analysis of new characters, or responding to my previous remarks (Emig, 2014). However, a difference in the taxonomic characters between *anomala* and *turbinata* , both current and fossil, has never been established, except for possible variations of a character. Logan & Long (2001) mention that the differences between the two supposed species are: ‟ mainly in the degree of calcification of the valves and the relative development and placement of the dorsal valve muscle scars. » ; however, these characteristics can be interpreted as simple variations, in any case they are not sufficient, except to prove that they are phylogenetic characters (hence the expectation of a cladistic analysis). And to be complete, these authors then mention: ‟ Neither the shell morphology nor geographical distribution of the two forms appears to be the result of ecological factors, such as depth or hydrodynamic action . ‟, but they still have to prove it, because today it is only a supposition. Like these authors, Robinson (2017) remained confined to descriptions of the single shell without taking into account either the anatomy, the history or the distribution of *N. anomala* for the said variety *turbinata* (Fig. 5-3) : how can this author explain that, in the vicinity of Marseilles, he identifies one or two specimens of *N. anomala* and *N. turbinata* attributing the specimens of Logan (1979) to the first species and to my specimens to the second according to my only published photographs (Emig, 2014), whereas it is probably, in this precise case, specimens of my own collections. Furthermore, Robinson (2017) forgot to consider the fossil forms of *N. anomala* , known from the Oligocene in the Mediterranean domain (Bitner *et al* ., 2013), except to mention that in the absence of material identifications remain problematic! In contrast, Cohen *et al* . (2014) reject ‟ traditional morphology ” while using it to identify the material on which they performed molecular analyzes (Emig, 2014).

Having two species of the same genus in the same niche is only possible, although exceptional, if there are significant differences, particularly in ethology and reproduction (maturation of gonads, larval type, etc.). Remember that ecological characters can also be taxonomic characters, especially when working on living species (see Appendix A). These remarks can also be repeated for the synonyms of *Megerlia truncata* and *Platidia anomioides* .

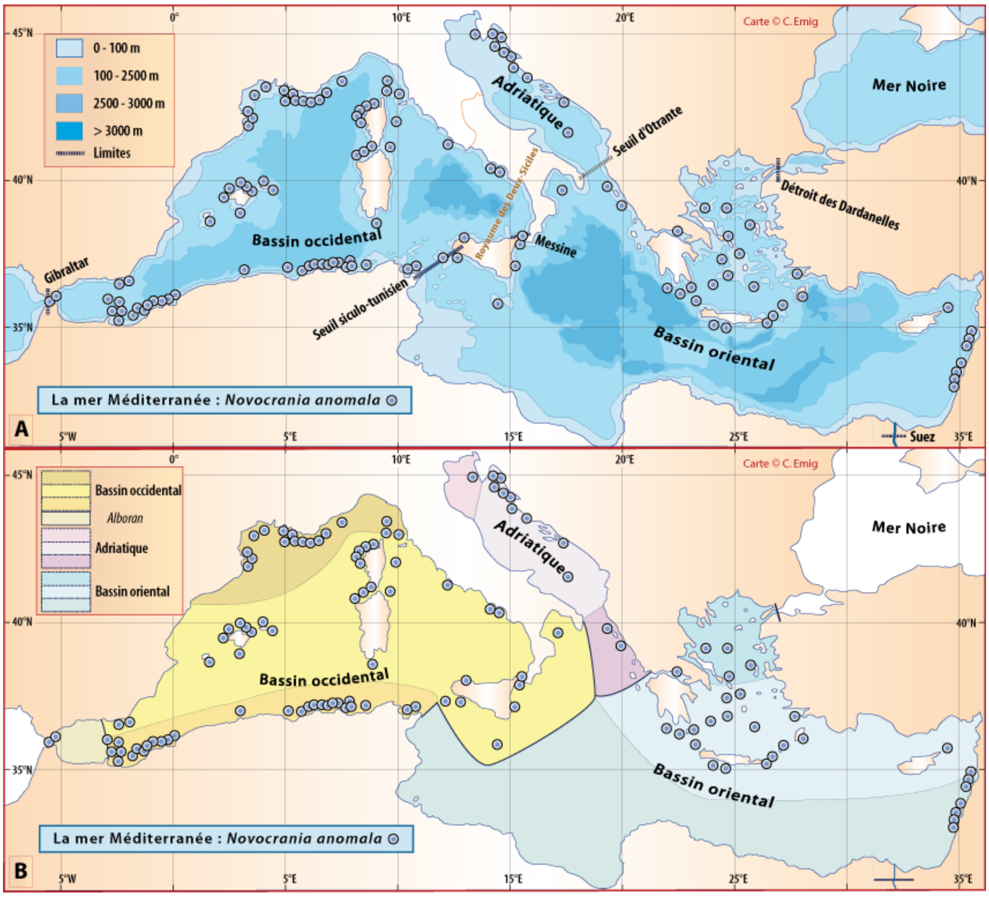

Figure 5-3 : Distribution of *Novocrania anomala* in the Mediterranean Sea (Emig, 2014). **A.** According to geography and bathymetry, with the main limits in the exchanges of water masses, which have evolved since the Miocene. **B.** _ According to the faunal zones in the different basins (modified, after Carpine, 1970). The circulation of water masses and variations in sea level during glaciations are key factors in the evolution of Mediterranean fauna (Emig & Geistdoerfer, 2004).

Appealing to genetics does not solve the problem, because the identification of specimens is based only on the morphology of the shell and nothing on the anatomy, whereas precisely genetics only uses the soft parts. . Also, we will consider that there is to date only one species of *Novocrania* in the Mediterranean Sea, whether it is named *N. anomala* or *N. turbinata* , but, in the latter case, it will be necessary to establish a diagnosis [10] on phylogenetic characters with their variations beyond those of the shell alone, which is not always technically within the reach of paleontologists. However, the latter "neglect" the anatomical characters, which leads to the impossibility of making a cladistic analysis. It remains to undertake an in-depth study of the variations in the taxonomic characters (including anatomy and ecology) of *N. anomala* within the different Mediterranean populations and to compare them with those of specimens from Sicily (Fig. 5-3), which may be considered to relate to *N. turbinata* ; moreover, several tens of specimens of various sources are necessary for the study of the characters.

According to our collections (including numerous observations during scuba diving), *N. anomala* lives on hard (rocky) substrate from a few meters down to around 280 m (Emig, 1997b); beyond that, it becomes impossible to sample along drop-offs and other deep rock structures, and therefore to know if its distribution is deeper. It is present in different biocoenoses of the infralittoral, circalittoral and bathyal stages (Fig. 4-5): remember that ecology must be taken into account in taxonomy. *N. anomala* is sometimes abundant, especially with *Terebratulina retusa* , and also the presence of *Gryphus vitreus* and *Megerlia truncata,* in the bathyal biocoenosis of deep white corals (also called " community of Cold-Water Corals ") (Pérès, 1982, 1985; Taviani *et al* ., 2017).

Subphylum Rhynchonelliformea
Class Rhynchonellata
Order Terebratulida
Suborder Terebratulidina
Superfamily Terebratuloidea
Family Terebratulidae
Subfamily Gryphinae
Gryphus Megerle von Mühlfeldt, 1811

Synonyms: no *Gryphus* Brisson, 1760; *Liothyris* DouvilIé, 1880 (not Conrad, 1875); *Liothyrina* Œhlert, 1887; see also Álvarez *et al* . (2005, p. 219), Emig (2018), Emig *et al* . (2018).

Gryphus vitreus (Born, 1778) [*Anomia vitrea* Born, 1778]

Synonyms: *Terebratula vitrea* : Lamarck (1801); *Terebratula minor* Philippi, 1836: Gaetani & Saccà (1984); Appendix B. – Pliocene fossil form *Terebratula affinis* Carus (1893); *Eurysina minor* : Cooper (1983).

Type-locality: Port-Mahon, Menorca (Balearic Islands, Spain).

Cast: Fig. 4-3, 4-5, 5-4, plate 2; see chapters 8 and 9.

Gryphus vitreus is known from the Miocene in the Mediterranean Sea, especially in bathyal fossil deposits in Italy; sometimes small specimens have also been named *Gryphus minor* which has been the subject of much debate among paleontologists as to its status (see Appendix B).

The distribution of this species has been the subject of intensive research both along the coasts of Languedoc and Provence and of Corsica. In addition to the data from the BraProv, BraCorse and Bathymed cruises, recent data provided by J. Martin (Ifremer, Nantes) and by A. Jadaud (Ifremer, Sète) were obtained during the "Meditis" 2012-2014 cruises (Tables 1, 10). The results have been the subject of numerous publications both on its geographical and bathymetric distribution (see Emig, 1985a, 1988, 1989a, 1989b, 1989c, 1997a, 2017a), with also about ten radials monitored by dredging over several years and whose three were traversed by submersible over their entire length (Emig, 1987; Emig & Arnaud, 1988; Emig & García-Carrascosa, 1991).

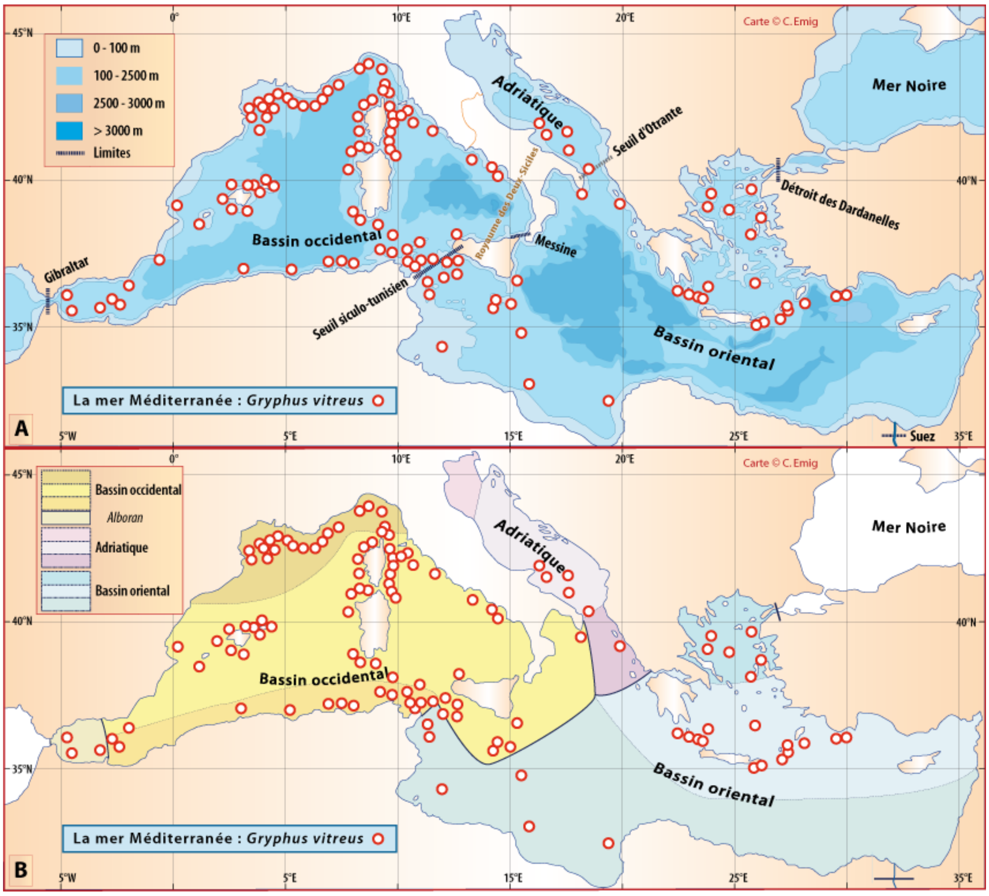

Figure 5-4 : Distribution of *Gryphus vitreus* in the Mediterranean Sea. **A.** and **B.** _ see Fig 5-3 for basemap legend.

Gryphus vitreus is today the largest living brachiopod species in the Mediterranean Sea. The variations of the shell and its internal taxonomic characters, within the thousands of specimens collected, surprised the paleontologists of the RCP 727, in particular Bernard Laurin and Jean-Henri Delance (University of Dijon, France): it is in juxtaposing individuals of similar size, whose shell varies from a round shape to a pentagonal, that these researchers arrived at a line formed by a hundred specimens. In the absence of such a comparison, paleontologists could have created at least three species of *Gryphus* on simple variations of characters, some of which are in no way taxonomic, let alone phylogenetic.

In addition to these variations in shell shape, there is a whole range of variations in other characters, notably the brachidium, within populations of *G. vitreus* : these are illustrated in Fig. 5-5 (Boullier *et al* ., 1986; Álvarez & Brunton, 2008). These results should be compared with the variability established in the synonym *G. minor* by Saccà (1985) who at no time mentions a comparison with *G. vitreus* . It therefore appears clearly that describing a new species or even a new genus with only a few individuals available can quickly lead to taking a variation for a discriminating criterion compared to another species, or even a genus. The literature on current and fossil species of brachiopods abounds with examples; for example: - in Antarctica, these species represent around 30% (Emig, 2017b); - in the Mesozoic in France, 16 species of " *Lingula* " have been described whereas only one or even two valid species can be estimated in this stock; - the case of the genus *Tichosina* with nineteen species described by Cooper (1977), most collected during the same cruise at sea in the Caribbean Sea (Rojas *et al* ., 2015).

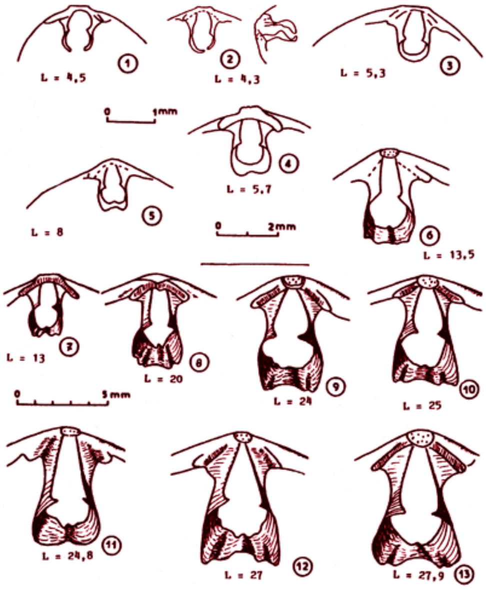

Fig. 6 - Aspects de la boucle brachiale au cours de la croissance chez *Gryphus vitreus* de Corse. 1 : sommet de la valve brachiale avec boucle incomplète. 2 : autre exemplaire en vues ventrale et latérale. 3-5 : boucles complètes, immatures. 6-7 : boucles matures dans les formes juvéniles. 8-13 : variabilité dans la position et l'acuité des crura, dans l'épaisseur et les extrémités antérieures de la bande transverse (L : longueur de la coquille, en mm).

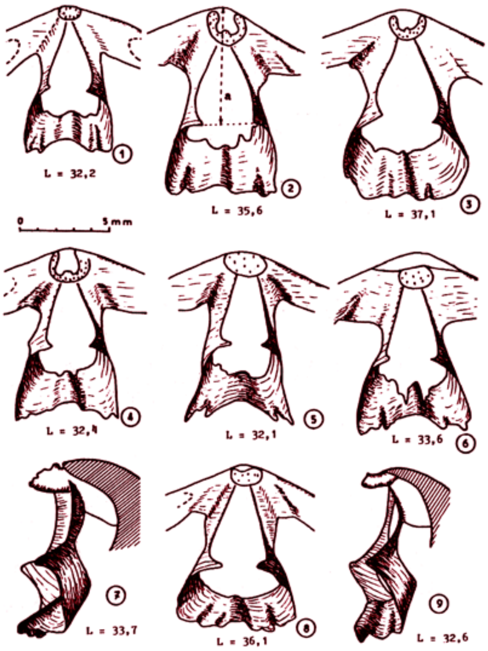

Fig.7 - Divers aspects de la boucle brachiale de *Gryphus vitreus* (en vue ventrale); exemplaires adultes provenant du Banc de Magaud (Iles d'Hyères) et de Corse (8-9). Processus cardinal développé en gouttière (2-4) ; bande transverse à extrémités arrondies (3,8), pointues (4) ou déchiquetées (5-6); vue latérale montrant l'importance du processus cardinal, la forme triangulaire des crura, la largeur et l'ondulation de la bandelette transverse (7-9) (L : longueur de la coquille en mm).

Figure 5-5 : Shape and variations of the brachidium of *Gryphus vitreus* (in facsimile of Boullier *et al* ., 1986).

G. vitreus is the only one to live on a loose substrate formed by detrital sand, quite well classified, containing a high proportion of small hard substrates (especially shellfish) on which *Gryphus* attaches itself by its peduncle. It is one of the characteristic species in the biocoenosis of the Bathyal Detrital Sands (SDB) (Fig. 4-1, 4-2, 4-3; Pl. 2) in the upper bathyal stage. The biotope is characterized by a constant hydrodynamics of average intensity decreasing in depth, by weak annual variations of temperature and salinity (Fig. 4-2). This biocoenosis extends in the form of a horizontal belt in the upper part of the continental slope; this extension depends on two main factors: the morphology of the slope and the direction of the currents on this slope (Fig. 4-1, 4-3). The consequences on the distribution of *G. vitreus* can be summarized in two points:

- the lower the slope, the lower the currents and the lower the bathymetric extension at depth.
- the steeper the slope, the stronger the currents, and the greater the extension in depth (up to 300 m off Cap Corse).

G. vitreus is also present, but not abundant, with other species of brachiopods, in the bathyal biocoenosis of deep white corals (also called " community of Cold-Water Coral ") (Pérès, 1982, 1985; Taviani *et al* ., 2017).

The infestation of *Gryphus* shells by the chlorophyceae *Ostreobium* algae has led to a review and redefinition of the lower limit of the phytal system in the Mediterranean Sea (see Chapter 6.)

In the years 1985, Cap Corse and Balagne (N and NW of Corsica) were devastated by forest fires, which in the following years led to heavy sedimentary discharges causing partial siltation of the Upper Bathyal. The affected area had been prospected before and after these events (Emig, 1985a, 1989b, 1989c, 1990): the effects analyzed made it possible to model possible fossilization by siltation to better understand future paleontological interpretations of brachiopod deposits.

Work on the predation of *G. vitreus* concerned the actions of naticid gastropods, which made it possible to question certain concepts for fossil deposits (Delance & Emig, 2004). Other experiments showed that *G. vitreus* could be a prey for lobsters (Emig, 1990). Indeed, the bathyal lobster, known as offshore lobster, *Palinurus mauritanicus* Gruvel, 1911 [11] , lives in the same biocoenosis, which is a trap fishing area in Provence and by entangling nets in Corsica. They fragment with their crushing mandibles the two anterior thirds of the shell which they hold with their maxillipeds, before eating the contents of the shell. This process could partly explain the presence of such fragments in the sediments.

One last point not to be overlooked: depending on the morphology, the Bathyal is also a trawling fishing area [12] , which disturbs both the distribution and the density of this species, this must be taken into account in the results (Emig & Garcia-Carrascosa, 1991). In our study area, this is the case in the Gulf of Lion and very rarely on the coasts of Provence; it is obviously the morphology of the slope which conditions the possibility of trawling. In addition, the rejection of trawl refusals can occur beyond the harvesting areas, which can lead to reports of brachiopods outside their natural habitat, therefore at unusual depths, which the authors of such reports never take into account. account.

Subphylum Rhynchonelliformea
Class Rhynchonellata
Order Terebratulida
Suborder Terebratulidina
Superfamily Cancellothyridoidea
Family Cancellothyrididae
Subfamily Cancellothyridinae
Terebratulina d'Orbigny, 1847

Terebratulina retusa (Linnaeus, 1758) [*Anomia retusa* Linnaeus, 1758]

Synonyms: *Anomia caputserpentis* Linnaeus, 1758 (see Linnaeus, 1767 and Emig *et al* ., 2015); *Terebratula caputserpe* ntis: Retzius (1781); *Criopoderma caput serpentis* : Poli (1795); *Terebratulina caput-serpentis* : d'Orbigny (1847); *Terebratula emarginata*

Risso, 1826: Dall (1920); *T. quadrata* Risso, 1826; *T. caput-serpentis* Philippi, 1830; *T. chemnitzii* Küster, 1830; T. _ *caputserpentis* var. *mediterranea* Jeffreys, 1878; see also Álvarez *et al* . (2005, p. 220), Emig (2012, 2017a, 2018), Emig *et al* . (2018).

Type-locality: Linné (1767) mentions p. 1151: “ *Habitat in pelago Norvegico* ” and p. 1153 for *caput-serpentis* : “ *Habitat en abysso M. Norvegici* ”

Cast: Fig. 4-5, 5-6; see chapters 8 and 9.

Terebratulina retusa lives attached to rocky substrates often concreted, or shells, dead corals…; it is frequently accompanied by the other brachiopods mentioned here, and in particular by *Megathiris detruncata* : in 43 out of 46 stations, for a total of 1129 individuals of *T. retusa* and 639 of *M. detruncata* (see chapter 8). It is also present, often very abundant, with other species of brachiopods, in the bathyal biocoenosis of deep white corals (also called “ community of Cold-Water Corals ”). On dead branches of *Madrepora* and *Lophelia* , Taviani *et al* . (2017) mention a density that can exceed 450 individuals per 0.2 m^2 , with *Novocrania anomala* , and a few specimens of *Gryphus vitreus* and *Megerlia truncata* , around 400 m deep.

Its two-layered shell, besides the periostracum, disintegrates in a few months in the natural environment (Collins, 1986; Emig, 1990), which explains a relative scarcity in the fossil record for *T. retusa* .

Between the Atlantic and Mediterranean populations of *T. retusa* , molecular and morphometric analyzes show low genetic variations and divergence (Cohen *et al* ., 1993), confirming that these populations indeed belong to the same species. But when these authors deduce that the Mediterranean populations they studied (from the coasts of Provence) would date from around 10,000 years ago, but without alluding to the presence of this species in the Mediterranean since the Miocene, or even earlier.

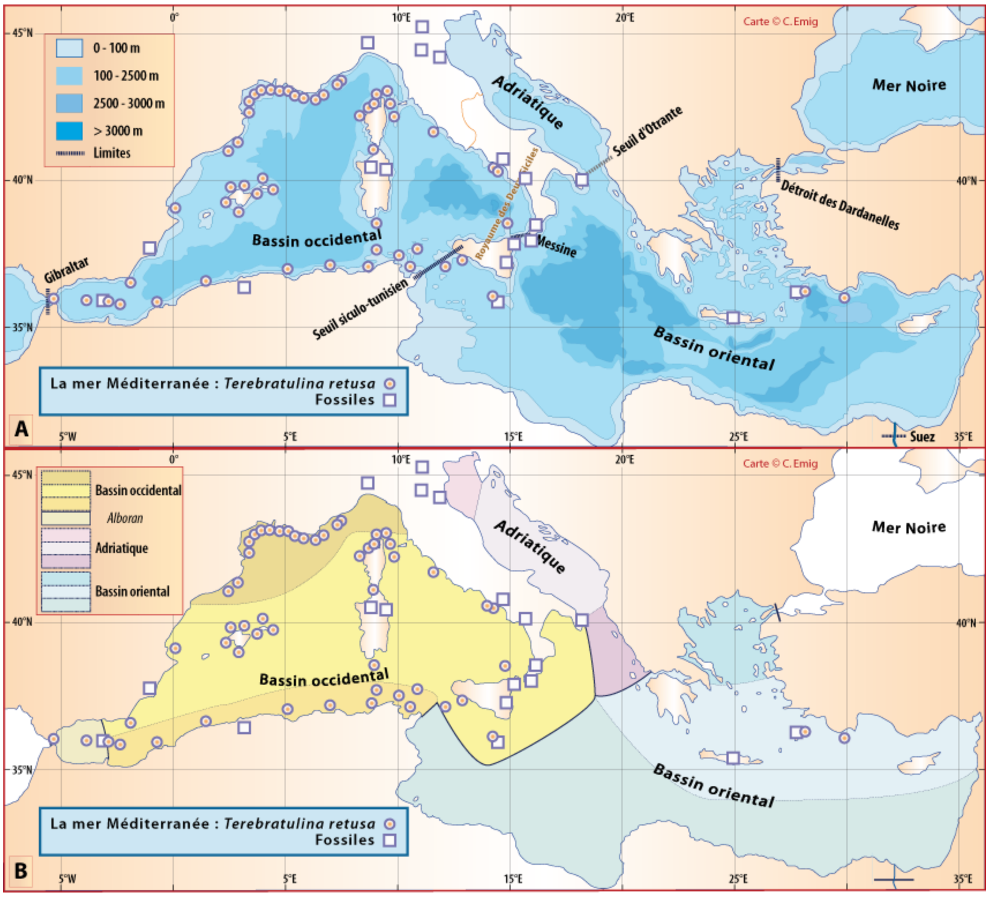

Figure 5-6 : Distribution of *Terebratulina retusa* in the Mediterranean Sea, as well as reports of fossil forms. **A.** and **B.** _ see Fig 5-3 for basemap legend.

Subphylum Rhynchonelliformea
Class Rhynchonellata
Order Terebratulida
Suborder Terebratellidina
Superfamily Megathyridoidea
Family Megathyrididae
Megathiris d'Orbigny, 1847

Synonyms: *Argiope* Eudes-Deslongchamps, 1842; *Megathyris* Bronn, 1848; *Argyope* Davidson, 1850; see also Emig (2018), Emig *et al* . (2018).

Megathiris detruncata (Gmelin, 1791) [*Anomia detruncata* Gmelin, 1791]

Synonyms: *Anomia decollata* Chemnitz, 1785; *Terebratula aperta* Blainville, 1828; *Terebratula dimidiata* Scacchi, 1833

Type-locality: “ *Habitat in* mari mediterraneo, *coralliis adhaerens* ” according to Gmelin (1791). Known from the Eocene.

Cast: Fig. 4-5, 5-7, pl. 2; see chapters 8 and 9.

Megathiris detruncata is a small, often cryptic species, living in formations on rocky substrates, mainly in the Circalittoral and Bathyal or in underwater caves. It attaches itself to dead corals (Pl. 2). It is usually accompanied by one or more other brachiopod species, notably *Terebratulina retusa* .

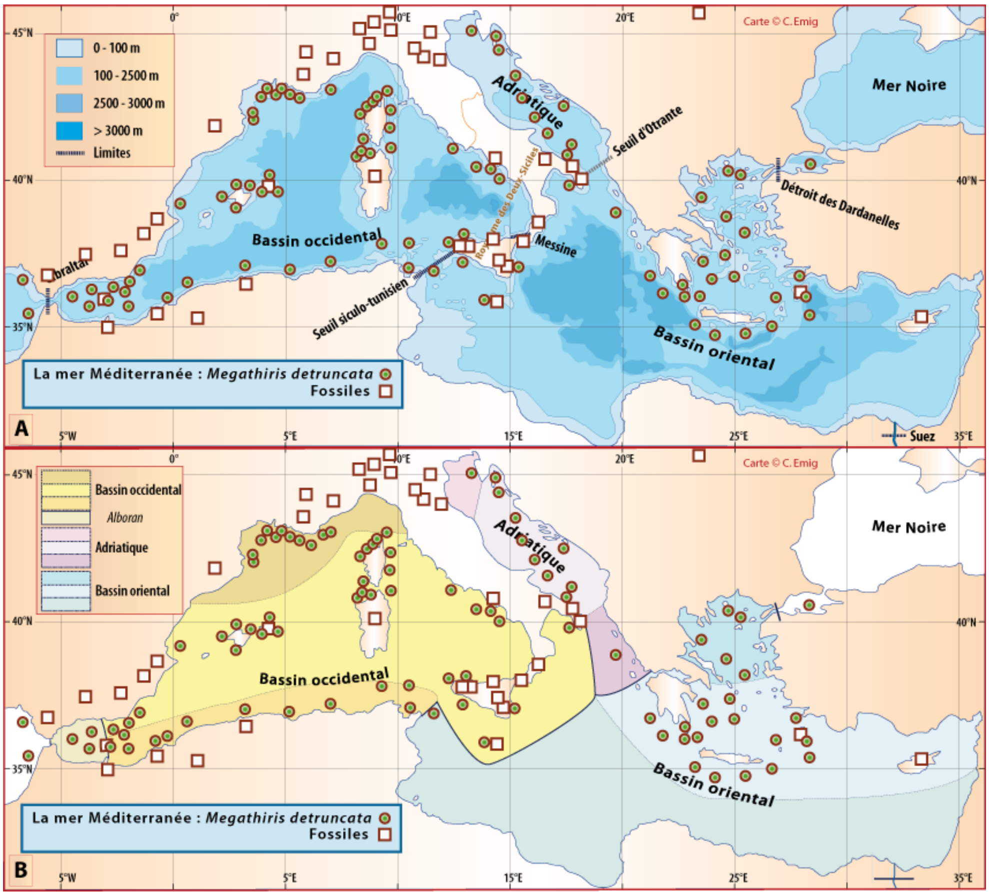

Figure 5-7 : Distribution of *Megathiris detruncata* in the Mediterranean Sea, as well as reports of fossil forms. **A.** and **B.** _ see Fig 5-3 for basemap legend.

Subphylum Rhynchonelliformea
Class Rhynchonellata
Order Terebratulida
Suborder Terebratellidina
Superfamily Platidioidea
Family Platidiidae
Subfamily Platidiinae
Platidia Costa, 1852

Synonyms: *Morrisia* Davidson, 1852; *Platydia* : Seguenza (1870); see also Álvarez *et al* . (2005, p. 222), Emig (2018), Emig *et al* . (2018).

Platidia anomioides (Scacchi and Philippi, 1844, *in* Philippi, 1844) [*Orthis anomioides* Scacchi and Philippi, 1844, *in* Philippi, 1844]

Synonyms: *Terebratula appressed* Forbes, 1843; *Morrisia anomioides* : Davidson (1852, 1869); *Morrisia davidsoni* Eudes-Deslongchamps, 1855; *Platidia davidsoni* Dall, 1870; *Platydia anomioides* : Jeffreys (1878); *Platydia davidsoni* : Davidson (1887).

Type-locality: Sicilian marine waters. Known since the Miocene. The type locality of *P. davidsoni* is off Tunis (Tunisia), a species described by Eudes-Deslongchamps (1855, p. 443).

Cast: Fig. 5-8; see chapters 8 and 9.

Platidia anomioides was collected only exceptionally in 13 stations. *P. davidsoni* is considered as a synonym of *P. anomioides* : the two species cohabited in particular in the Mediterranean Sea and their external appearance is identical. Some authors have only used the slightly larger shell width for *P. davidsoni* and the presence of numerous small pustules on the ventral valve from characters suggested by Cooper (1973), Brunton & Curry (1979), for distinguish these species. However, Logan (1979), rejecting Cooper's arguments, finds only one criterion that can distinguish the two species, namely that the brachial support at a more advanced stage of development in *P. anomioides* than in *P. davidsoni* ; this has already been pointed out by Davidson (1886) when mentioning the similarity of the two species. Also, in the absence of a study on the variations of this support and its undeniable phylogenetic character, proving that a stage of development of the brachidium can be a constant taxonomic character, *P. davidsoni* is treated as a synonym of *P. anomioides* . Logan (1979) specifies: " As *P. davidsoni* represents merely a less advanced state of development of the brachial support than in adult *P. anomioides,* no new genus has been created for its reception at the present time . Finally, many localizations are subject to caution, because the authors assigned their specimens to one or the other of the species according to subjective observations. This *Platidia* case is similar to that of *Novocrania anomala* (see Emig, 2014; and Appendices A and C).

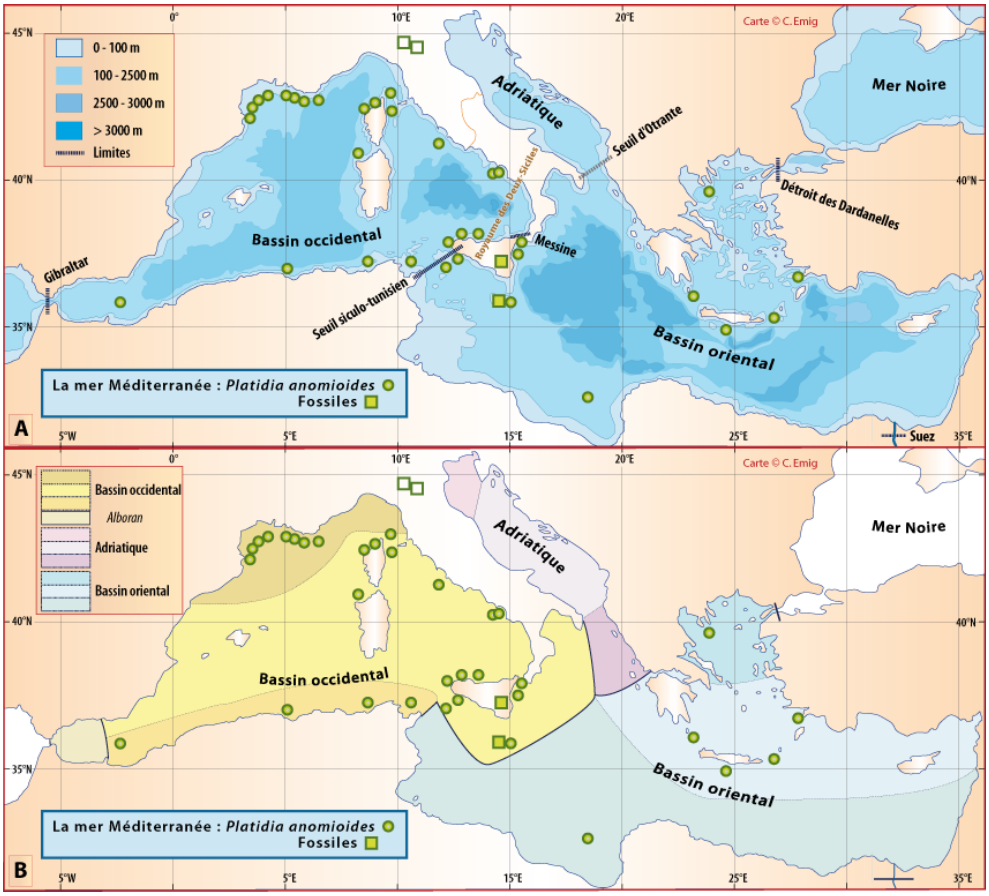

Figure 5-8 : Distribution of *Platidia anomioides* in the Mediterranean Sea, as well as reports of fossil forms. **A.** and **B.** _ see Fig 5-3 for basemap legend.

In addition, the history of *Terebratula seminulum* Philippi, 1836 is developed in Appendix C. Because, according to some authors, it would be synonymous with *Platidia anomioides* or/and *Joania cordata* , while recent works classify it in the genus *Amphithyris* , unknown in the Mediterranean Sea and with a distribution restricted to the south of the Southern Hemisphere. The type locality of *T. seminulum* is Trapani in Sicily (Italy).

Subphylum Rhynchonelliformea
Class Rhynchonellata
Order Terebratulida
Suborder Terebratellidina
Superfamily Kraussinoidea
Family Kraussinidae
Subfamily Megerliinae
Megerlia King, 1850

Synonyms: *Mühlfeldtia* Bayle, 1880; *Megerlia* Filhol, 1885; *Megerlia* Brazier, 1889; *Pantellaria* Dall, 1919; see also Emig (2018), Emig *et al* . (2018).

Megerlia truncata (Linnaeus, 1767) [*Anomia truncata* Linnaeus, 1767]

Synonyms: *Terebratula truncata* : Retzius (1781); *Criopoderma truncatum* : Poli (1795); *Mühlfeldtia truncata* : Fischer and Œhlert (1891); *Mühlfeldtia disculus* : Dall (1920) (not Pallas 1766).
Terebratula monstrosa Scacchi, 1833; *Megerlia truncata* var. *monstrous* : Montecristo (1875); *Mühlfeldtia monstruosa* Fischer and Œhlert, 1891; *Pantellaria monstrosa* : Dall (1920).
Morrisia gigantea Deshayes, 1863.
Megerlia echinata (Fischer and Œhlert, 1890).

Type-locality: " *Habitat in Pelago* Norvegico *supra coralline* ". Known since the Miocene.

Cast: Fig. 5-9, Pl. 2; and see chapters 8 and 9.

Megerlia truncata is mainly attached to relatively flat and vertical substrates, notably on the dead branches of the scleractinia *Dendrophyllia cornifera* on which it can reach densities of 10-20 individuals per branch (Pl. 2). These are both thanatocoenoses and still living species feeding these particular funds. *M. truncata* is also present on flat bedrock along with *Novocrania anomala* . These two species coexist in 41 out of 47 stations: 30 stations in Corsica with a presence ratio of 69% (765 individuals) for *Megerlia* and only 31% for *Novocrania* (243 individuals); 11 resorts in Provence with respectively 73% (267 ind.) and 27% (37 ind.).

In the Bathyal stage, *M. truncata* lives in the biocoenosis of Bathyal Detrital Sands, in the biocoenosis of Deep White Corals, in particular on *Lophelia and Madrepora* corals ; this last biocoenosis is also called " community of Cold-Water Corals " (Pérès, 1982, 1985; Taviani *et al* ., 2017). For the Circalittoral, see fig. 5-7 and also in semi-dark, sometimes shallow, underwater caves.

As noted by Thomson (1927), *Megerlia truncata* can be very variable in its shell shape and adapt to its environment. This characteristic had led to the description of several species and varieties, which have long been debated: *M. monstruosa* (even with the creation of the genus *Pantellaria*), *M. echinita* and *M. gigantea* (see Bitner & Logan, 2016; Álvarez *et al* . , 2017; Emig *et al* ., 2018). The material described under *M. gigantea* is deposited at the National Museum of Natural History in Paris: it has been studied and compared to Mediterranean specimens of *M.*

truncata . Deshayes (1863) described *Morrisia gigantea* as " Bourbon's species is the largest known of the genus . from a single specimen collected from a crustacean at a depth of 366 m (200 fathoms).

Predation by borer gastropods has been studied in fossil *Megerlia* in the Pliocene of Algeria (Baumiller *et al* ., 2006); however, this is extremely rare according to the samples taken during the campaigns cited in this work.

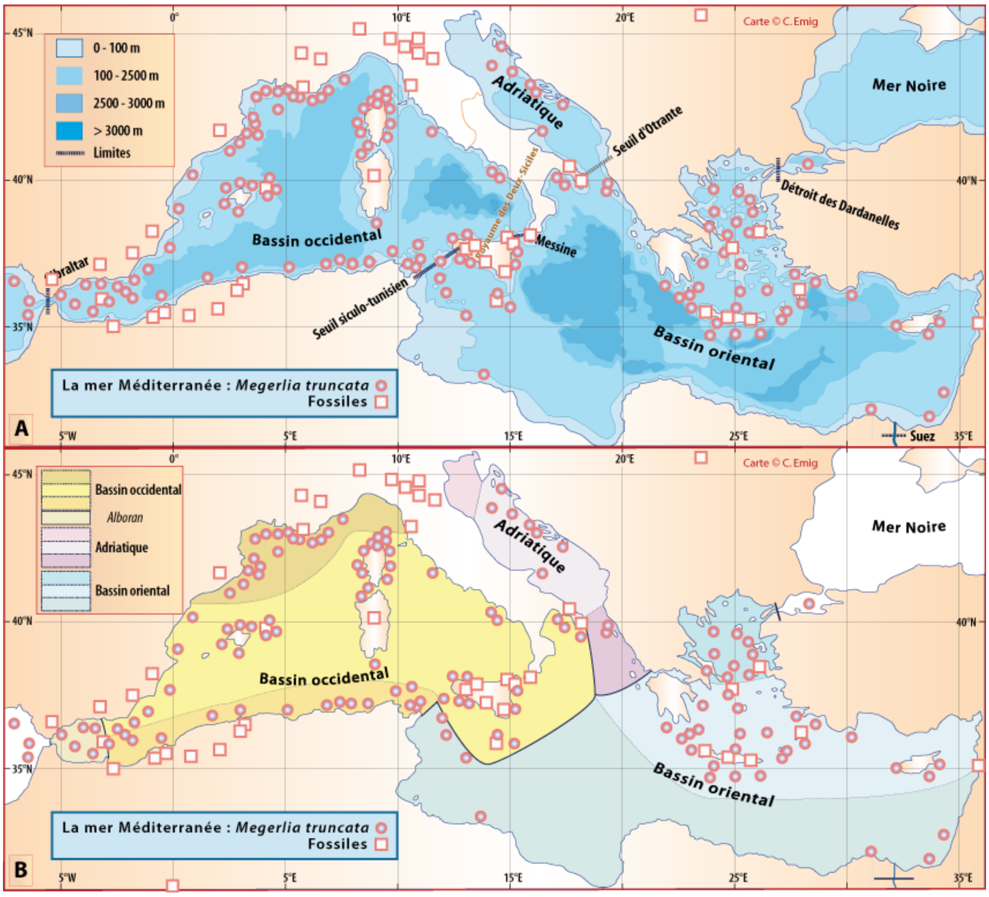

Figure 5-9 : Distribution of *Megerlia truncata* in the Mediterranean Sea, as well as reports of fossil forms. **A.** and **B.** _ see Fig 5-3 for basemap legend.

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[5] Now named Oceanological Observatory of Banyuls-sur-Mer. This laboratory was founded in 1881 by Henri de Lacaze-Duthiers (1821-1901), professor at the University of Paris.

[6] Today, the premises are shared between the Mediterranean Institute of Biodiversity and Marine and Continental Ecology (IMBE) and the Mediterranean Institute of Oceanology (MIO). It was founded in 1889 by Antoine-Fortuné Marion (1846-1900), professor at the University of Aix-Marseille, on the site in Malmousque, a small district of Marseille, facing the sea.

[7] Now called Ocean Observatory of Villefranche-sur-mer. Created in 1884 by Alexis de Korotneff (1852-1915), professor at the University of kyiv, in the former premises of the Russian naval base. It was not until 1932 that the premises were ceded to France and made available to the University of Paris.

[8] This museum was founded in 1889 by Prince Albert I of Monaco (1848-1922) – many brachiopods were collected and described during his campaigns in the Mediterranean Sea and the Atlantic Ocean. It belongs to the Fondation Albert Ier, Prince de Monaco (foundation under French law).

[9] The submersible used for the three dives had the Arsenal of Toulon (National Navy) as its home port, created in 1609 by the King of France Henri IV. The Mediterranean Oceanographic Mission which is based there has been of great help to me in the exploitation of the bathymetry of the stations of my cruises by the provision of very precise nautical charts making it possible to obtain detailed profiles of the radials.

[10] Extract from the International Code of Zoological Nomenclature (ICZN, 1999)

> **Recommendation 13A. Presentation of the elements of differentiation.** When describing a new nominal taxon, an author should clearly indicate the differentiating elements of this taxon. by giving a diagnosis, that is to say a summary of the characters which differentiate this nominal taxon from comparable taxa.
> **Diagnose** , *sf,* Written statement establishing all the characters of a taxon that are sufficient to distinguish it from other taxa with which it can be usefully compared.
> **Recommendation 13A. Intent to differentiate.** When describing a new nominal taxon, an author should make clear his or her purpose to differentiate the taxon by including with it a diagnosis, that is to say, a summary of the characters that differentiate the new nominal taxon from related or similar taxa.
> **Diagnosis** , *n* . A statement in words that purports to give those characters which differentiate the taxon from other taxa with which it is likely to be confused.

[11] Rarely the red or common lobster *Palinurus elephas* (Fabricius, 1787), living on the continental shelf, with a possible extension beyond the edge up to around 150 m, or even beyond. This species is an emblematic species of the North Atlantic Ocean and the Mediterranean; it is the most expensive of the lobster.

[12] Since June 2017, the European Union has banned trawling deeper than 800 m in its waters.

Plate 2 : AB : branches of the scleractinia *Dendrophyllia cornigera* , with many brachiopods (*Novocrania anomala* , *Megerlia truncata* , *Platidia anomioides*), st. BM 30 (Corsica), A 36, A 91 (Provence). **C** : *Megerlia* fixed on *Novocrania* . **D** : Rocky bottom (-255 m) off Île de Porquerolles (Provence, France), with *Novocrania anomala* , *Megathiris detrunctata* and many *Megerlia truncata* , some of which show the monstrous formwith deformation of the shell depending on the substrate . **E** : Würmian thanatocoenosis at *Venus casina* Linné, 1758, around 230 m depth with *Gryphus vitreus* (submersible dive at Banc du Magaud, BraProv 2; Emig, 1987). **F** : Excerpt from video recording during the submersible dive off the island of Porquerolles, BraProv 10; Emig & & Garcia-Carrascosa, 1991). © Photos CC Emig. **G** : *Gryphus* photographed by a ROV at a depth of 470 m in the Cap Sicié canyon (near Toulon) during the MedSeaCan campaign (Goujard & Fourt, 2012). © Photo Marine Protected Areas Agency.

Note : Many photographs of various species of brachiopods are online at http://paleopolis.rediris.es/LOPH-Album/

6. Distribution of *Ostreobium* in *Gryphus shells*

The first report of the unicellular perforating green alga *Ostreobium quekettii* Bornet and Flahaut, 1889 in the shell of *Gryphus vitreus* , a strictly bathyal species, was made in the Mediterranean Sea by Fredj & Falconetti (1977), then studied by Fredj-Reygrobellet & Fredj (1982). *O. quekettii* , considered a cosmopolitan species, is perforating in shells of molluscs and brachiopods; it reproduces by zoospores with four flagella (see Kornmann &. Sahling, 1980; Cormaci *et al* ., 2014).

The shells of *Gryphus vitreus* are found to be rarely infested along the French mainland coasts (Emig, 1989c), with the exception of individuals from around the Hyères Islands. Further west of these islands, the waters are relatively turbid, with greatly reduced light penetration in connection with the Ligurian current which is the northern component of the anticyclonic current circulating in the western basin of the Mediterranean Sea. This Ligurian current drains from East to West, along the coasts, the important discharges into the sea from the cities and rivers of Italy and France and then towards the Spanish coasts.

On the other hand, the clarity of the waters is better in Corsica where many infested *Gryphus* have been collected in a large number of dredging and trawling stations, in particular the NW and NE of Corsica and north of Cap Corse (Fig. 6-1) (Emig, 1985a, 1989a): eight radials were chosen, representing the different geomorphological profiles and density zones of *G. vitreus* (Fig. 4-1, 4-3); *Gryphus* counts were made based on shell color: white estimated without infestation, greenish to green with *Ostreobium* . The raw data is given in chapter 8.

The results in green *Gryphus* (Fig. 6-1) are briefly commented. Overall, the percentages are low to nil in zone 1 (Fig. 4-3), which can be explained by the threshold effect which manifests itself at the level of the edge of the continental shelf with a particular hydrodynamics, which can be notoriously vertical. over several meters, even ten meters. It is in zones 2 and 3 that the highest percentages are observed, down to a depth of about 150 to 200 m, and up to more than 300 m north of Cap Corse. Several radials (Fig. 6-1) require some additional explanation, including similarities between radials C4, C5 and C8 regarding the consequences of siltation, which may be a case of taphonomy (Emig, 1989c, 2002).

- Radial C6N . The extension in depth of green *Gryphus* is the most important, up to 310-315 m, because the continental shelf north of Cap Corse is subject to strong hydrodynamics, with low turbidity at depth, linked to its distance from the coast. .
- Radial C4 . Following numerous forest fires in the hinterland of Balagne (Emig, 1989c), the plateau and the edge of the continental slope silted up, down to around 135 m in depth, with an influence extending over the entire "offshore" shelf up to around 150 m. This induced a significant decrease in the density of living individuals of G. *vitreus* and a net decrease in the shells of G. *vitreus* infested by *Ostreobium,* as for radial C 5.
- Radial C5 . Between 1985 and 1987, Emig (1989c, 1990) mentions a significant mortality of G. *vitreus* , with a sharp drop in density down to around 170-180 m depth; beyond that, there is a normal density of G. *vitreus* (approximately 250-300 individuals per dredging) . The presence of shells infested by *Ostreobium* is limited to 130-135 m. This radial is located near an underwater canyon. The origin of the siltation could be linked to strong terrigenous discharges following the brutal deforestation by fire of the surrounding coastal mountain ranges.
- Radial C8 . The siltation of the C8 radial probably comes from the proximity of the mouth of the Le Golo river to

alluvial discharges, as well as the "graus" of the Biguglia pond (Emig, 1989c). Its *Gryphus* density is low with a few shells infested with *Ostreobium* .

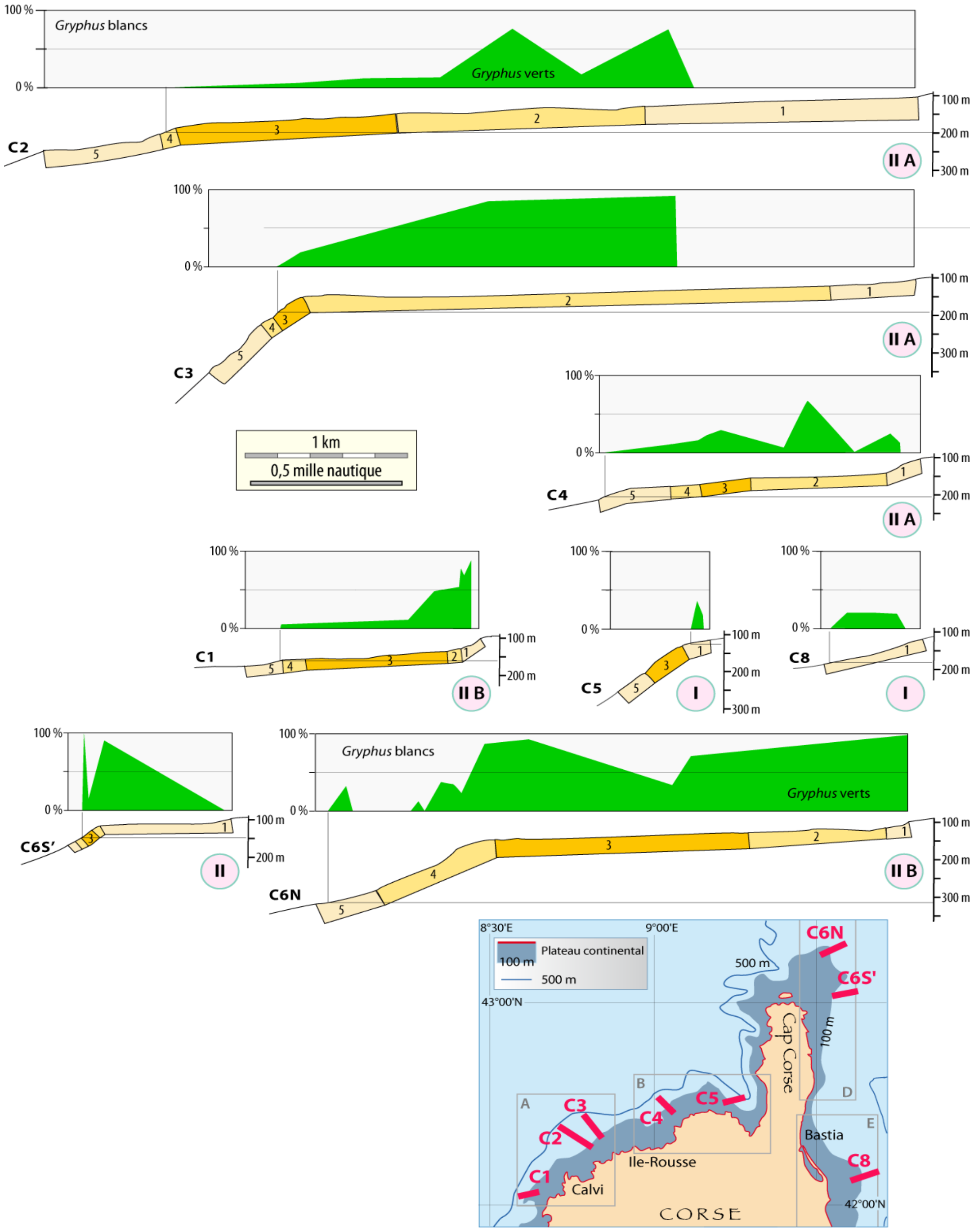

Figure 6-1 : Location of the radials with the percentages of"green" *Gryphus along the profile of each radial with the densities of Gryphus* (see explanation Fig. 4-3).

7. The limit of the phytal system: *Gryphus* as a marker

The biological boundary between the phytal and aphytal system [13] , defined by the benthic flora and fauna, was a debate during the last century, which has hardly evolved since. In summary, according to Pérès & Picard (1964): " the set of four levels… constitutes the *littoral system* , or, since it is characterized by the presence of benthic chlorophyllous plants, the *phytal system* . Pérès (1982) mentions: " In the phytal system four vertical zones may be distinguished. Their names always include the suffix "littoral"" and that the deepest stage in the phytal system, named Circalittoral, has as its lower limit "down to the maximal depth consistent with the survival of photoautotrophic multicellular algae" . »

An intermediate zone between the Circalittoral and the Bathyal with the presence of unicellular algae had been created and named Bathylittoral by Ercegovic (1957), a term taken up by Pérès & Picard (1964). Then, Pérès (1982) integrates this zone into the Circalittoral, while considering it as a transition and specifying "a true bathylittoral zone with specific organismic assemblages does not exist. Many authors continued to conform to this view, such as Falconetti (1980), Bellan-Santini (1983), Bellan-Santini *et al* . (1994), Pergent *et al* . (2007), Dauvin (pers. comm.), and can be found in various biological dictionaries, such as the Ifremer glossary (see http://envlit.ifremer.fr/infos/glossaire/e/etages_benthiques), the Bathyal stage being considered him as part of the aphytal system.

It was only with the numerous campaigns at sea carried out within the framework of the RCP-CNRS 728 program (1983-1989), with a multidisciplinary approach, that the position of this so-called intermediate zone was defined as being the Upper Bathyal (Emig, 1989a, 1889b, 1997a; Laubier & Emig, 1993; Emig & Geistdoerfer, 2004). Consequently, the boundary of the phytal system is found to be independent of the layering, bathymetry and distribution of only benthic photosynthetic multicellular organisms.

In fact, the limit at the edge of the continental shelf between the Circalittoral and the Bathyal is not linked to illumination, but to a change in factors (thus of biotope in the present case), among which illumination does not can be retained or used as a discriminating factor. This limit marks (or is only) the passage from the littoral domain to the deep domain (Emig, 1997a), not between the phytal and aphytal system. Because the limit between these two systems depends on the turbidity of the waters.

The results on the presence of the unicellular green alga *Ostreobium* in the shells of *Gryphus* (see chapter 6, above) made it possible to resume the debate on the limit of the phytal system by confirming our statements above: the distribution of the shells with *Ostreobium* is well related to deep penetration. Practically absent on the coasts of Provence because of the turbidity of the water, these shells are present in Corsica down to around 150-200, even 300 m (Fig. 6-1).

It is generally accepted that the lower limit of the phytal system corresponds to an irradiance of 1%. This limit can only be measured by the extension of photosynthetic microalgae or unicellular algae (Tett, 1990); the case of *Ostreobium* is a good example for using a benthic species. If we often read that this limit is around 200 m, it should be remembered that its depth is valid only at the place of measurement, as evidenced by its bathymetric variations in Corsica (Fig. 6-1).

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[13] Also called photic zone and aphotic zone.

8. Station books

List of station books and brachiopod collections: Tables 3 to 10.

Provence	**chapter 8: resorts**	**chapter 9: maps**
Bra Prov 0-10	Table 3 and Table 4	Figures 9-2 , 9-3
IsoBra and DEPROG	Table 5	Figures 9-1 , 9-2
Corsica		
BraCors 1-6	Table 6 and Table 7	Figures 9-4 , 9-5 , 9-6 , 9-7 , 9-8
BathyMed	Table 8 and Table 9	Figures 9-4 , 9-5 , 9-6
Meditis 2-4	Table 10	Figures 9-4 , 9-7

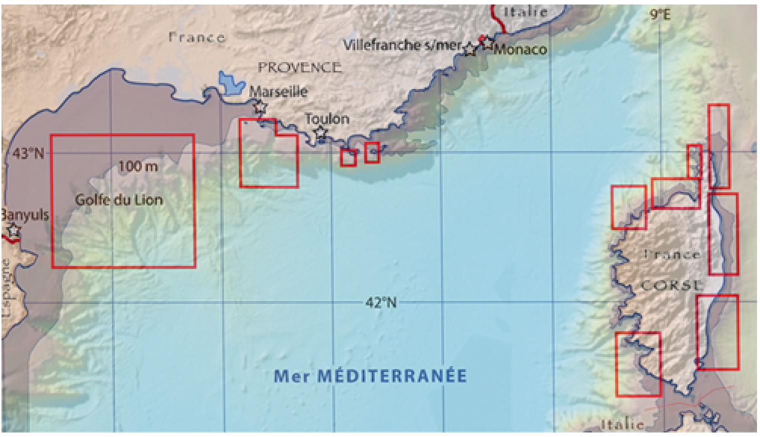

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Table 3 : BraProv campaigns (CNRS; head of mission: Christian C. Emig). Figures 9-2 and 9-3 .

[Caption at end of table]

Campaigns and Stations		Area	Teacher [D - F]		Cape	Distance	Latitude N [D]	Longitude E [D]	Latitude N [F]	Longitude E [F]	gear	Brachiopoda
0	A 1		0		70		43°07'36	5°32'12			DF	B
0	At 2		160		80		43°06'27	5°32'12			DF	B
0	At 3				0		43°07'24	5°33'30			DF	B
0	At 4		145		0		43°07'03	5°33'42			DF	B
0	AT 5		160		45		43°06'30	5°33'36			DF	B
0	At 6		250	220	45		43°06'42	5°30'12			DF	B
1	A 1		120	?	0		43°07'27	5°33'24			DF	
1	At 2		240	130	0		43°06'54	5°33'21			DF-	B
1	At 3		140	100	45		43°06'45	5°33'36			DF	B
1	At 4		240	?	45		43°06'39	5°34'21			DF	B
1	AT 5		250	240	90		43°03'18	5°30'18			DF-	
1	At 6		250	280	90		43°03'18	5°30'18			DF-	B
1	At 7		250	?	90		43°03'12	5°30'21			DF-	
1	AT 8	B	220	150	270		43°01'35	5°41'05			DF-	
1	At 9	B	180	?	270		43°01'00	5°41'10			DF	B
1	At 10	B	220	140	270		43°01'20	5°41'20			DF	
1	At 11	B	200	?	270		43°00'20	5°40'10			DF	B
1	AT 12	B	210	230	0		42°58'10	5°41'10			DF	

1	At 13	B	250	160	45°		42°58'24	5°36'24			DF	B
1	At 14	B	280	155	45		42°58'48	5°35'42			DF	B
1	At 15	B	250	155	45		42°59'36	5°34'51			DF	B
2	XL 16	M	345	70			43°01'57	6°38'45			SUBM	B
3	At 17	B	200	140	45		43°00'18	5°35'06			DF-	B
3	At 18	B	200	160	60		42°58'30	5°36'30			DF	B
3	At 19	B	160	180	340		42°58'51	5°35'51			DF	B
3	At 20	M	110	105	250		43°02'21	6°38'24			DF	B
3	At 21	M	120	110	250		43°02°06	6°38'09			DF	
3	At 22	M	120	130	70		43°01'51	6°38'00			DF	B
3	At 23	M	120	?	250						DF-	
3	At 24	M	120	160	250		43°01'12	6°37'51			DF	B
3	At 25	M	245	235	40		43°01'12	6°37'27			DF-	B
3	At 26	M	245	210	240		43°00'48	6°36'06			D-	B
3	At 27	M	200	120			43°02'09	6°38'36			DF-	B
3	At 28	M	380	420			43°02'00	6°39'24			DF	
3	At 29	M	180	120	260		43°02'18	6°39'00			DF	B
3	At 30	computer	220	160	260		43°58'18	6°23'00			DF	B
3	At 31	computer	180	120	260		43°58'06	6°22'24			DF	
3	At 32	computer	120	110	250		43°58'36	6°22'30			DF	B
3	At 33	computer	330	360	220		43°57'48	6°20'24			HAS-	
3	At 34	B	160	170			42°59'24	5°35'39			DF	
3	At 35	B	180	260	130		42°58'42	5°36'09			DF-	B
3	At 36	B	175	180	160		42°53'36	5°36'24			DF	B
3	At 37	B	320	360			42°58'21	5°36'03			D	
3	At 38	B	360	360	90		42°59'18	5°33'42			D	
3	At 39	B	180	155	340		43°00'54	5°33'24			DF	B
4	CL 40		110	140			43°40.64	7°18.71	43°41.15	7°18.90	ROVs	
4	CL 41		200	55	325		43°41.42	7°24.86	43°41.97	7°24.26	ROVs	
4	CL 42		430	380	230		43°41.30	7°26.13	43°40.94	7°24.93	ROVs	
5	At 44	B	140	140	340		43°01.35	5°33.65			DF	
5	At 45	B	140	140	310		43°01.35	5°33.65			DF	B
5	At 46	B	150	140	130		43°01.20	5°33.60			DF	B
5	At 47	B	140	150	130		43°01.20	5°33.60			D-	
5	At 48	B	130	125	330		43°01.85	5°34.30			D	B
5	At 49	B	130	125	140		43°01.95	5°34.45			L	B
5	At 50	B	140	140	330		43°02.00	5°33.50			VS	
5	A 51		140	170	310		43°05.80	5°33.75			VS-	
5	A 52	B	155	160	120		43°00.50	5°34.70			VS	B
5	A 53	B	160	165	320		43°00.50	5°34.60			L	
5	A 54	B	160	160	330		43°00.70	5°34.20			D	B
5	At 55	B	250	260	330		42°59.65	5°34.40			D	B
5	A 56	B	220	260	290		43°00.25	5°33.30			L	
5	A 57	B	240	230	290		42°59.90	5°33.90			VS-	B
5	At 58		240	280	340		43°06.05	5°31.60			D-	
6	CL 59	computer	120	96	70		42°58.74	6°23.67	42°58.95	6°24.00	DF	B
6	CL 60	computer	170	140	260		42°58.62	6°23.64	42°58.62	6°23.26	D-	B
6	CL 61	computer	250	130	300		42°58.10	6°21.95	42°58.32	6°21.07	DF	B
6	CL 62	computer	150	160	85		42°58.30	6°21.24	42°58.28	6°21.74	DF	B
6	CL 61	computer	160	160	130		42°58.30	6°21.67	42°57.65	6°22.42	L	
6	CL 64	computer	1000	800	60		42°56.23	6°22.75	42°56.40	6°23.00	D-	
6	CL 65	computer	1000	800	60		42°56.42	6°22.93	42°56.59	6°23.42	D-	
6	CL 66	P	130	129	110		42°58'30	6°06'57	42°58.47	6°06.56	DF	B
6	CL 67	P	132	132	285		42°58'19	6°07'07	42°58.17	6°07.55	DF	B
6	CL 68	P	132	132	105		42°58'20	6°06'43	42°58.40	6°06.25	L	
6	CL 69	P	132	132	285		42°58'12	6°06'55	42°58.07	6°07.37	D	
6	CL 70	P	132	132	160		42°58'34	6°06'38	42°58.40	6°06.10	VS-	
6	CL 71	P	125	132	280		42°57'35	6°08'54	42°57.49	6°09.34	VS	B
6	CL 72	P	230	212	85		42°57'04	6°07'06	42°57.18	6°06.33	DF	B
6	CL 73	P	320	180	270		42°57'17	6°06'47	42°57.20	6°07.69	L	
6	CL 74	P	410	375	90		42°56.70	6°07.46	42°56.56	6°07.97	D-	
6	CL 75	P	400	310	120		42°56'11	6°08'37	42°56.56	6°08.19	DF-	
6	At 76	P	320	350	110		42°55'31	6°09'44	42°55.93	6°09.08	L	
6	CL 77	P	280	230	45		42°55.32	6°10.76	42°55.78	6°11.22	DF-	B
6	CL 78	P	900	590	45		42°55.35	6°12.57	42°56.16	6°13.41	DF-	
6	CL 79	P	400	270	235		42°55'56	6°11'49	42°56.07	6°13.29	L	
6	CL 80	P	1200	1100	310		42°54'51	6°07'55	42°54.22	6°09.56	D-	
7	A 81	B	130	130	110		43°01.75	5°35.00			D-	
7	A 82	B	130	133	320		43°01.60	5°35.10			D	B

7	A 83	B	145	140	320		43°01.65	5°34.60			DF	B
7	A 84	B	145	140	325		43°01.85	5°34.50			DF	B
7	At 85	B	130	135	320		43°02.30	5°33.80			L	
7	A 86	B	135	140	320		43°01.95	5°34.40			VS-	
7	A 87	B	140	140	310		43°01.95	5°34.40			VS	B
7	At 88	B	190	180	115		43°00.10	5°34.15			D	B
7	At 89	B	200	195	305		42°59.10	5°33.85			DF	B
7	At 90	B	190	210	310		42°59.10	5°33.65			L	
7	A 91	B	195	200	290		42°59.10	5°33.40			VS-	B
7	A 92	B	245	250			42°59.40	5°33.25			D-	
7	A 93	B	245	250			42°59.70	5°32.90			D-	
7	A 94	B	250	260			42°59.65	5°33.15			DF	B
7	At 95	B	245	280			42°59.60	5°33.05			L	
7	A 96	P	150	145	325		42°57.20	6°08.25			D	
7	A 97	P	155	145			42°57.20	6°08.25			DF	B
7	At 98	P	150	140			42°57.20	6°07.50			L	
7	At 99	P	170	220	310		42°51.25	6°07.10			D	
7	100	P	195	210	120		42°57.20	6°07.30			DF-	B
7	To 101	P	220	190	115		42°57.15	6°08.10			L	
7	A 102	P	143	138	100		42°58.00	6°07.90			DF	B
7	A 103	P	128	130	340		42°58.40	6°07.60			DF	B
7	A 104	P	260	220	300		42°57.05	6°08.10			DF	B
7	At 105	P	280	260	100		42°57.05	6°07.70			D	
7	A 106	P	240	260	300		42°57.10	6°07.30			L	
7	A 107	P	125	120	140		42°57.30	6°09.40			DF	B
7	A 108	P	150	140	320		42°57.00	6°08.90			D	
8	XL 109	B	420	150	0		42°58'43	5°34'30	43°01'13	5°34'28	SUBM	B
9	K110	B	445	469	310	0.20	42°59.00	5°33.00	42°59.00	5°32.80	DF	
9	K111	B	537	546	95	0.18	42°58.83	5°33.54	42°58.78	5°33.78	D-	
9	K112	B	439	463	275	0.12	42°59.06	5°32.98	42°59.08	5°32.82	D-	
9	K113	B	473	475	100	0.69	42°58.88	5°33.45	42°58.63	5°34.37	L	
9	K114	B	362	378	300	0.15	42°59.04	5°34.06	42°59.06	5°33.88	DF	
9	K115	B	353	358	130	0.20	42°58.48	5°35.15	42°58.30	5°35.41	D	
9	K116	B	352				42°58.28	5°35.57			B	
9	K117	B	300	302	260	0.19	42°59.23	5°34.58	42°59.41	5°34.34	D	
9	K118	B	302				42°59.41	5°34.34			B	B
9	K119	B	270	259	120	0.61	42°59.11	5°34.97	42°58.69	5°35.74	L	
9	k 120	B	151	149	310	0.16	43°00.18	5°34.71	43°00.53	5°34.58	DF	
9	K121	B	147				43°00.70	5°34.49			B	
9	K122	B	146	149	150	0.17	43°00.45	5°34.91	42°59.64	5°35.49	L	
9	K123	B	148	147	310	0.20'	43°00.05	5°35.20	43°00.36	5°34.97	D	
9	K124	B	147	149	150	0.82'	43°00.00	5°35.20	42°59.48	5°36.06	VS	B
9	K125	B	155	160	290	0.82	42°59.10	5°35.60	43°00.14	5°34.59	VS	B
9	K126	B	166				43°00.49	5°33.80			B	
9	K127	B	191	189	290	0.21	43°00.54	5°33.37	43°00.71	5°33.12	D	B
9	K128	B	192				43°00.59	5°33.22			B	
9	K129	B	188	170	130	0.76	43°00.35	5°33.90	42°59.91	5°35.00	L-	
9	K130	B	118	119	270	0.15	43°02.10	5°34.80	43°02.29	5°34.44	DF	B
9	K131	B	115	120	0	0.16	43°03.00	5°33.80	43°03.32	5°33.83	DF	B
9	K132	P	170	193	90	0.17	42°57.22	6°08.00	42°56.94	6°OS.18	D-	B
9	K133	P	200				42°57.21	6°08.03			B	
9	K134	P	190	200		0.17	42°57.30	6°06.90	42°57.22	6°06.62	DF	B
9	K135	P	133	126		0.14	42°58.16	6°08.11	42°58.11	6°07.49	DF-	
9	K136	P	132				42°57.86	6°08.41			B	
9	K137	P	131	130	315	0.14	42°58.04	6°08.06	42°58.16	6°07.89	DF	B
9	K138	P	131	129	127	0.76	42°58.14	6°07.94	42°57.67	6°08.56	L	
9	K139	P	302	294	280	0.32	42°57.00	6°07.84	42°57.05	6°07.31	D	
9	K140	P	180	183	270	0.29	42°57.27	6°07.22	42°57.24	6°06.84	SF	B
9	K141	P	183				42°57.24	6°06.84			B	
9	K142	P	387	395	90	0.15	42°56.68	6°07.88	42°56.61	6°07.94	D-	
9	K143	P	395				42°56.61	6°07.94			B	
9	K144	P	415	419	140	0.18	42°56.50	6°08.00	42°56.36	6°08.10	DF	
9	K145	P	393	457	320	0.77	42°56.50	6°07.50	42°56.75	6°06.96	L	
9	K146	P	100	99	350	0.21	42°59.00	6°08.73	42°59.29	6°08.52	DF	
9	K147	P	99				42°59.26	6°08.47			B	
9	K148	P	129	130	130	0.53	42°58.85	6°07.00	42°58.41	6°07.55	VS	B
10	XL 149	P	600	80	20		42°56.000	6°07.20	42°59.40	6°09.20	SUBM	B

Depths in meters and coordinates of the beginning [D] and end [F] of traict on the bottom. Distances are in nautical miles.

BRAPROV 0: March 1983 (N/O Antedon)
BRAPROV 1: February 28 to March 2, 198((N/O Antedon)
BRAPROV 2: January 27, 1986 (BISM Triton & SMI Griffon)
BRAPROV 3: December 11 to 14, 1986 (N /O Antedon)
BRAPROV 4: January 12 to 16, 1987 (N/O Catherine-Laurence & ROV Modea)
BRAPROV 5: March 4 to 6, 1987 (N/O Antedon)
BRAPROV 6: March 30 to April 3, 1987 (N/O Catherine-Laurence)
BRAPROV 7: June 1 to 5, 1987 (N/O Antedon)
BRAPROV 8: October 22, 1987 (BISM Triton & SMI Griffon)
BRAPROV 9: November 16 to 25, 1987 (N/O Korotneff)
BRAPROV 10: October 13 1989 (BISM Triton & SMI Griffon)

Sampling gear: B = Shipeck tipper; C = small beam trawl (2m wide); D = Charcot-Picard dredge with underpants (burlap); DF = Charcot-Picard dredger (without underpants) with a 10mm mesh net, protected by a 10-mesh net; L = sledge; ROV = remotely operated vehicle or unmanned underwater vehicle; SUBM = submersible. -: indicates an incomplete or empty sample (damage).

Table 4 : Distribution of brachiopods (in number of individuals) in BraProv campaign stations (Table 3). Figures 9-2 and 9-3 . At some stations, counts were made of *Gryphus* according to the color of the white or green shell colonized by the algae *Ostreobium* . For the complete legend: see Table 3.

Campaign and Stations		Areas	Depth [D-F]		Dist [miles]	gear	*Gryphus*	*Gryphus* b/v	*Terebratulina*	*Megerlia*	*Megathiris*	*Novocrania*	*Platidia*
0	A1		0			DF							
0	A2		160			DF							
0	A3					DF							
0	A4		145			DF							
0	AT 5		160			DF							
0	A6		250	220		DF							
1	At 2		240	130		DF-	10		10	10			
1	A3		140	100		DF	10						
1	A4		240	?		DF	60						
1	A6		250	280		DF-			40	10		10	
1	At 9	B	180	?		DF	10					2	
1	At 11	B	200	?		DF	20					40	
1	At 13	B	250	160		DF	90		2	15		1	
1	At 14	B	280	155		DF	25						
1	At 15	B	250	155		DF	100		60	60			
2	XL 16	M	345	70		SUBM	+++						
3	At 17	B	200	140		DF-	20	/0					
3	At 18	B	200	160		DF	4	/0	1				
3	At 19	B	160	180		DF	49	9/40					
3	At 20	M	110	105		DF	38	6/32	2	12		1	
3	At 22	M	120	130		DF	34	19/15	6	14	7	3	
3	At 24	M	120	160		DF	56	12/44	25	67	16		1
3	At 25	M	245	235		DF-	7	/0					
3	At 26	M	245	210		D-				40	20		60
3	At 27	M	200	120		DF-	10	8/2					
3	A29	M	180	120		DF	140	/0	4	17			
3	At 30	computer	220	160		DF	10	/0	2				
3	At 32	computer	120	110		DF	2	/0		1			
3	At 35	B	180	260		DF-	5	/0					
3	At 36	B	175	180		DF	10	/0	3	14			
3	At 39	B	180	155		DF	137	/0					
5	At 45	B	140	140		DF	24	/0		4			
5	At 46	B	150	140		DF	6	/0					
5	At 48	B	130	125		D	1	/0					
5	At 49	B	130	125		L	300			2	6	1	2
5	A 52	B	155	160		VS	2000		4	8		4	
5	A 54	B	160	160		D	1	/0					
5	At 55	B	250	260		D	3	/0					
5	A 57	B	240	230		VS-	68	/0	2	5		2	
6	At 59	computer	120	96		DF	5	/0	12	25			
6	At 60	computer	170	140		D-	20	/0	20	20			
6	A 61	computer	250	130		DF	5	/0	5	8			
6	A 62	computer	150	160		DF	20	/0	20	20			
6	A 66	P	130	129		DF	70	/0		1			
6	A 67	P	132	132		DF	250	/0					
6	A 71	P	125	132		VS	1500		1	5		1	
6	A 72	P	230	212		DF	10	/0					

6	At 77	P	280	230		DF-	2	/0					
7	A 82	B	130	133		D	20						
7	A 83	B	145	140		DF	22	/0					
7	A 84	B	145	140		DF	85	83/2		5		2	
7	A 87	B	140	140		VS	>1000		2	60	1		
7	At 88	B	190	180		D	10		10	10	10		
7	At 89	B	200	195		DF	163						
7	A 91	B	195	200		VS-	20		2	20	10		
7	A 94	B	250	260		DF	20						
7	A 97	P	155	145		DF	127						
7	100	P	195	210		DF-	12						
7	A 102	P	143	138		DF	55						
7	A 103	P	128	130		DF	52						
7	A 104	P	260	220		DF	2						
7	A 107	P	125	120		DF	33						
8	XL 109	B	420	150		SUBM	+++						
9	K118	B	302			B	12						
9	K124	B	147	149	0.82	VS	80		10	80	40	10	10
9	K125	B	155	160	0.82	VS	80		10	80	40	10	10
9	K127	B	191	189	0.21	D	80						
9	K130	B	118	119	0.15	DF	6						
9	K131	B	115	120	0.16	DF	12						
9	K132	P	170	193	0.17	D-	12						
9	K134	P	190	200	0.17	DF	34						
9	K137	P	131	130	0.14	DF	50						
9	K140	P	180	183	0.29	DF	32						
9	K148	P	129	130	0.53	VS	500						
10	XL 149	P	600	80		SUBM	+++						

Table 5 : IsoBra cruise (CNRS; mission leader: Christian C. Emig) with the N/O Catherine-Laurence: st. IB 2-6 in September 1996 and st. IB 9 in March 1999 - gear: Charcot-Picard dredge with nets (DF). DEPROG cruise (IFREMER) with N/O Europe in April 1996 - gear: beam trawl. Figures 9-1 and 9-2 .

[D] are the data when launching the gear; [F] at the time of the ascent of the machine. Cap du traict and the number of *Gryphus* harvested. Only stations with brachiopods are listed.

Campaign and Stations	Depth [D-F]		Latitude N [D]	Longitude E [D]	Latitude N [F]	Longitude E [F]	course in°	*Gryphus*
IsoBra IB 2 DF	128	129	43°02'.54	5°33'.26	43°02'.15	5°33'.71	275	3
IsoBra IB 4 DF	156	157	43°01'.11	5°32'.67	43°01'.44	5°31'.44	280	200
IsoBra IB 6 DF	162	155	43°01'.85	5°30'.55	43°02'.34	5°30'.38	280	200
IsoBra IB 9 DF	155	154	43°02'.29	5°30'.28	43°02'.01	5°30'.69	150	180
DEPROG D-2	986	1030	42°43'.57	4°46'.99	42°42'.55	4°46'.60		2
DEPROG D-3	1129	1193	42°44'.57	4°29'.47	42°43'.90	4°29'.50		5
DEPROG D-4	1096	1179	42°34'.68	4°07'.40	42°33'.37	4°08'.19		4
DEPROG D-5	1136	1157	42°28'.52	4°05'.74	42°27'.66	4°07'.00		3
DEPROG D-6	1600	1630	42°20'.73	3°58'.93	42°19'.92	4°00'.45		1
DEPROG D-14	1153	1275	42°15'.67	3°42'.90	42°14'.27	3°44'.25		1
DEPROG D-17	744	725	42°29'.60	3°40'.34	42°29'.30	3°40'.85		2

Table 6 : BraCors campaigns (CNRS; head of mission: Christian C. Emig). Figures 9-4 , 9-5 , 9-6 , 9-7 and 9-8 .

[Caption at end of table]

Campaigns and Stations	Teacher [D - F]	Cape	Latitude N [D]	Longitude E [D]	Latitude N [F]	Longitude E [F]	gear	Brachiopoda
1 CL 1	125 125	50	42°32'52	8°39'15	42°33'01	8°39'42		B
1 CL 1	130		42°33'03	8°39'38			B	
1 CL 1	125 125		42°33'03	8°39'38	42°32'50	8°39'18		B
3 CL 1/2	146 150	0	42°32'53	8°39'15	42°33'21	8°39'10		B
3 CL 1/2	153 148	180	42°33'21	8°39'10	42°33'00	8°39'12	B	
1 CL 2	125 135	0	42°32'58	8°39'08	42°33'35	8°39'07		B
1 CL 2	135		42°33'35	8°39'07			B	
4 CL 2-85	125 130	10	42°32'48	8°39'06	42°33'39	8°38'47	B-	
4 CL 2-85	135 140	220	42°33'48	8°38'46	42°33'37	8°38'16		B
1 CL 3	130 130	25	43°33'27	8°39'03	43°33'40	8°39'13		B
1 CL 4	138 130	80	43°34'22	8°40'08	43°34'27	8°40'37		B
1 CL 4	138		43°34'23	8°40'32			-	
1 CL 5	120 120	202	42°34'15	8°41'03	42°33'38	8°40'55	VS	

1 CL 6	140 135	120	42°33'59	8°39'50	42°33'48	8°40'13	-	
1 CL 7	120 100	120	42°33'32	8°40'35	42°33'10	8°41'12	VS	
1 CL 8	135 130	72	42°34'06	8°39'30	42°34'13	8°40'00	VS-	
1 CL 9	130 130	72	42°34'15	8°40'08	42°34'20	8°40'30		B
1 CL 10	130 105	76	42°34'34	8°41'05	42°34'37	8°41'28		B
1 CL 11	130 110	76	42°34'36	8°41'27	42°34'37	8°41'35		B
1 CL 12	110		42°34'35	8°41'23			B	
1 CL 12	125 105	76	42°34'36	8°41'27	42°34'37	8°41'23		B
1 CL 13	120 100	90	42°31'41	8°36'38	42°31'43	8°37'16		B
4 CL 13-1	140	100	42°31'18	8°35'43	42°31'17	8°35'46		B
4 CL 13-2	150 160	210	42°31'42	8°35'18	42°31'18	8°35'06		B
4 CL 13-3	130 110	40	42°31'51	8°36'15	42°32'04	8°36'34	DF-	
4 CL 13-4	115 120	220	42°32'12	8°36'52			DF-	
4 CL 13-5	130 135	220	42°31'29	8°36'18	42°31'47	8°36'28	DF	
4 CL 13-6	125 125	70	42°32'09	8°37'12				B
4 CL 13-7	110 115		42°31'57	8°37'17	42°31'50	8°36'34		B
4 CL 13-8	110 115	220	42°31'54	8°37'17			DF-	
4 CL 13-9	115 120	220	42°32'09	8°37'17			DF-	
4 CL 13-10	120 125	240	42°31'57	8°36'57	42°31'53	8°36'49	DF	
4 CL 13-11	120 120	60	42°31'56	8°37'06	42°32'00	8°36'16		B
4 CL 13-12	105 110	240	42°31'48	8°37'01	42°31'43	8°36'42	DF	
5CL 13-13	140 140	25	42°31'48	8°36'00	42°32'18	8°36'42		B
5CL 13-14	135 135	25	42°31'42	8°36'30	42°32'18	8°36'48		B
5CL 13-14	136		42°32'18	8°36'48			B	
5CL 13-15	117		42°31'42	8°34'30				B
5CL 13-16	128 115		42°31'27	8°36'33	42°31'54	8°36'77		B
5 CL 13-17	142 137		42°31'48	8°36'00	42°32'30	8°37'15	D*	
5CL 13-18	125 125	70	42°31'47	8°37'00	42°32'08	8°37'27		B
5CL 13-19	107 98	70	42°31'50	8°37'00	42°31'47	8°37'17		B
5CL 13-20	135 127	70	42°32'17	8°37'10	42°32'21	8°37'37		B
5CL 13-21	123 110	70	42°31'43	8°36'43	42°31'50	8°37'10		B
1 CL 14	115 105	70	42°31'06	8°36'56	42°31'03	8°37'28		B
1 CL 14	105		42°31'02	8°37'30			B	
3 CL 14	140 85	90	42°31'05	8°36'55	42°31'33	8°37'43		B
1 CL 15	100 95	90	42°30'41	8°36'42	42°30'42	8°37'06		B
1 CL 15	95		42°30'42	8°37'06			B	
3 CL 15	110 98	90	42°30'42	8°36'38	42°30'40	8°37'22		B
3 CL 15bis	150 97	90	42°30'45	8°36'27	42°30'43	8°37'19		B
3 CL 15bis	96		42°30'38	8°37'05			B	
3 CL 15b2	155 139	90	42°30'45	8°36'27	42°30'55	8°36'52		B
3 CL 15b3	160 143	90	42°30'45	8°36'23	42°30'38	8°36'35		B
3 CL 15b4	160 135	90	42°30'48	8°30'05	42°30'37	8°36'45		B
3 CL 15b5	145		42°32'55	8°39'15			B	
3 CL 15ter	145 97	90	42°30'55	8°36'30	42°30'43	8°37'19	DF-	
3 CL 15-4	110 110	210	42°31'03	8°37'30	42°30'37	8°37'20		B
1 CL 16	140 105	90	42°32'27	8°36'53	42°32'13	8°37'47		B
1 CL 16	105		42°32'13	8°37'47			B	
1 CL 17	130 140	218	42°36'23	8°40'58	42°35'54	8°40'27		B
1 CL 18	130 135	218	42°36'03	8°41'27	42°36'02	8°40'52		B
1 CL 18	130 135		42°36'07	8°40'57			B	
1 CL 19	68 72	240	42°39'24	8°51'55	42°39'12	8°51'30	DF	
1 CL 19	71		42°39'12	8°51'30			B	
1 CL 20	85 90	240	42°39'37	8°51'30	42°39'32	8°51'07	DF	
1 CL 20	90		42°39'32	8°51'07			B	
1 CL 21	93 90	240	42°39'42	8°50'37	42°39'25	8°50'02		B
3 CL 21	105 105	60	42°39'25	8°50'00	42°39'33	8°50'07		B
3 CL 21-2	112 112	60	42°39'33	8°50'07	42°39'46	8°50'12	D	
4 CL 21	100 85	180	42°39'45	8°50'22	42°39'31	8°50'16	DF	
4 CL 21-1	100 95	80	42°39'33	8°48'49	42°39'31	8°49'13	DF	
4 CL 21-2	105 95	180	42°40'	8°50'	42°39'46	8°49'27	DF	
1 CL 22	116 125	245	42°40'29	8°49'15	42°40'23	8°48'50		B
1 CL 22	125		42°40'23	8°48'50			B	
1 CL 23	120 130	245	42°40'28	8°48'55	42°40'12	8°48'15		B
1 CL 23	130		42°40'12	8°48'15			B	
1 CL 24	160 150	65	42°39'05	8°44'47	42°39'32	8°45'42	VS	
1 CL 24	150		42°39'32	8°45'42			B	
1 CL 25	123 128	233	42°38'53	8°46'23	42°38'35	8°46'10		B
1 CL 25	126		42°38'44	8°46'25			B	
1 CL 26	140 145	235	42°39'08	8°45'00	42°38'54	8°45'33		B

1 CL 26	145		42°39'03	8°46'52			B*	
3 CL 26	150 150	55	42°38'54	8°45'33	42°39'17	8°45'47		B
3 CL 26	150 150	205	42°39'17	8°45'47	42°39'04	8°45'38	D	
4 CL 26	135 140	235	42°39'19	8°45'54	42°39'05	8°45'31	B	
4 CL 26-1	155 160	235	42°38'51	8°44'20	42°38'45	8°43'48		B
1 CL 27	165 145	165	42°39'27	8°45'15	42°38'52	8°45'15		B
1 CL 27	148		42°39'08	8°45'18			B	
1 CL 28	92 78	180	42°35'40	8°46'08	42°35'17	8°46'06	DF	
1 CL 29	72 68	180	42°35'18	8°46'14	42°34'55	8°46'07	DF	
1 CL 30	300 250	235	42°37'45	8°43'52	42°37'12	8°43'23		B
1 CL 31	200 120	235	42°36'30	8°44'30	42°36'09	8°44'06		B
1 CL 32	110 110	80	42°42'16	8°56'22	42°42'25	8°56'41	DF-	
1 CL 33	?300 200	165	42°41'32	8°59'08	42°40'35	8°59'53'	DF	
1 CL 34	200 150	140	42°45'15	9°00'50			DF-	
1 CL 34'	160 140	140	42°44'52	9°01'05	42°44'13	9°01'13		B
1 CL 34'	145		42°44'17	9°01'09			B	
3CL 34'	?		42°44'50	9°01'05			D*	
3 CL 34'1	170 180	170	42°44'50	9°01'05	42°44'08	9°00'57		B
3 CL 34'2	? ?	170	42°44'50	9°01'05	42°44'38	9°01'00	D-	
3 CL 34'3	? ?	170	42°44'38	9°01'00	42°44'12	9°00'47	D-	
3 CL 34'4	? ?	170	42°44'38	9°01'00	42°44'16	9°00'40	D-	
1 CL 35	105 125	40	42°44'15	9°02'00	42°44'36	9°02'15		B
1 CL 35	125		42°44'36	9°02'15			B	
3 CL 35-1	150 150	30	42°44'15	9°01'57	42°45'03	9°02'05		B
3 CL 35-2	150 150	180	42°45'03	9°02'05			D*	
1 CL 36	?370 210	235	42°41'42	8°58'25	42°41'35	8°38'18	DF-	
1 CL 37	58 55 135		42°43'54	9°02'12	42°43'47	9°03'13	DF	
1 CL 38	117 120	135	42°42'38	9°01'12	42°42'29	9°01'39		B
1 CL 39	?220 180	200	42°42'52	8°57'37	42°42'35	8°57'31		B
1 CL 39	215		42°42'55	8°57'45			B	
1 CL 40	115 110	245	42°40'02	8°49'00	42°39'45	8°48'28	DF	
1 CL 40	110		42°40'04	8°48'43			B	
1 CL 41	125 125	60	42°40'30	8°48'15	42°41'00	8°49'00		B
1 CL 41	122		42°40'58	8°49'05			B	
1 CL 42	135 123	220	42°41'10	8°49'16	42°40'52	8°49'00		B
1 CL 42	125		42°41'00	8°49'07			B	
1 CL 43	145 230	230	42°41'34	8°48'12	42°40'53	8°47'40		B
1 CL 43	150		42°41'00	8°47'46			B	
1 CL 44	180 136	230	42°41'08	8°46'17	42°40'51	8°45'55		B
1 CL 44	163		42°40'50	8°45'59			B	
3CL 44bis	? ?	55	42°41'07	8°46'16			DF-	
1 CL 45	160?	50	42°40'54	8°46'04	42°41'18	8°46'48	DF-	
1 CL 46	170 150	190	42°41'30	8°47'03	42°40'44	8°47'03		B
1 CL 46	149		42°40'46	8°47'04			B	
3CL 46bis	280 220	55	42°41'21	8°47'00	42°41'18	8°47'00	DF-	
3 CL 46b	280 220	180	42°41'18	8°47'00	42°41'06	8°47'09	D*	
4 CL 46	150 135	160	42°41'15	8°46'49	42°41'10	8°47'17		B
1 CL 47	170 143	180	42°41'37	8°47'08	42°40'46	8°47'44		B
1 CL 47	143		42°40'47	8°47'50			B	
1 CL 48	? ?	170	42°41'50	8°46'21	42°41'15	8°46'48	DF-	
1 CL 49	?150 130	270	42°46'27	9°13'38	42°46'33	9°13'18		B
1 CL 50	135 120	270	42°46'33	9°13'22	42°46'36	9°12'55		B
1 CL 51	? ?	245	42°43'53	9°12'58	42°45'37	9°12'30	DF	
1 CL 52	160 115	245	42°45'37	9°12'33	42°45'28	9°12'05		B
3 CL 52	? ?	250	42°45'36	9°12'17	42°45'30	9°11'53	DF	
3 CL 52-1	? ?	180	42°45'28	9°12'22	42°44'55	9°12'12	DF	
1 CL 53	160 115	245	42°45'28	9°12'08	42°45'25	9°12'05		B
1 CL 54	120 60	245	42°45'30	9°12'15	42°45'23	9°11'38	DF	
1 CL 55	150 115	245	42°45'40	9°12'30	42°45'31	9°12'18	D	
1 CL 56	140 120	245	42°45'33	9°12'23	42°45'28	9°12'06	D	
1 CL 57	? 150	245	42°45'44	9°12'40	42°45'43	9°12'22	DF	
1 CL 58	? 150	245	42°45'42	9°12'34	42°45'35	9°12'23	DF	
1 CL 59	? ?	245	42°45'48	9°12'85	42°45'43	9°12'21	DF-	
1 CL 59'	180 190	245	42°45'45	9°12'36	42°45'43	9°12'21		B
1 CL 60	? 180	200	42°46'00	9°13'52	42°45'32	9°13'26		B
1 CL 61	140 105	185	42°45'25	9°14'26	42°45'08	9°14'25		B
1 CL 62	140 110	205	42°43'55	9°17'30	42°43'35	9°17'12	DF	
1 CL 63	150 105	135	42°47'27	9°18'10	42°47'10	9°18'25		B
1 CL 64	150 77	85	42°47'53	9°19'18	42°47'52	9°19'45	DF	

1 CL 65	140 110	90	42°50'03	9°16'50	42°50'00	9°17'34	DF	
1 CL 66	? ?	125	42°51'53	9°18'04	42°51'42	9°18'31		B
1 CL 67	130 85	20	42°54'08	9°16'52	42°54'25	9°16'56	DF	
1 CL 68	115 95	50	42°54'03	9°17'21	42°54'27	9°17'40		B
1 CL 69	? ?	180	42°55'17	9°17'58			DF-	
1 CL 70	210 130	60	42°57'04	9°18'32	42°57'20	9°18'50		B
1 CL 71	?	210	43°00'54	9°17'46	43°00'40	9°17'35	DF-	
1 CL 72	190 160	210	43°00'45	9°17'30	43°00'37	9°17'15		B
1 CL 73	125 90	180	42°48'05	8°10'00	42°47'54	8°10'11		B
1 CL 74	110 170	205	42°48'08	8°09'32	42°47'43	8°09'22		B
3 CL 74	120 143	180	42°48'08	9°09'32	42°47'24	9°09'12		B
3 CL 74	152 150	180	42°48'08	9°09'32	42°47'57	9°09'15		B
3 CL 74-1	150 110	180	42°47'32	9°08'17	42°46'53	9°07'43		B
3 CL 74-2	150 90	155	42°46'25	9°06'08	42°46'15	9°06'2?		B
3 CL 74-3	200 180	150	Canceled	presence of	nets			B
3 CL 74-4	190 160	90	42°43'38	9°00'20	42°43'35	9°00'35		B
3 CL 74-5	? ?	90	42°43'20	9°00'37	42°43'57	9°01'28	DF	
1 CL 75	? ?	180	42°41'36	8°47'08	42°41'10	8°47'07	DF	
4 CL 75-85	140 135	180	42°41'36	8°47'11	42°41'	8°47'	DF	
1 CL 76	? ?	155	42°41'30	8°47'00			DF	
1 CL 77	? ?	150	42°41'25	8°47'18	42°41'10	8°47'50	DF	
1 CL 78	? ?	180	42°41'25	8°47'18	42°41'00	8°47'22	DF	
2 CL 79	150 95	200	41°38'47	8°49'27	41°58'22	8°49'12	DF	
2 CL 80	150 140	130	41°39'03	8°46'54	41°38'47	8°47'00		B
2 CL 81	150	130	41°38'50	8°46'54	41°38'47	8°47'10	DF-	
2 CL 82	145 115	130	41°38'54	8°47'03	41°38'42	8°47'25	DF	
2 CL 83	123 97	130	41°38'36	8°47'24	41°38'32	8°47'30		B
2 CL 84	100 58	140	41°38'27	8°47'30	41°38'14	8°47'45	DF	
2 CL 85	150 122	110	41°35'47	8°44'33	41°35'44	8°44'55		B
2 CL 86	125 110	110	41°35'42	8°44'55	41°35'40	8°45'12	DF	
2 CL 87	128 110	90	41°35'15	8°44'52	41°35'20	8°45'15		B
2 CL 87bis	110		41°35'18	8°45'05			B	
2 CL 88	100 87	90	41°35'25	8°45'12	41°35'24	8°45'24		B
2 CL 88bis	88		41°35'24	8°45'25			B	
2 CL 89	150 122		41°42'33	8°38'48	41°42'42	8°38'04	DF-	
2 CL 90	105 68		41°47'06	8°41'27	41°47'18	8°42'03	DF-	
2 CL 91	142	40	41°24'18	8°51'00	41°24'24	8°51'11		B
2 CL 92	127?	40	41°24'37	8°51'25	41°24'52	8°51'42	DF	
2 CL 93	110 118	70	41°24'42	8°54'30	41°24'45	8°54'40	DF	
2 CL 94	130 130	60	41°20'20	8°56'00	41°20'30	8°56'30	DF	
2 CL 95	120	60	41°20'48	8°57'00	41°20'55	8°57'30	DF-	
2 CL 96	150 160	315	41°35'09	9°29'33	41°35'12	9°29'21		B
2 CL 97	150 137	215	41°35'12	9°29'15	41°35'06	9°28'57		B
2 CL 98	160 145	285	41°35'16	9°29'15	41°35'00	9°28'48		B
2 CL 98	145		41°35'09	9°29'05			B	
2 CL 99	145		41°35'09	9°29'05	41°35'06	9°28'57		B
2 CL 100	145 145	340	41°35'06	9°28'54	41°35'24	9°28'57		B
2 CL 101	155 142	285	41°35'09	9°29'27	41°35'11	9°28'45		B
2 CL 102	117 113	275	41°35'00	9°27'53	41°35'06	9°27'27	DF	
2 CL 103	124 125	340	41°32'33	9°29'06	41°32'49	9°29'02		B
2 CL 104	146 140	280	41°32'51	9°29'54	41°32'54	9°29'30		B
2 CL 104	140		41°32'54	9°29'30			B	
2 CL 105	146 154	358	41°33'15	9°29'47	41°33'48	9°29'39	VS-	
2 CL 106	148 154	358	41°32'15	9°29'47	41°33'30	9°29'43		B
2 CL 106	145		41°33'30	9°29'43			B-	
2 CL 107	150 120	238	41°43'46	9°26'13	41°43'38	9°25'59		B
2 CL 108	150 117	238	41°43'46	9°26'13	41°43'36	9°26'10	DF	
2 CL 109	150 100	238	41°43'34	9°26'11	41°43'26	9°25'48	DF	
2 CL 110	150 145	205	41°49'17	9°28'06	41°48'56	9°27'35		B
2 CL 110	150		41°48'45	9°27'36			B	
2 CL 111	155 130	180	42°22'09	9°37'15	42°21'37	9°37'00		B
2 CL 111	128		42°21'37	9°37'00			B	
2 CL 112	150 127		42°22'09	9°37'15	42°21'41	9°36'57		B
2 CL 112	146		42°22'09	9°37'15			B	
2 CL 113	+150?	180	42°39'51	9°33'25	42°39'23	9°33'11	DF-	
2 CL 114	200 150	150	42°39'19	9°33'06	42°38'55	9°33'22		B
2 CL 115	135 117	175	42°38'30	9°33'12	42°38'10	9°33'11		B
2 CL 116	150 119	225	42°38'22	9°33'24	42°38'20	9°32'58		B
2 CL 116	116		42°38'20	9°32'58			B	

2 CL 117	155 137		42°37'30	9°35'42	42°37'05	9°35'50		B
2 CL 118	123+150	340	42°37'12	9°35'39	42°37'33	9°35'28		B
2 CL 119	150?	145	42°37'21	9°37'54	42°36'42	9°38'24	DF-	
2 CL 120	150?	235	42°36'48	9°38'22	42°36'18	9°37'24	DF	
2 CL 121	150 95	235	42°36'10	9°37'22	42°36'03	9°36'49	DF-	
2 CL 122	69 67	300	42°36'00	9°36'27	42°36'11	9°36'12	D	
2 CL 123	150 130		42°37'32	9°35'38	42°37'04	9°35'49		B
2 CL 123	156		42°37'32	9°35'38			B	
2 CL 124	132 155	0	42°31'06	9°35'50	42°37'28	9°35'44		B
2 CL 125	140 128	160	42°37'19	9°35'29	42°36'58	9°35'45		B
2 CL 126	147 154	300	42°37'42	9°34'39	42°37'58	9°34'03		B
2 CL 126	155		42°37'58	9°34'03			B	
2 CL 127	150 113	270	42°37'58	9°34'03	42°37'55	9°33'19	DF-	
6 CL 128	200 220	235	42°40'30	8°44'35	42°40'09	8°44'04	DF-	
6 CL 129	181 192	235	42°40'30	8°44'56	42°40'17	8°44'29		B
6 CL 130	166 175	235	42°40'25	8°45'08	42°40'11	8°44'68		B
6 CL 131	156 162	235	42°40'04	8°45'30	42°39'50	8°45'07		B
6 CL 132	170 253	235	42°39'20	8°44'28	42°39'04	8°44'08		B
6 CL 133	420 460	235	42°40'17	8°43'00	42°39'48	8°42'02	D	
6 CL 134	325 330	235	42°38'34	8°39'34	42°38'28	8°39'19	D	
6 CL 135	335 343	235	42°38'17	8°38'28	42°38'02	8°38'04	D-	
6 CL 136	320 327	230	42°38'32	8°39'37	42°38'25	8°39'18	DF-	
6 CL 137	127 118	230	42°44'17	9°02'05	42°44'07	9°01'48		B
6 CL 138	155 164	230	42°45'07	9°01'35	42°44'43	9°01'06		B
6 CL 138-1	155 163	230	42°44'58	9°01'33	42°44'43	9°01'04		B
6 CL 139	165 169	230	42°44'55	9°01'08	42°44'37	9°00'42		B
6 CL 140	310 325	225	42°45'16	8°59'34	42°45'11	8°59'21	D-	
6 CL 141	330 340	225	42°44'59	8°59'00	42°44.83	8°58.78	D-	
6 CL 142	345 355	230	42°45'04	8°59'15	42°45.00	8°58.50	D	
6 CL 143	110 99	240	42°42'20	8°56'22	42°42.46	8°56.26		B
6 CL 144	455 350	225	42°43'27	8°55'31	42°43.24	8°55.32	D	
6 CL 145	120 127	300	42°47'50	9°11'23	42°48.00	9°11.02		B
6 CL 146	170 245	295	42°47'59	9°11'32	42°48.26	9°11.00	DF-	
6 CL 147	180 197	125	42°48'02	9°11'18	42°78.00	9°11.43		B
6 CL 148	163 178	305	42°48'04	9°11'10	42°48.22	9°10.97		B
6 CL 149	145 174	125	42°47'58	9°11'17	42°47.71	9°11.89		B
5 CL 150	220 161	95	42°40'32	8°45'08	42°40'34	8°45'43		B
5 CL 150	159		42°40'34	8°45'43			B	
5 CL 151	180 210	30	42°40'47	8°45'38	42°41'07	8°46'17		B
5 CL 151	220		42°41'07	8°46'17			B	
5 CL 152	180 146	120	42°41'00	8°46'18	42°40'48	8°46'55		B
5 CL 154-1	330 271	220	43°06'36	9°36'24	43°04'54	9°36'36	DF-	
5 CL 154-2	240 208	290	43°04'36	9°36'30	43°05'12	9°35'42		B
5 CL 155	280 240	260	43°05'18	9°36'30	43°05'30	9°36'00	DF	
5 CL 156	330 285	260	43°05'30	9°36'54	43°05'48	9°36'00		B
5 CL 157	120 111	260			43°05'54	9°34'30		B
5 CL 158	110 100	225	43°06'12	9°34'00	43°06'06	9°32'48		B
5 CL 159	130 140	330	43°07'42	9°34'24	43°08'39	9°34'12		B
5 CL 160	230 240	330	43°08'57	9°34'09	43°10'00	9°34'00		B
5 CL 161	225 150	330	43°10'00	9°34'00	43°10'45	9°33'27		B
5 CL 162	147 143	330	43°10'45	9°33'27	43°11'42	9°32'48		B
5 CL 163	290 310	347	43°12'54	9°33'06	43°13'42	9°32'42		B
5 CL 164	280 290	347	43°14'03	9°33'12	43°15'54	9°32'36		B
5 CL 165	160 160	6	42°56'18	9°33'00	42°56'57	9°33'27		B
5 CL 166	190 150	6	42°57'06	9°33'30	42°57'42	9°33'42		B
5 CL 166	154		42°57'42	9°33'42			B	
5 CL 167	200 195	185	42°57'39	9°33'48	42°57'24	9°33'42		B
5 CL 167	195		42°57'24	9°33'42			B	
5 CL 168	147 103	290	42°57'30	9°33'18	42°57'36	9°33'00		B
5 CL 169	220 210	6	42°58'00	9°34'06	42°58'54	9°33'54		B
5 CL 170	263 236	355	42°59'48	9°35'00	43°01'00	9°34'36		B
5 CL 170	236		43°01'30	9°34'42			B	
5 CL 171	150 105	355	42°58'06	9°33'24	42°58'36	9°33'42		B
5 CL 171	120		42°58'24	9°33'36			B	
5 CL 172	100 200	85	42°45'00	9°29'24				B
5 CL 173	100 190	80	42°45'21	9°29'45	42°45'26	9°30'15	DF	
5 CL 174	100 175	70	42°45'34	9°30'05	42°46'01	9°30'28		B
5 CL 175	230 110	280	42°53'48	9°33'12	42°53'24	9°32'18		B
5 CL 176	240 110	320	42°55'48	9°34'12	42°55'54	9°33'36		B

5 CL 176	250 120	320	42°53'48	9°33'12	42°54'00	9°32'18	DF-	
5 CL 176	248 110	320	42°53'48	9°33'12	42°54'00	9°32'18	DF-	
5 CL 177	280 250	10	42°55'48	9°34'12	42°55'54	9°33'36	DF	
5 CL 177	250		42°55'54	9°33'36			B	
5 CL 178	320 295	10	42°55'54	9°34'36	42°56'18	9°32'00	DF	
5 CL 179	211 160	10	42°56'36	9°33'36	42°56'24	9°33'36		B
5 CL 179	190		42°55'42	9°33'06			B	
5 CL 180	130 120	180	42°56'30	9°33'42	42°55'48	9°33'12		B
5 CL 180	124		42°55'42	9°33'12			B	
5 CL 181	90 120	90	42°44'43	9°29'18	42°44'28	9°29'47		B
5 CL 182	100 107	50	42°45'30	9°29'52	42°45'35	9°30'15		B
5 CL 182-2	120 105	10	42°45'35	9°30'15	42°45'47	9°30'19		B
5 CL 183	120 115	30	42°45'16	9°30'03	42°45'18	9°30'13		B
5 CL 184	160 140	195	42°45'18	9°30'16	42°44'41	9°29'55		B
5 CL 184	140		42°44'30	9°29'54			B	
5 CL 185	220 195	225	42°45'30	9°31'20	42°45'00	9°31'30	DF	
5 CL 185	195		42°45'00	9°31'29			B	
5 CL 186	130 105	200	42°45'35	9°29'50	42°45'17	9°29'46		B
5 CL 186-2	140 130	200	42°43'40	9°30'05			DF	
5 CL 187	145 150	205	42°45'34	9°30'23	42°45'08	9°30'07		B
5 CL 188	130 125	205	42°45'30	9°30'18	42°44'45	9°29'52		B
5 CL 189	130 125	205	42°45'05	9°30'03	42°44'43	9°29'45	D	
5 CL 190	150 148	205	42°45'37	9°30'28	42°44'57	9°30'00		B
5 CL 191	150 120	120	42°57'45	9°18'20	42°57'23	9°18'52		B
5 CL 192	120 75	90	42°57'25	9°18'45	42°57'27	9°19'00	DF	
5 CL 193	115 97	240	43°00'15	9°18'34	43°00'08	9°18'00	DF	
5 CL 194	140 65	240	43°00'23	9°17'55	43°00'08	9°17'20	DF	
5 CL 195	150 115	240	43°00'56	9°16'51	43°00'56	9°16'34	DF	
5 CL 196	107 115	330	42°49'11	9°17'43	42°49'30	9°17'26	DF	
5 CL 197	115 95	5	42°49'30	9°17'26	42°49'42	9°17'55	DF	
5 CL 198	141,200	290	42°47'28	9°12'03	42°47'47	9°11'22		B
5 CL 199	250 300	285	42°47'43	9°12'30	42°47'54	9°12'11	DF	
6 CL 200	580 620	310	42°48'03	9°12'23	42°48'27	9°11'48	D	
6 CL 201	166 160	345	43°11'09	9°33'10	43°11'29	9°32'56		B
6 CL 202	140 135	330	43°11'59	9°32'24	43°12'20	9°32'19		B

Depths in meters and coordinates of the beginning [D] and end [F] of traict on the bottom. Heading in °. D* sediment sampling with the Charcot-Picard dredge with underpants. See also Table 3bra.

BRACORS 1: May 31 to June 9, 1983 (N/O Catherine-Laurence)
BRACORS 2: April 9 to 15, 1984 (N/O Catherine-Laurence)
BRACORS 3: July 2 to 6, 1984 (N/O Catherine-Laurence)
BRACORS 4: July 4 to 8, 1985 (N/O Korotneff)
BRACORS 5: November 4 to 22, 1985 (N/O Catherine-Laurence)
BRACORS 6: January 19 to 23, 1987 (N/O Catherine-Laurence)

Sampling gear: B = Shipeck tipper; C = small beam trawl (2m wide); D = Charcot-Picard dredge with underpants (burlap); DF = Charcot-Picard dredger (without underpants) with a 10mm mesh net, protected by a 10-mesh net; L = sledge. -: indicates an incomplete or empty sample (damage).

Table 7 : Distribution of brachiopods (in number of individuals) in the BraCors campaign stations (Table 6). Figures 9-4 , 9-5 , 9-6 , 9-7 and 9-8 . At some stations, counts were made of *Gryphus* according to the color of the white or green shell colonized by the algae *Ostreobium* . For the complete legend: see Table 6.

Station		Country	gear	Prof [m]	Dist [miles]	*Gryphus*	*Gryphus* b/v	*Terebratulina*	*Megerlia*	*Megathiris*	*Novocrania*	*Platidia*
CL	1	1983 -1	D	125 125	.35	25		1	1			
CL	1	1983 -1	VS	125 125	.20	40						
CL	1/2	1984 -3	DF	146 150	.40	36						
CL	2	1983 -1	VS	125 135		40		40	10	1		
CL	2-85	1985 -4	DF	125 130		61	28 / 33					
CL	3	1983 -1	VS	130 130		7		8	1			
CL	4	1983 -1	VS	138 130		2		2	12	1		1
CL	6	1983 -1	VS	140 135	.22	3						
CL	9	1983 -1	VS	130 130	.20	3						
CL	10	1983 -1	VS	130 105	.39	8			1			
CL	11	1983 -1	VS	130 110	.50	5						
CL	12	1983 -1	DF	125 105	.24	20		1				
CL	13	1983 -1	DF	120 100	.34	40		40	20	20		
CL	13-1	1985 -4	DF	140		219	194 / 25	10	2		1	
CL	13-2	1985 -4	DF	150 160		135	130 / 5					
CL	13-6	1985 -4	DF	125 125		61	13 / 48	40				

CL	13-7	1985 -4	DF	110 115		56	8 / 48					
CL	13-11	1985 -4	DF	120 120		24	7 / 17					
CL	13-13	1985 -5	DF	140 140	.39	200	200 / 15					
CL	13-14	1985 -5	DF	135 135	.43	264	144 / 120					
CL	13-15	1985 -5	DF	117	.27			10	10	10		
CL	13-16	1985 -5	DF	128 115	.79			40	20	20	20	
CL	13-18	1985 -5	DF	125 125	.27	10		10	10	10	10	
CL	13-19	1985 -5	DF	107 98	.32	10		10	10	10	10	
CL	13-20	1985 -5	DF	135 127	.34	372	172 / 193	10	10			
CL	13-21	1985 -5	DF	123 110	.36			10	10	10	10	
CL	14	1983 -1	DF	115 105	.18			55	104	76	30	1
CL	14	1984 -3	DF	140 85	.48	20		20	20	20	20	
CL	15	1983 -1	DF	100 95	.27			40	100	40	68	
CL	15	1984 -3	DF	110 98	.39			10	10	10		
CL	15a	1984 -3	DF	150 97	.46			20	20	20		
CL	15b2	1984 -3	DF	155 139	.40			15	18			
CL	15b3	1984 -3	DF	160 143	.25	2						
CL	15b4	1984 -3	DF	160 135	.34			13	24	15	2	
CL	15-4	1984 -3	DF	110 110	.32			20	20	10		
CL	16	1983 -1	VS	140 105	.53	40		20	10		1	
CL	17	1983 -1	VS	130 140	.50	40						
CL	18	1983 -1	VS	130 135	7.02	30		2	7			
CL	21	1983 -1	DF	93 90	.43	40						
CL	21	1984 -3	DF	105 105	.23	4		32	24	24	7	
CL	22	1983 -1	DF	116 125	.41	40						
CL	23	1983 -1	VS	120 130	.44	100		1				
CL	25	1983 -1	VS	123 128	.39	40		2	1			
CL	26	1983 -1	VS	140 145	.35	20		40	20	1	1	30
CL	26	1984 -3	DF	150 150	.42	90						
CL	26	1985 -4	DF	135 140		84	68 / 16	68	16	1		
CL	26-1	1985 -4	DF	155 160		8	6 / 2	6	2			
CL	27	1983 -1	DF	165 145	.43	7						
CL	30	1983 -1	DF	300 250	.52	1			2		2	
CL	31	1983 -1	DF	200 120	.24	100		100	100	100		100
CL	34'	1983 -1	DF	160 140	.32	40						
CL	34' 1	1984 -3	DF	170 180	.51	90						
CL	35	1983 -1	DF	105 125	.37	9		100	9	4		
CL	35-1	1984 -3	DF	150 150	.69	27						
CL	38	1983 -1	DF	117 120	.38	5						
CL	39	1983 -1	DF	220 180	.24	8			2		2	
CL	41	1983 -1	DF	125 125	.43	40						
CL	42	1983 -1	DF	135 123	.60	40						
CL	43	1983 -1	DF	145 230	.66	40						
CL	44	1983 -1	VS	?180 136	.35	23		7	20			
CL	46	1983 -1	DF	170 150	.45	100		1				
CL	46	1985 -4	DF	150 135		158	20 / 138					
CL	47	1983 -1	DF	170 143	.64	40						
CL	49	1983 -1	DF	150 130	.25	8						
CL	50	1983 -1	DF	135 120	.29	6		4	2			
CL	52	1983 -1	DF	160 115	.28	5		85	77	6	2	
CL	53	1983 -1	DF	160 115	.10	1						
CL	59'	1983 -1	DF	180 190	.20				1			
CL	60	1983 -1	DF	200 180	.35	2					1	
CL	61	1983 -1	DF	140 105	.25	1		1				
CL	63	1983 -1	DF	150 105	.20	1		5	1	2		
CL	66	1983 -1	DF	200 160	.20	1						
CL	68	1983 -1	DF	115 95	.24				1			
CL	70	1983 -1	DF	210 130	.24				3			
CL	72	1983 -1	DF	190 160	.14	1		1			1	
CL	73	1983 -1	DF	125 90	.25			8	2	4		
CL	74	1983 -1	DF	110 170	.15	11		120	124	69	1	
CL	74	1984 -3	DF	120 143	.37	4		10	10	10		
CL	74-1	1984 -3	DF	150 110	.51	30						

CL	74-2	1984 -3	DF	150 90	.16	8		16			1
CL	74-3	1984 -3	DF	200 180		12					
CL	74-4	1984 -3	DF	190 160	.29			3	4		4
CL	80	1984 -2	DF	150 140	.43	1		1			
CL	83	1984 -2	DF	123 97	.14				15		1
CL	85	1984 -2	DF	150 122	.35				2	1	
CL	87	1984 -2	DF	128 110	.25			4	24	22	1
CL	88	1984 -2	DF	100 87	.13				13	8	1
CL	91	1984 -2	DF	142?	.39				30		
CL	96	1984 -2	DF	160 150	.26	1					
CL	97	1984 -2	DF	150 137	.43	50					
CL	98	1984 -2	DF	160 145	.57	40					
CL	99	1984 -2	D	145 145	.10	15		1	20		
CL	100	1984 -2	DF	145 145	.54	15					
CL	101	1984 -2	DF	155 142	.43	100					
CL	103	1984 -2	DF	124 125	.44	10					
CL	104	1984 -2	DF	146 140	.46	300					
CL	106	1984 -2	DF	148 154	.50	30					
CL	107	1984 -2	DF	150 120	.13	2		5	4	5	
CL	110	1984 -2	DF	+150 145	.56	14					
CL	111	1984 -2	DF	155 130	.42	<100					
CL	112	1984 -2	DF	150 127	.59	38					
CL	114	1984 -2	DF	200 150	.14	5					
CL	115	1984 -2	DF-	135 117	.25	1		2			
CL	116	1984 -2	DF	150 119	.31	9					2
CL	117	1984 -2	DF	155 137	.57	6					
CL	118	1984 -2	DF	123 150	.25	14	11 / 3				
CL	123	1984 -2	DF	150 130	.53				1		
CL	124	1984 -2	DF	132 155	.43	15					
CL	125	1984 -2	DF	140 128	.43	10			1		
CL	126	1984 -2	DF	147 154	.46	7					
CL	129	1987 -6	DF	181 192	.31	218	210 / 0				
CL	130	1987 -6	DF	166 175	.34	296	296 / 0				
CL	131	1987 -6	DF	156 162	.35	4					
CL	132	1987 -6	DF	170 253	.25	69	69 / 0				
CL	137	1987 -6	DF	127 118	.24	8	8 / 0	37	51	5	2
CL	138	1987 -6	DF	155 164	.38	582	491 / 91				
CL	138-1	1987 -6	DF	155 163	.36	250	194 / 56	3	1		
CL	139	1987 -6	DF	165 169	.34	430	380 / 50				
CL	143	1987 -6	DF	110 99	.37	15	13 / 2	12	3		
CL	145	1987 -6	DF	120 127	.25	35	30 / 5	2			
CL	147	1987 -6	DF	180 197	.24	295					
CL	148	1987 -6	DF	163 178	.19	149					
CL	149	1987 -6	DF	145 174	.46	32	32 / 0				
CL	150	1985 –5	DF	220 161	.18	278	277 / 1	8	10		
CL	151	1985 –5	DF	180 210	.56	21	21 / 0	10	5		
CL	152	1985 –5	DF	180 146	.35	148	120 / 28	10	10		
CL	154-2	1985 –5	DF	240 208	.41	33	33 / 0				
CL	156	1985 –5	DF	330 285	.61	1	0 / 1				
CL	157	1985 –5	DF	120 111	.55	45	0 / 45				
CL	158	1985 –5	DF	110 100	.60	1	0 / 1	2	2		
CL	159	1985 –5	DF	130 140	.51	577	164 / 413				
CL	160	1985 –5	DF	230 240	.72	5	5 / 0				
CL	161	1985 –5	DF	225 150	.53	29	21 / 8				
CL	162	1985 –5	DF	147 143	.59	750	35 / 715				
CL	163	1985 -5	DF	290 310	.57	33	22 / 11				
CL	164	1985 -5	DF	280 310	.77	47	47 / 0				
CL	165	1985 -5	DF	160 160	.43	7	6 / 1				
CL	166	1985 -5	DF	190 150	.41	230	230 / 0				
CL	167	1985 -5	DF	200 195	.49	30	30 / 0				
CL	168	1985 -5	DF	147 103	.31	19	5 / 14				
CL	169	1985 -5	DF	220 210	.65	46	46 / 0				

CL	170	1985 -5	DF	263 236	.38	1	1 / 0				
CL	171	1985 -5	DF	150 105	.31	43	33 / 10				
CL	172	1985 -5	DF	100 200	.62	27	27 / 0				
CL	174	1985 -5	DF	100 175	.56	1	0 / 1				
CL	175	1985 -5	DF	230 110	.48	10	10 / 0				
CL	176	1985 -5	DF	248 110	.70	10	10 / 0				
CL	179	1985 -5	DF	211 160	.19	93	93 / 0				
CL	180	1985 -5	DF	130 120	.41	17	11 / 6				
CL	181	1985 -5	DF	90 120	.43	15	1 / 14				
CL	182	1985 -5	DF	100 107	.56	2	2 / 0				
CL	182-2	1985 -5	DF	120 105	.46	2	1 / 1				
CL	183	1985 -5	DF	120 115	.39	2	2 / 0				
CL	184	1985 -5	DF	160 140	.63	52	52 / 0				
CL	186	1985 -5	DF	130 105	.22	55	33 / 32				
CL	187	1985 -5	D	145 150	.36	2	2 / 0				
CL	188	1985 -5	DF	130 125	.60	269	220 / 49				
CL	190	1985 -5	DF	150 148	.58	1	1 / 0				
CL	191	1985 -5	DF	150 120	.43	1					
CL	195	1985 -5	DF	150 115	.38			10	10		
CL	198	1985 -5	DF	141,200	.57	248	248 / 0				
CL	201	1987 -6	DF	166 160	.28	10	10 / 0				
CL	202	1987 -6	DF	140 135	.24	15	10 / 5	5	5	3	10

Table 8 : BathyMed campaign (CNRS; head of mission: Christian C. Emig), from November 7 to 22, 1988 (N/O Catherine-Laurence). Figures 9-4 , 9-5 and 9-6 .

Depths in meters and coordinates of the beginning [D] and end [F] of traict.

Sampling gear: B = Shipeck tipper; C = small beam trawl (2m wide); D = Charcot-Picard dredge with underpants (burlap); DF = Charcot-Picard dredger (without underpants) with a 10mm mesh net, protected by a 10-mesh net; L = sledge. -: indicates an incomplete or empty sample (damage).

Campaign and Stations	Depth [D - F]		course	Latitude N [D]	Longitude E [D]	Latitude N [F]	Longitude E [F]	gear	Transect	Brachiopoda
BM 1	200	180	60	42°45.00	9°01.04	42°45.38	9°02.15'	D-	C4	
BM 2	220	220	240	42°45.71	9°02.64	42°45.44	9°02.21	D-	C4	
BM 3	200	186	230	42°45.46	9°02.14	42°45.22	9°01.56	DF	C4	B
BM 4	200	200		42°45.20	9°01.31			B	C4	
BM 5	200	200	230	42°45.70	9°02.69	42°45.41	9°02.07	D	C4	
BM 6	173	199	230	42°45.30	9°01.87	42°45.25	9°01.55	L	C4	
BM 7	155	156	255	42°45.20	9°01.86	42°45.12	9°01.50	DF	C4	B
BM 8	155	155		42°45.12	9°01.50			B	C4	
MB 8'	155	155		42°45.12	9°01.50			B	C4	
BM 9	146	168	255	42°45.17	9°01.92	42°45.13	9°01.40	dj	C4	
BM 10	149	164	255	42°45.30	9°02.16	42°45.13	9°01.41	VS-	C4	
BM 11	150	159	255	42°45.18	9°01.91	45°44.81	9°00.88	VS	C4	B
BM 12	146	145		42°45.00	9°02.19	45°44.71	9°01.80	DF-	C4	
BM 13	147	144		42°44.98	9°02.15	42°44.68	9°01.80	DF	C4	B
BM 14	141	140	230	42°44.88	9°02.16	42°44.61	9°01.78	dj	C4	
BM 15	139	139		42°44.61	9°01.81	42°44.58	9°01.76	B	C4	
BM 15'	140	141		42°44.56	9°01.64	42°44.55	9°01.63	B	C4	
BM 16	460	457	230	42°46.65	9°00.99	42°46.30	9°00.34	D	C4	
BM 17	464	464		42°46.69	9°01.18	42°46.71	9°01.20	B-	C4	
BM 18	463	442		42°46.69	9°01.18	42°46.08	8°59.70	L	C4	
BM 19	143	141		42°45.03	9°02.34	42°44.62	9°01.76	DF-	C4	B
BM 20	137	123		42°44.51	9°01.64	42°43.88	9°01.32	DF	C4	B
BM 21	119	115		42°44.28	9°01.84	42°43.94	9°01.41	D-	C4	
BM 22	115	115		42°44.61	9°02.23			D-	C4	B
BM 23	117	118	210	42°44.76	9°02.73	42°44.59	9°02.41	DF	C4	B
BM 24	114	122		42°44.65	9°02.29			B-	C4	
BM 25	135	133		42°44.88	9°02.34	42°44.06	9°01.47	L	C4	
BM 26	132	128		42°41.31	8°48.86	42°41.20	8°48.47	DF	C3	B
BM 27	128	132		42°41.17	8°48.43	42°41.01	8°47.93	DF	C3	B
BM 28	143	136		42°41.56	8°48.47	42°41.51	8°48.14	DF	C3	B
BM 29	149	142		42°41.57	8°48.70	42°41.59	8°48.09	DF	C3	B
BM 30	147	139	250	42°41.67	8°48.11	42°41.60	8°47.61	DF	C3	B
BM 31	124	122	230	42°39.26	8°47.45	42°38.95	8°47.32	DF	C2	B
BM 32	124	122	230	42°39.54	8°47.10	42°39.34	9°46.78	DF	C2	B
BM 33	130	128		42°39.62	8°46.72	42°39.21	8°46.25	DF	C2	B

BM 34	126	126		42°39.15	8°46.27			B	C2	
BM 35	133	129		42°39.31	8°46.12	42°38.97	8°45.87	dj	C2	
BM 36	131	129	220	42°39.77	8°46.75	42°39.09	8°45.95	L	C2	
BMW 37	143	141		42°39.84	8°45.94	42°39.48	8°45.55	DF	C2	B
BMW 38	150	152		42°39.62	8°45.25	42°39.28	8°44.88	DF	C2	B
BMW 39	164	165	230	42°40.57	8°45.19	42°40.20	8°44.79	DF	C2	B
BM 40	181	176	230	42°42.37	8°44.47	42°40.03	8°44.21	D	C2	B
BM 41	176	177	220	42°40.47	8°44.71	42°39.87	8°44.05	L	C2	
BM 42	176	176		42°39.81	8°44.05			B-	C2	
BM 43	175	175		42°39.80	8°44.08			B-	C2	
BM 44	175	175		42°39.75	8°44.12			B-	C2	
BM 45	174	176		42°40.32	8°44.66	42°39.80	8°44.07	VS	C2	B
BM 46	197	192	220	42°40.24	8°44.09	42°39.90	8°43.74	DF	C2	B
BM 47	231	238	220	42°40.39	8°43.78	42°40.27	8°43.44	DF-	C2	
BM 48	231	224	220	42°40.47	8°43.85	42°40.03	8°43.50	DF	C2	B
BM 49	231	238	40	42°40.19	8°43.52	42°40.81	8°44.54	D	C2	
BM 50	230	230		42°40.85	8°44.87			B	C2	
BM 51	175	175		42°39.77	8°44.07			B	C3	
BM 52	420	460		42°40.37	8°42.93	42°41.38	8°44.58	D-	C3	
BM 53	473	471	70	42°41.50	8°45.48	42°42.16	8°47.18	J-	C3	
BM 54	450	465	240	42°42.28	8°47.53	42°41.91	8°46.36	L-	C3	
BM 55	434	468	250	42°42.00	8°46.70	42°41.67	8°45.93	D	C3	
BM 56	368	420		42°41.95	8°46.97	42°42.11	8°48.12	D-	C3	
BMW 57	448	448		42°42.22	8°48.37			B	C3	
BM 57'	448	448		42°42.22	8°48.37			B	C3	
BMW 58	150	162	260	42°41.62	8°48.35	42°41.78	8°47.71	DF	C3	B
BMW 59	170	188		42°41.78	8°47.65	42°41.73	8°47.09	DF	C3	B
BM 60	214	250		42°41.79	8°47.51	42°41.76	8°48.39	DF	C3	B
BM 61	345	373	240	42°41.92	8°47.20	42°41.79	8°46.41	DF	C3	B
BM 62	350	350		42°41.90	8°46.95			B	C3	
BM 63	230	230		42°41.79	8°47.39			B	C3	
BMW 64	171	171		42°41.78	8°47.71			B	C3	
BM 64'	170	170		42°41.78	8°47.70			B	C3	
BMW 65	145	145		42°41.62	8°48.19			B-	C3	
BMW 66	148	148		42°41.58	8°48.22			B-	C3	B
BMW 67	210	212	10	42°56.55	9°33.62	42°57.10	9°33.73	DF	C6S	B
BMW 68	234	237	190	42°57.07	9°33.99	42°56.43	9°33.78	DF	C6S	B
BMW 69	234	234	10	42°56.47	9°33.75	42°56.97	9°33.99	D	C6S	
BM 70	303	310	190	42°56.80	9°35.83	42°56.12	9°35.46	D	C6S	
BMW 71	382	390	10	42°55.34	9°40.07	42°56.87	9°40.34	D	C6S	
BM 72	392	392		42°57.01	9°40.48			B	C6S	
BMW 73	303	303		42°56.80	9°35.86			B	C6S	
BMW 74	230	230		42°57.08	9°33.97			B	C6S	
BMW 75	180	180		42°46.94	9°33.44			B	C6S	
BMW 76	182	196	190	42°57.46	9°33.55	42°56.76	9°33.48	DF	C6S	B
BMW 77	160	172	10	42°56.97	9°33.41	42°57.68	9°33.49	DF	C6S	B
BMW 78	163	170	190	42°57.72	9°33.49	42°57.13	9°33.45	D	C6S	B
BMW 79	142	146	10	42°57.29	9°33.35	42°57.74	9°33.44	DF-	C6S	
BM 80	142	146	190	42°57.76	9°33.43	42°57.14	9°33.36	DF	C6S	B
BM 81	128	134	10	42°57.20	9°33.31	42°57.66	9°33.37	DF	C6S	B
BM 82	148	146	190	42°57.43	9°33.36	42°56.27	9°33.12	VS	C6S	B
BM 83	125	122	10	42°56.40	9°33.14	42°57.03	9°33.26	DF	C6S	B
BMW 84	111	105	190	42°57.01	9°33.18	42°56.39	9°32.78	DF	C6S	B
BMW 85	106	106		42°56.40	9°32.77			B	C6S	
BMW 86	136	136		42°57.68	9°33.40			B	C6S	
BMW 87	116	108	10	42°57.69	9°33.32	42°58.38	9°33.41	DF	C6S	
BMW 88	152	150	350	43°12.05	9°32.53	43°12.93	9°32.22	DF	C6 N	B
BMW 89	182	190	170	43°12.98	9°32.37	43°12.36	9°32.58	DF	C6 N	B
BM 90	215	233	350	43°12.44	9°32.66	43°13.23	9°32.35	DF	C6 N	B
BMW 91	278	290	170	43°13.20	9°32.64	43°12.33	9°33.06	DF	C6 N	B
BMW 92	340	353	350	43°12.37	9°33.68	43°13.57	9°33.26	D	C6 N	
BMW 93	410	410	186	43°14.08	9°35.57	43°13.34	9°35.49	D	C6 N	
BMW 94	410	410		43°13.34	9°35.52			B	C6 N	
BMW 95	350	350		43°13.34	9°33.22			B	C6 N	
BMW 96	314	320		43°13.31	9°32.89	43°12.36	9°33.42	B	C6 N	
BMW 97	232	232		43°12.26	9°32.74			B	C6 N	

BMW 98	154	154		43°12.31	9°32.49			B	C6 N	
BMW 99	173	248	170	43°12.12	9°32.56	43°10.88	9°33.18	VS	C6 N	B

Table 9 : Distribution of brachiopods (in number of individuals) in the stations of the BathyMed campaign (Table 8). Figures 9-4 , 9-5 and 9-6 . In some stations, counts were made on the *Gryphus* according to the color of the white or green shell colonized by the algae *Ostreobium* . For the complete legend: see Table 8.

Campaign and Stations	Depth [D-F]		Dist [miles]	Transect	*Gryphus*	*Gryphus* b/v	*Terebratulina*	*Megerlia*	*Megathiris*	*Novocrania*	*Platidia*
BM 3D	200	186		C4	36	36/0	3				
BM 7 D	155	156		C4	11	11/0	19	1		1	
BM 11 C	150	159		C4	421	302/119					
BM 13 D	147	144		C4	7	6/1					
BM 19 D	143	141		C4	10	10/0	1				
BM 20 D	137	123	0.49	C4	3	1/2					
BM 22 DJ	115	115		C4	1		8	15	7	1	
BM 23 D	117	118	0.25	C4	8	6/2	25	11	2		
BM 26 D	132	128	0.24	C3	14		4	11	2		
BM 27 D	128	132	0.36	C3	138	8/130	2	1		1	
BM 28 D	143	136	0.24	C3	16	16/0	29	7	2	3	
BM 29 D	149	142	0.37	C3			5	13		2	
BM 30 D	147	139	0.35	C3	2		21	41			36
BM 31 D	124	122	0.20	C2			3		3		
BM 32 D	124	122	0.21	C2	2		5	2			
BM 33 D	130	128	0.44	C2	29	5/24					
BM 37 D	143	141	0.36	C2	9	1/8					
BM 38 D	150	152	0.39	C2	7	6/1					
BM 39 D	164	165	0.41	C2	166	155/11					
BM 40 DJ	181	176	0.35	C2	21	2/19					
BM 45 C	174	176	0.68	C2	441	424/17					
BM 46 D	197	192	0.38	C2	92	92/0					
BM 48 D	231	224	0.56	C2	2	2/0					
BM 58 D	150	162	0.47	C3			5	7		1	4
BM 59 D	170	188	0.39	C3			13	11		26	
BM 60 D	214	250	0.44	C3	32	32/0	25	6		1	1
BM 61 D	345	373	0.67	C3	2	2/0					
BM 66 B	148	148		C3			1	10			3
BM 67 D	210	212	0.46	C6S	76	75/1					
BM 68 D	234	237	0.41	C6S	12	12/0					
BM 76 D	182	196	0.49	C6S	74	74/0					
BM 77 D	160	172	0.62	C6S	28	0/28					
BM 78 DJ	163	170	0.34	C6S	5	5/0					
BM 80 D	142	146	0.33	C6S	43	39/4					
BM 81 D	128	134	0.43	C6S	7	7/0					
BM 82 C	148	146	0.76	C6S	351	260/91					
BM 83 D	125	122	0.55	C6S	15	14/1					
BM 84 D	111	105	0.42	C6S	24	10/14					
BM 88 D	152	150	0.57	C6 N	56	5/51					
BM 89 D	182	190	0.56	C6 N	18	7/11		1			
BM 90 D	215	233	0.53	C6 N	12	11/1					
BM 91 D	278	290	0.77	C6 N	32	32/0					
BM 99 C	173	248	0.83	C6 N	374	231/143					

Table 10 : Meditis 2-4 cruises (IFREMER) with N/O Europe. They took place in May or June between 2012 and 2014; only stations with brachiopods have been listed. Figures 9-4 and 9-7 .

[D] are the data when setting the trawl; [F] when trawling. Traict distance in meters, its duration in minutes and the number of *Gryphus* harvested with a trawl.

Year	Station	Latitude N [D]	Longitude E [D]	Depth [m] [D]	Latitude N [F]	Longitude E [F]	Depth [m] [F]	Duration [min]	Distance [m]	*Gryphus*
2012	2-7	42°14.22'	9°37.70'	110	42°15.65'	9°38.38'	108	30	2815	141
2012	2-10	41°56.60'	9°33.73'	142	41°55.48'	9°32.49'	130	30	2685	4237
2012	2-13	42°21.20'	9°39.47'	318	42°24.25'	9°40.28'	361	60	5759	5
2012	2-15	42°34.75'	9°40.78'	337	42°37.32'	9°39.67'	365	54	5000	1
2012	2-16	42°22.35'	9°37.16'	113	42°20.83'	9°37.14'	112	31	2833	374
2012	2-20	41°35.21'	9°31.98'	383	41°32.34'	9°33.22'	376	60	4777	15

2012	2-21	41°28.46'	9°28.53'	92	41°29.82'	9°27.61'	88	30	2815	1
2012	2-22	41°38.54'	9°27.64'	106	41°37.11'	9°28.32'	117	30	2796	506
2012	2-23	41°36.91'	9°32.05'	479	41°34.34'	9°34.21'	482	60	5630	17
2012	2-80	42°52.28'	4°40.17'	330	42°50.33'	4°43.17'	313	61	5556	35
2013	3-2	42°28.11'	9°37.38'	89	42°26.64'	9°37.19'	77	30	2741	6
2013	3-5	42°20.95'	9°37.19'	112	42°22.49'	9°37.16'	110	29	2852	2894
2013	3-11	41°32.17'	9°33.21'	377	41°35.02'	9°32.09'	370	60	5519	42
2013	3-13	41°36.79'	9°28.43'	114	41°38.15'	9°27.78'	105	30	2667	5219
2013	3-15	41°46.04'	9°28.92'	479	41°48.58'	9°31.26'	493	60	5704	41
2013	3-19	41°56.77'	9°33.91'	143	41°55.54'	9°32.64'	129	29	2852	2391
2013	3-20	42°14.30'	9°37.73'	106	42°15.71'	9°38.35'	106	29	2760	23
2013	3-35	42°47.13'	3°54.31'	350	42°44.07'	3°55.19'	478	60	5815	1
2013	3-75	42°52.33'	4°39.62'	158	42°50.89'	4°41.92'	269	60	5574	94
2013	3-76	42°49.12'	4°41.75'	345	42°46.13'	4°43.38'	760	60	6000	3
2014	4-3	42°40.96'	9°34.40'	300	42°38.34'	9°36.49'	268	60	5667	3
2014	4-6	42°14.76'	9°38.00'	110	42°16.18'	9°38.43'	106	30	2759	19
2014	4-9	41°37.42'	9°31.40'	448	41°34.96'	9°33.79'	484	60	5556	51
2014	4-10	41°37.19'	9°28.21'	114	41°38.59'	9°27.57'	105	30	2741	1
2014	4-12	41°47.37'	9°30.06'	460	41°44.81'	9°27.81'	351	60	5667	36
2014	4-13	41°57.17'	9°37.14'	446	41°54.14'	9°36.52'	554	60	5667	7
2014	4-16	41°57.17'	9°34.34'	151	41°56.01'	9°33.03'	135	31	2797	2106
2014	4-19	42°22.50'	9°37.12'	111	42°20.86'	9°37.14'	112	30	3037	517
2014	4-21	41°58.53'	9°37.78'	440	42°01.22'	9°39.48'	386	61	5500	4
2014	4-69	42°35.69'	4°13.25'	750	42°32.90'	4°12.20'	897	60	5371	1
2014	4-75	42°52.36'	4°40.13'	272	42°50.30'	4°43.08'	315	60	5556	52

9. Cards

A. Maps of the campaigns in Languedoc and Provence

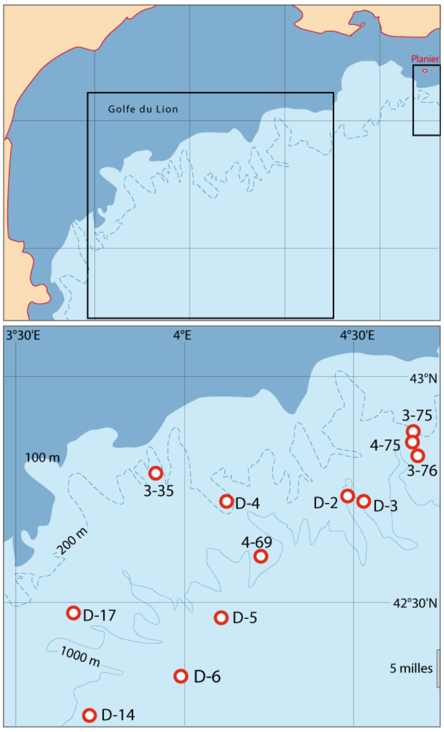


Figure 9-1 : Gulf of Lion. Location of the harvesting area - and - *Gryphus vitreus* harvesting stations during the Deprog campaign. See Table 5.

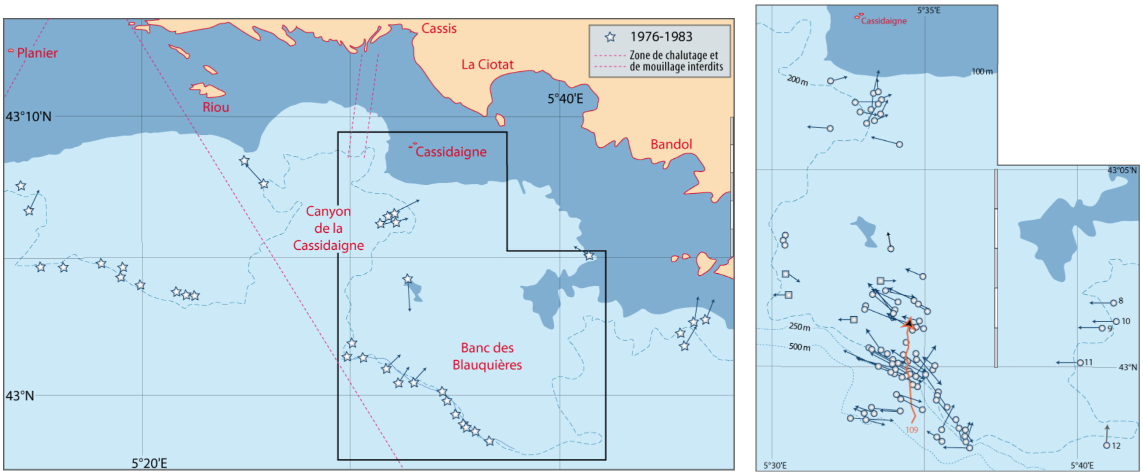
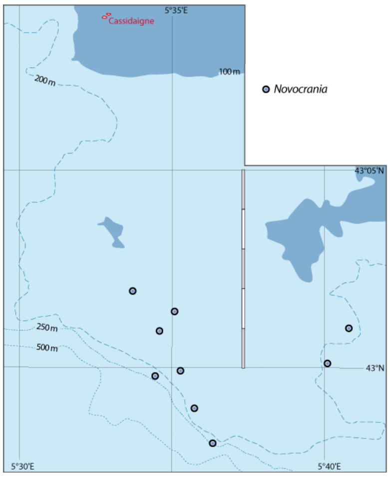
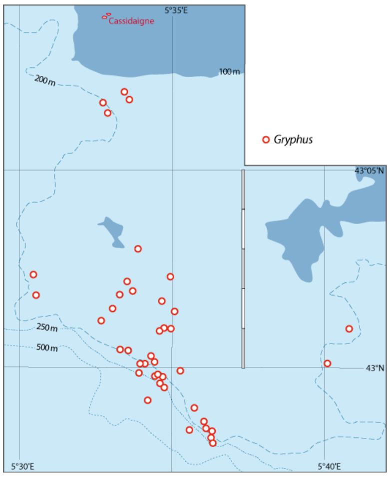
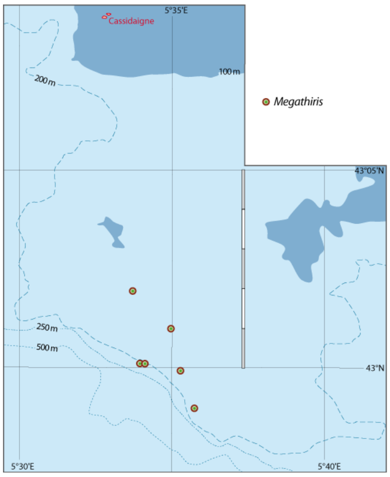


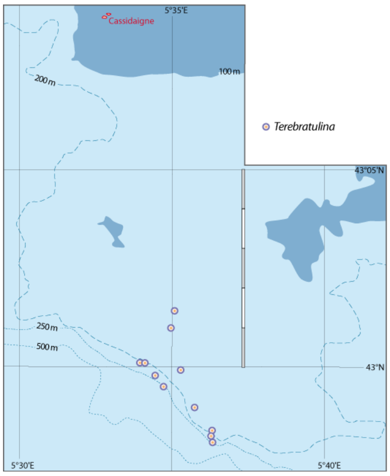
Figure 9-2 : West Provence. Location of harvest areas. The stars indicate the survey stations on brachiopods between 1976 and 1983 - and - Stations of the BraProv (CNRS) and IsoBra (CNRS) campaigns. See Tables 3 and 5.

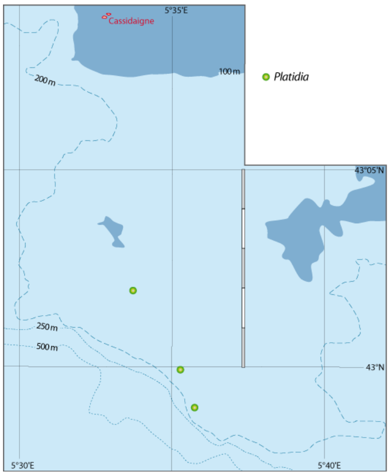
Below are the distribution maps of *Novocrania anomala* . -Gryphus *vitreus* . - *Megathiris detruncata* . - *Terebratulina retusa* . - *Platidia anomioides* . -Megerlia *truncata* . See Tables 4 and 5.

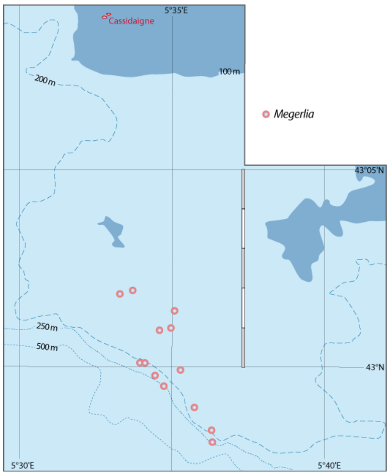












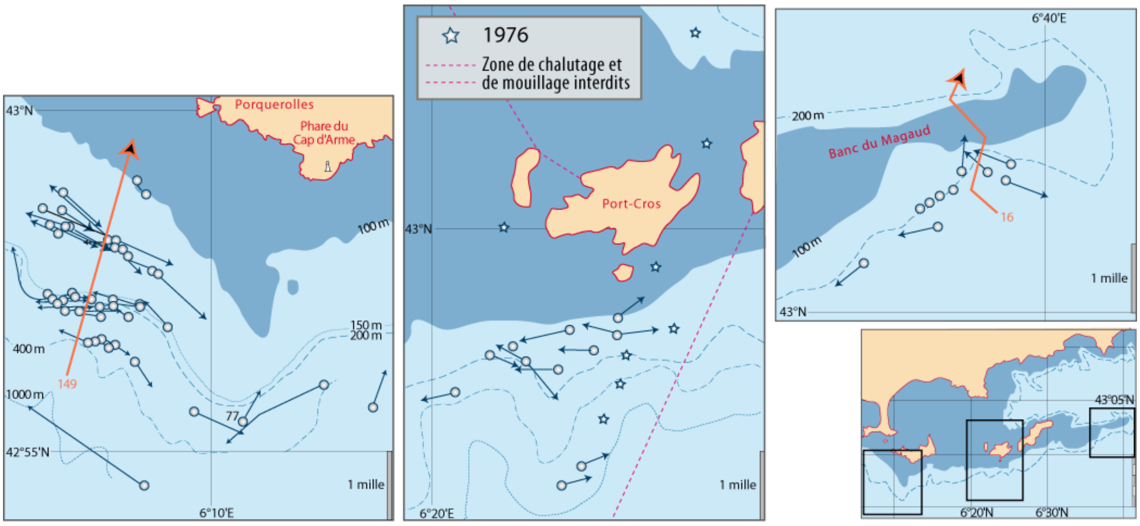
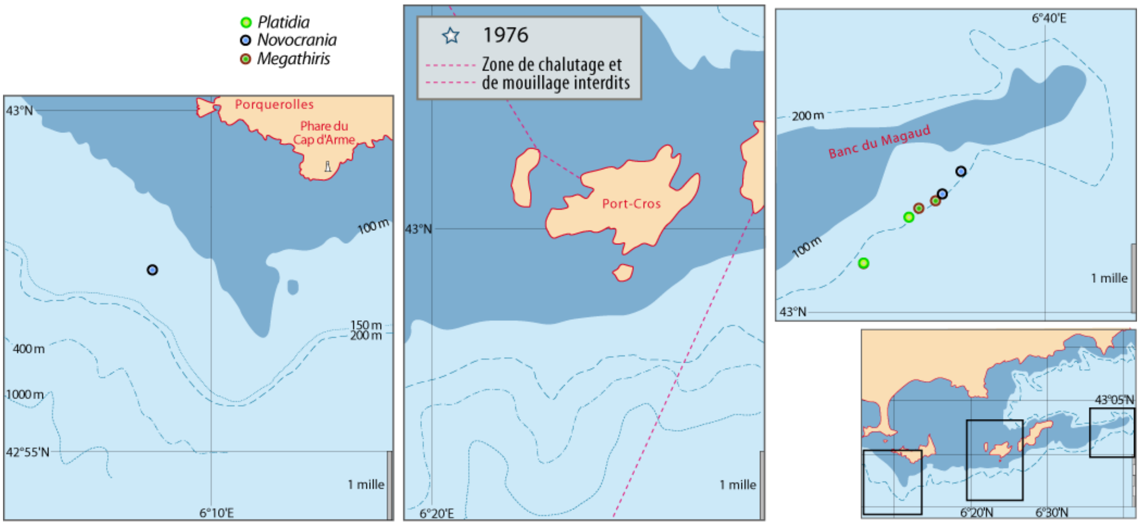
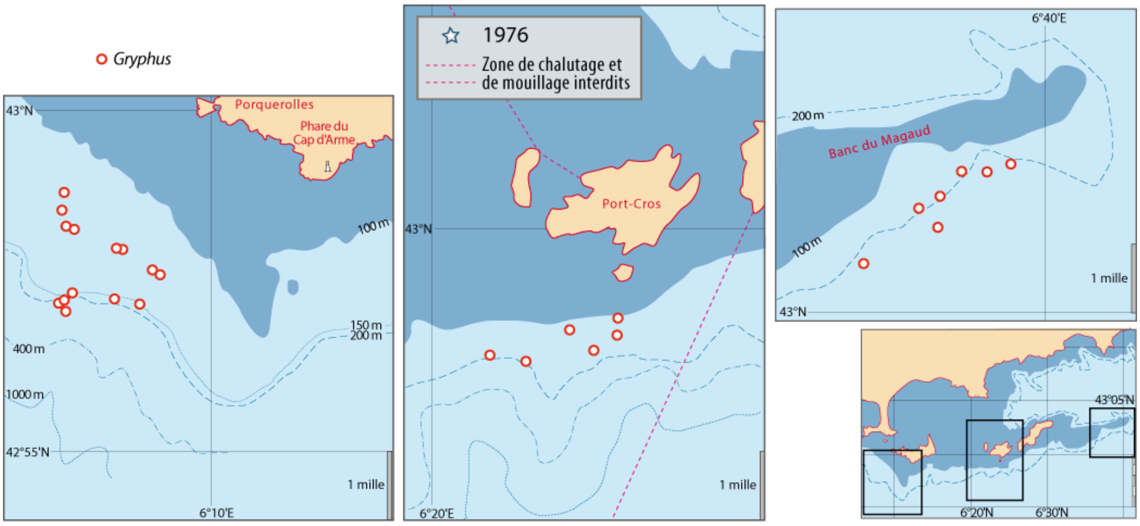
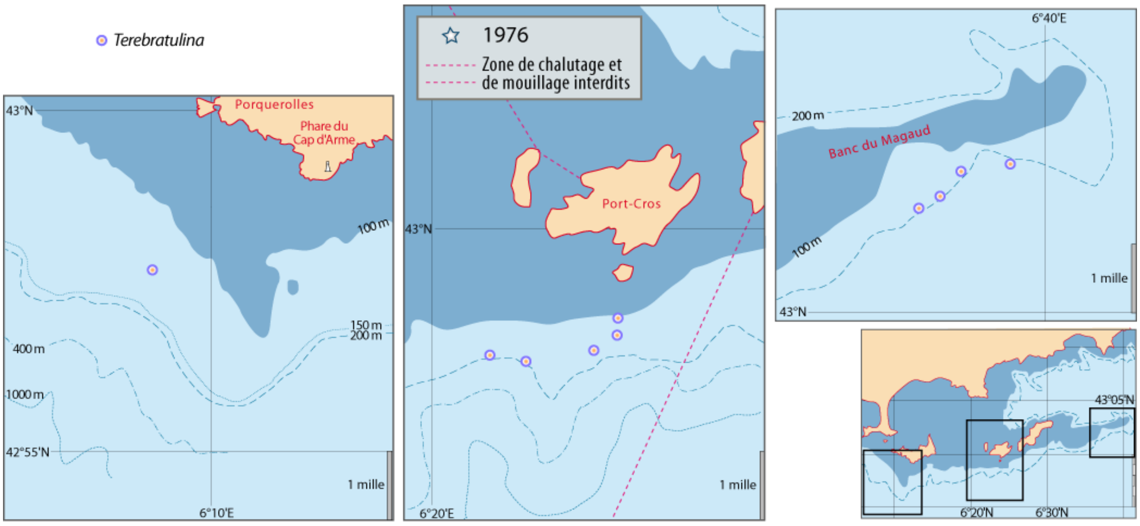


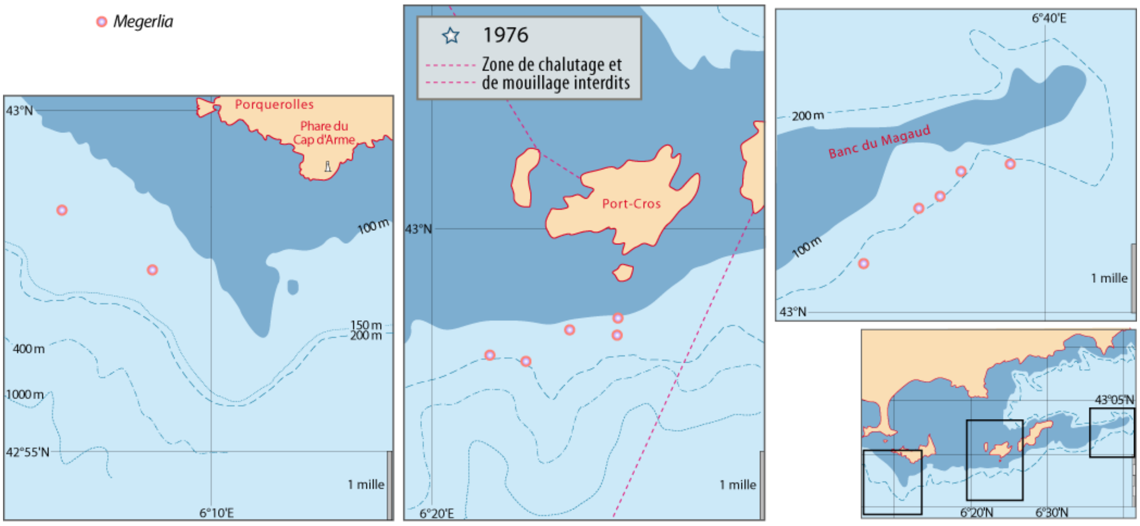
Figure 9-3 : Eastern Provence. Location of harvesting areas and BraProv campaign stations (CNRS). See Table 3. The stars indicate the survey stations on brachiopods in 1976 during a campaign with the N/O Antedon in the Marine National Park of Port-Cros. This area includes two of the radials (arrows) followed by submersible.

Below are the distribution maps of *Novocrania anomala.* - *Megathiris detruncata* . - *Platidia anomioides* . *Gryphus vitreus* . - *Terebratulina retusa* . -Megerlia *truncata* . See Table 4.









B. Maps of campaigns in Corsica

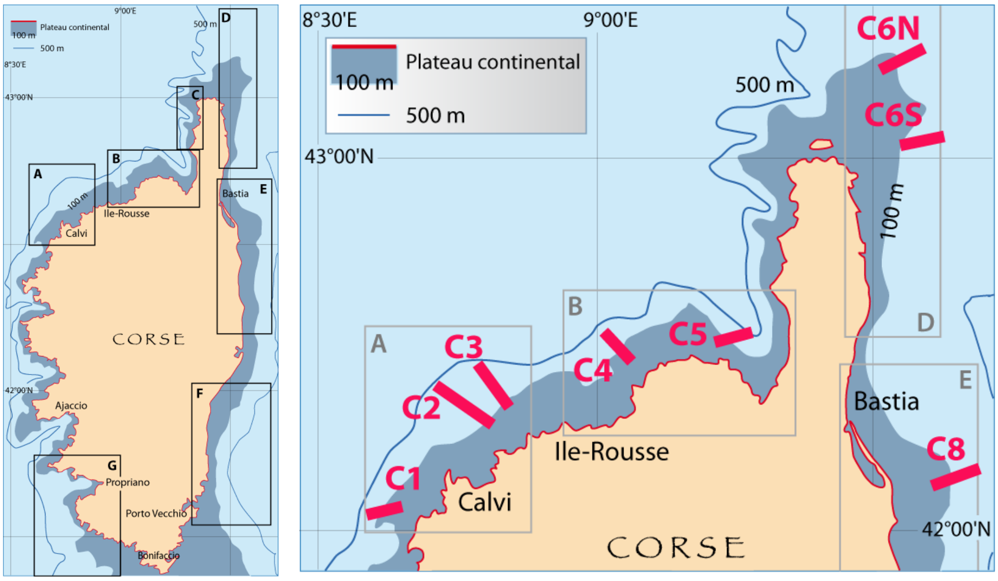


Figure 9-4 : Campaigns in Corsica:
Left - Location of harvest areas (A to G) during the BraCors (CNRS), BathyMed (CNRS) and Meditis (Ifremer) campaigns. See Tables 6, 8, 10.
Right - Radials that have been tracked over several years. See chapter 6.

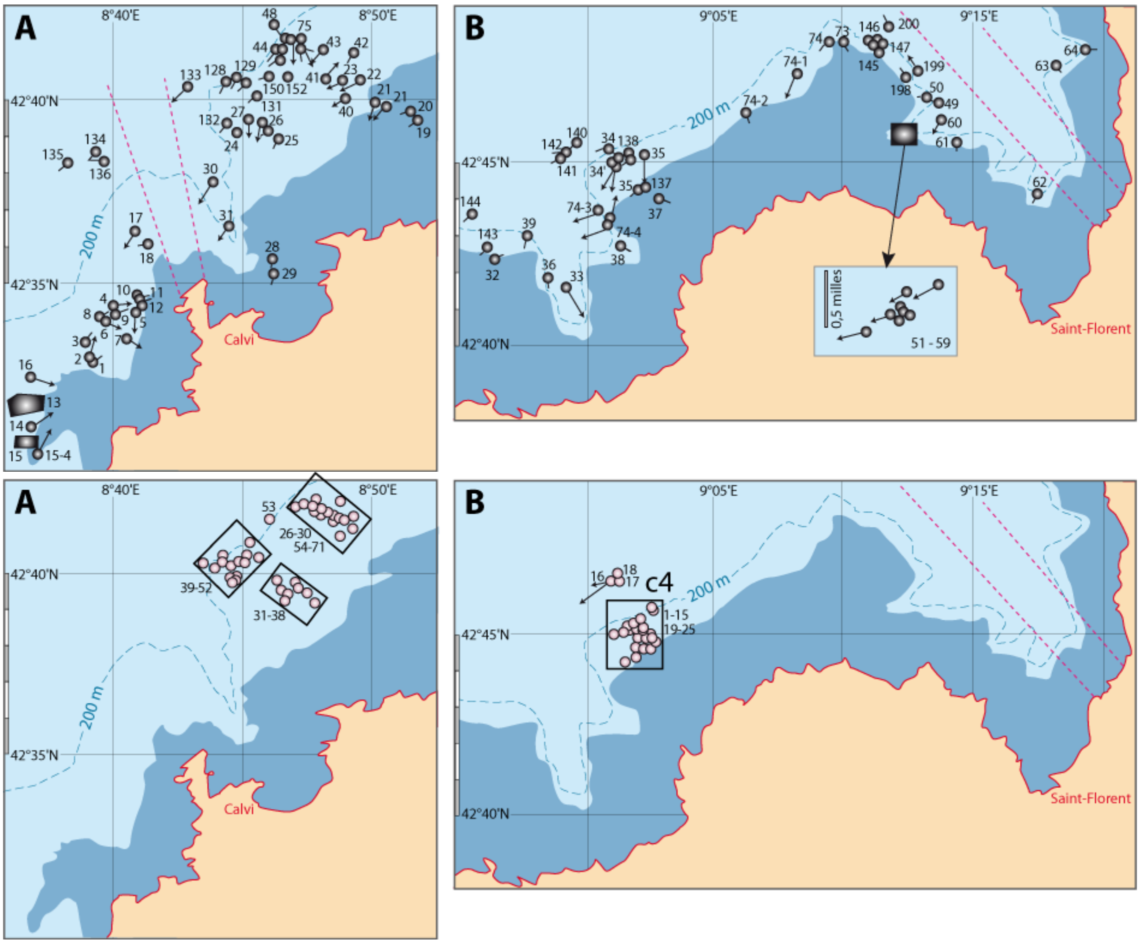
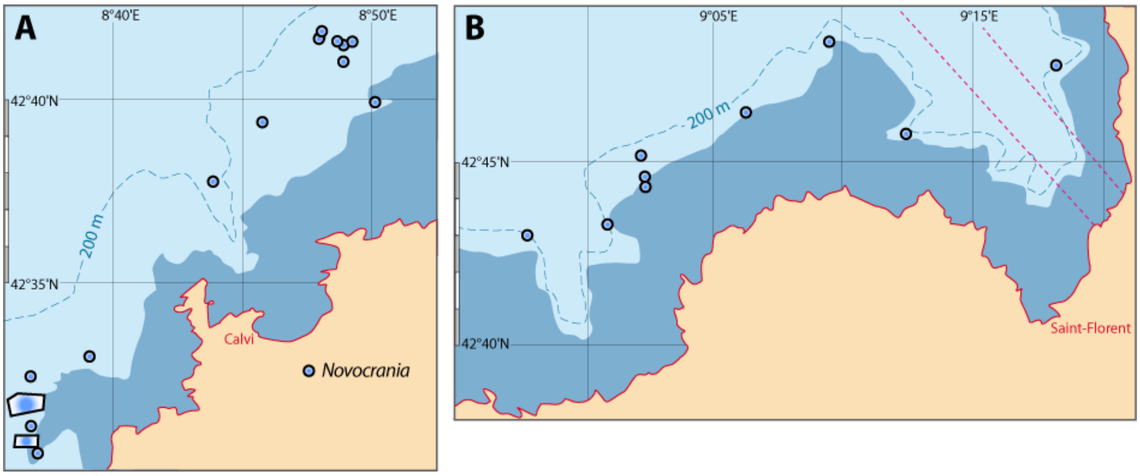
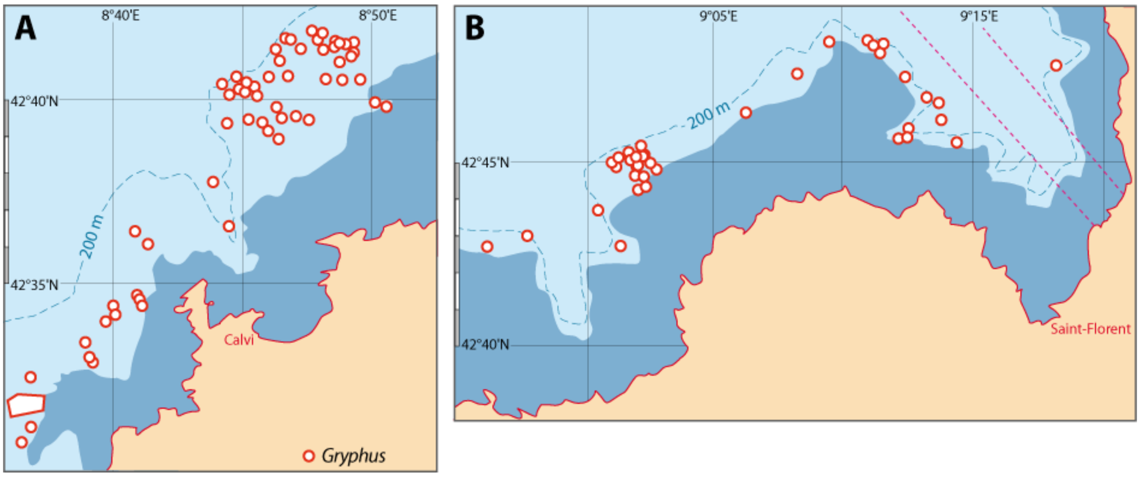
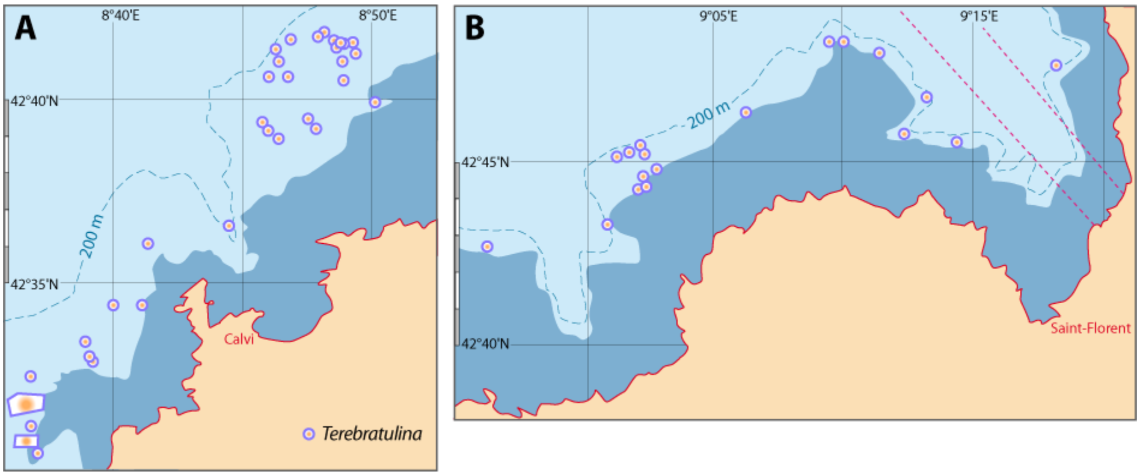


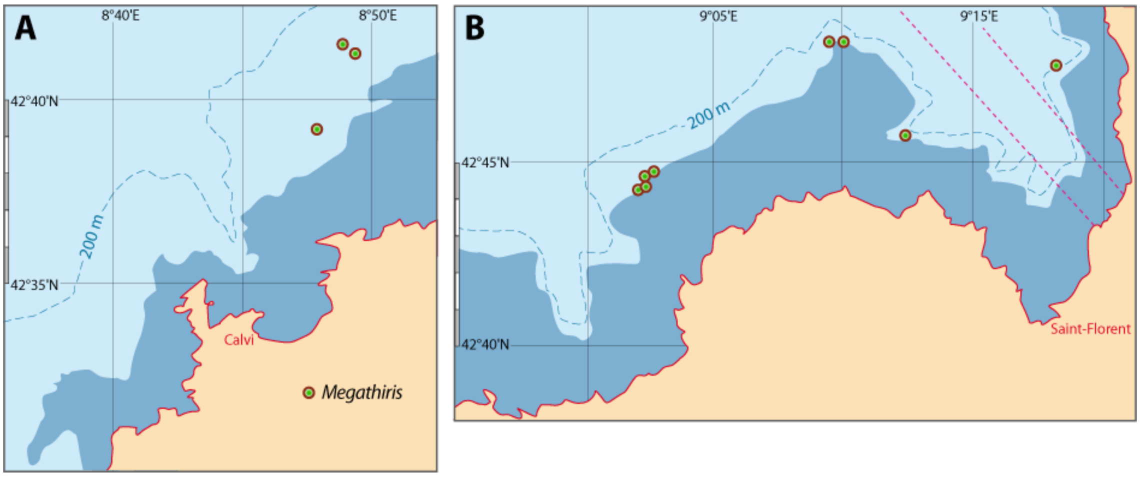
Figure 9-5 : North-West Corsica: zones A and B.
Top maps: location of BraCors campaign stations (CNRS).
Bottom map: location of BathyMed campaign stations (CNRS).

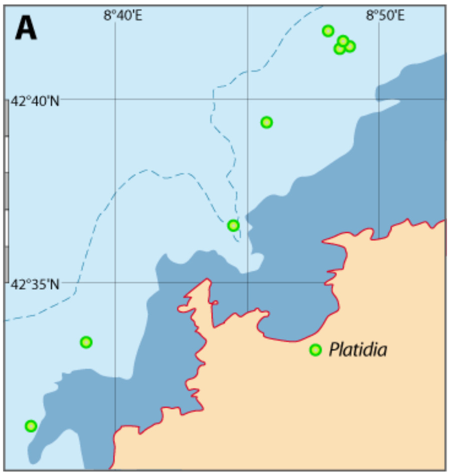
Below are distribution maps of *Novocrania anomala* . -Gryphus *vitreus* . - *Terebratulina retusa* . - *Megathiris detruncata* . - *Platidia anomioides* . -Megerlia *truncata* . See Tables 7, 9, 10.

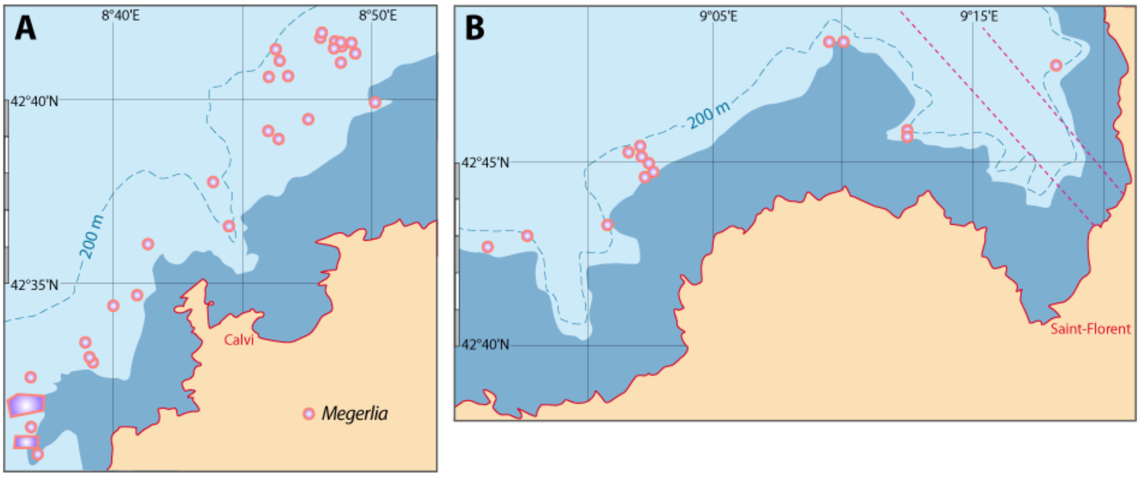





A
8°40'E
8°50'E
42°40'N
42°35'N
200 m
Calvi
Terebratulina
B
9°05'E
9°15'E
42°45'N
42°40'N
200 m
Saint-Florent


A
8°40'E
8°50'E
42°40'N
42°35'N
200 m
Calvi
Megathiris
B
9°05'E
9°15'E
42°45'N
42°40'N
200 m
Saint-Florent


A
8°40'E
8°50'E
42°40'N
42°35'N
Platidia


A
8°40'E
8°50'E
42°40'N
42°35'N
200 m
Calvi
Megerlia
B
9°05'E
9°15'E
42°45'N
42°40'N
200 m
Saint-Florent

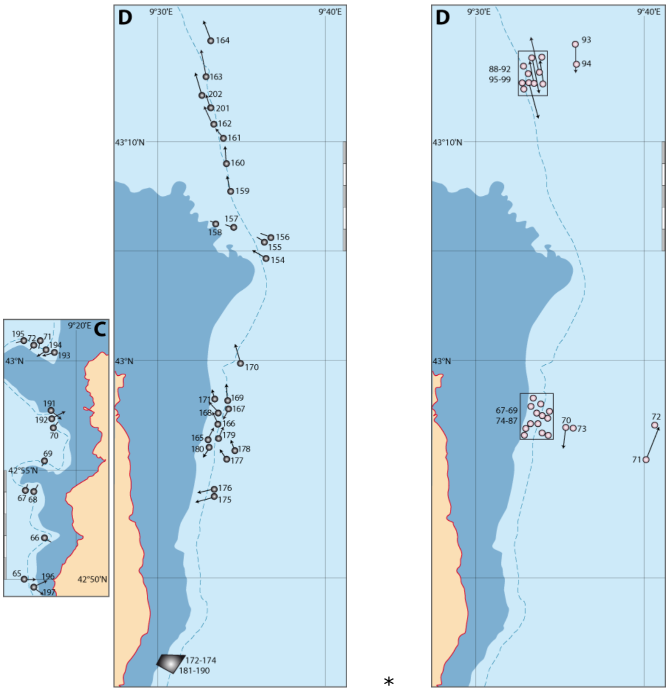
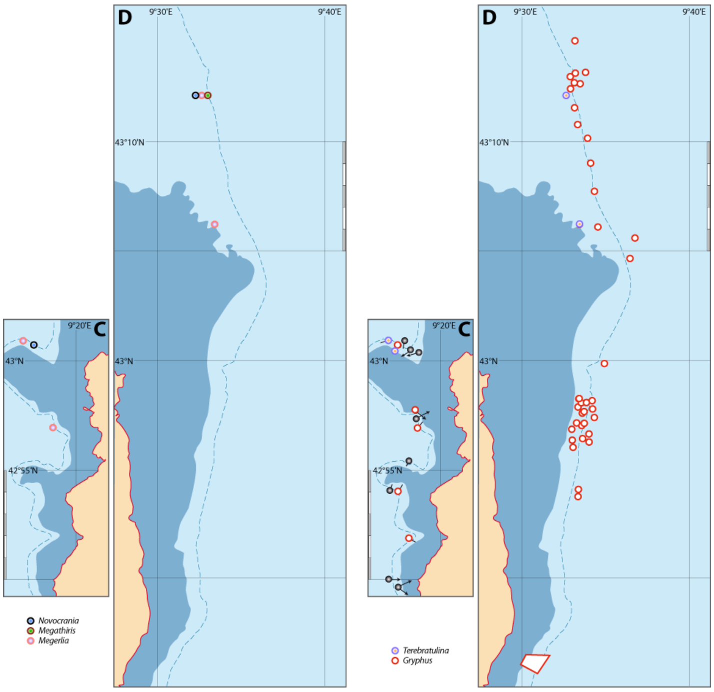


Figure 9-6 : North Corsica: zones C and D. Location of BraCors (CNRS) and BathyMed (CNRS) campaign stations. See Tables 6 and 8.

Below are distribution maps of *Novocrania anomala* . -Gryphus *vitreus* . - *Terebratulina retusa* . - *Megathiris detruncata* . - *Megerlia truncat* a. See Tables 7 and 9.



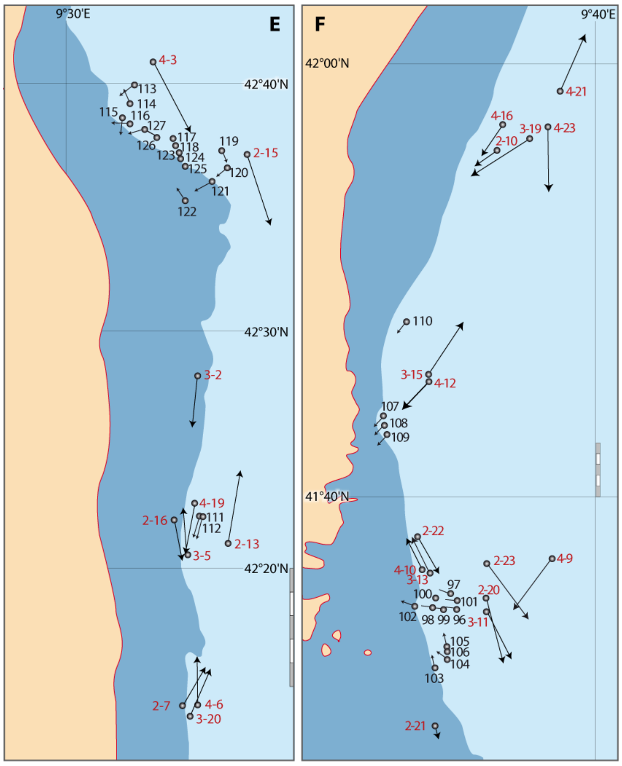
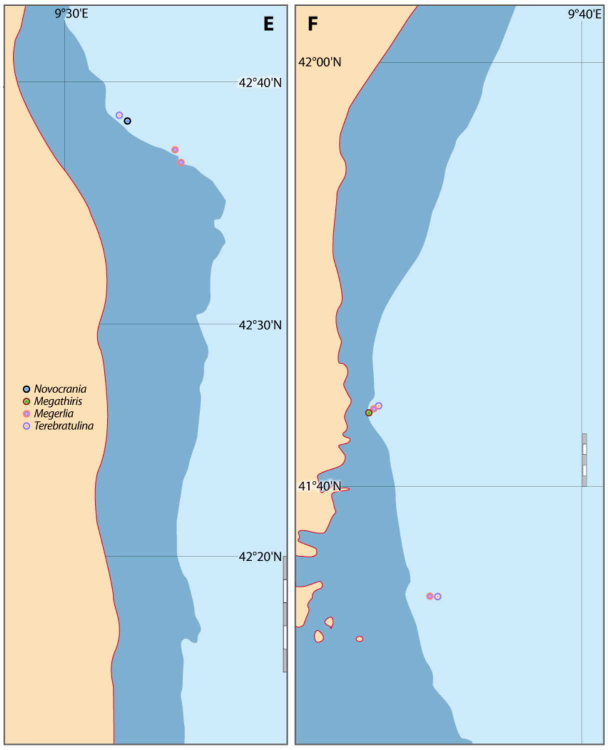
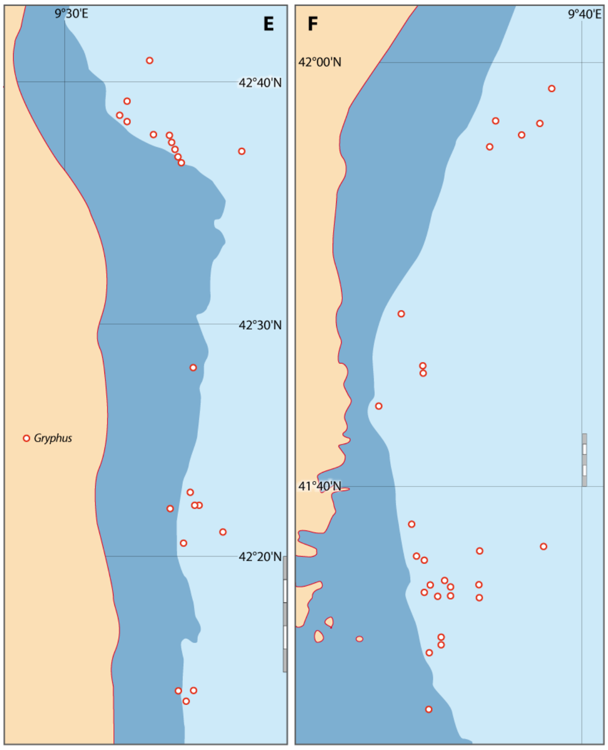


Figure 9-7 : Eastern Corsica: zones E and F. Location of BraCors (CNRS) campaign stations – numbered in black - and Meditis (Ifremer) – numbered in red. See Tables 6 and 10.

Below are distribution maps of *Novocrania anomala* . - *Terebratulina retusa* . - *Megathiris detruncata* . - *Megerlia truncat* a. -Gryphus *vitreus* . See Tables 7 and 10.





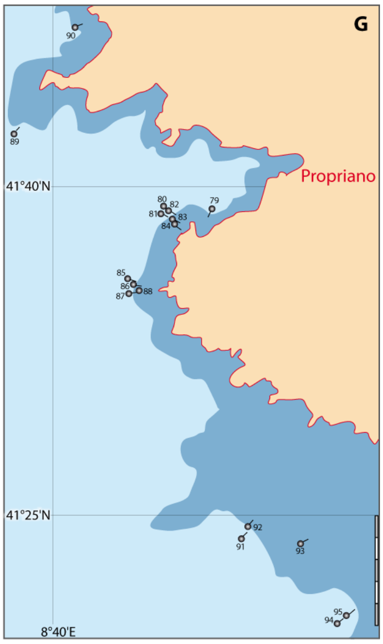


Figure 9-8 : South Corsica: zone G. Location of BraCors campaign stations (CNRS). See Table 6.

Below are distribution maps of *Novocrania anomala* . - *Terebratulina retusa* . - *Megathiris detruncata* . - *Megerlia truncat* a. -Gryphus *vitreus* . See Table 7.

C. Atlantic and Channel distribution maps

On the nautical charts (above in A and B) with the results of the campaigns reported in this work, it seems judicious to supplement these data by reproducing the maps of the geographical distribution of the six species of brachiopods along the French metropolitan coasts in the Atlantic Ocean and the English Channel, based on maps published by Emig (2016, 2017a).

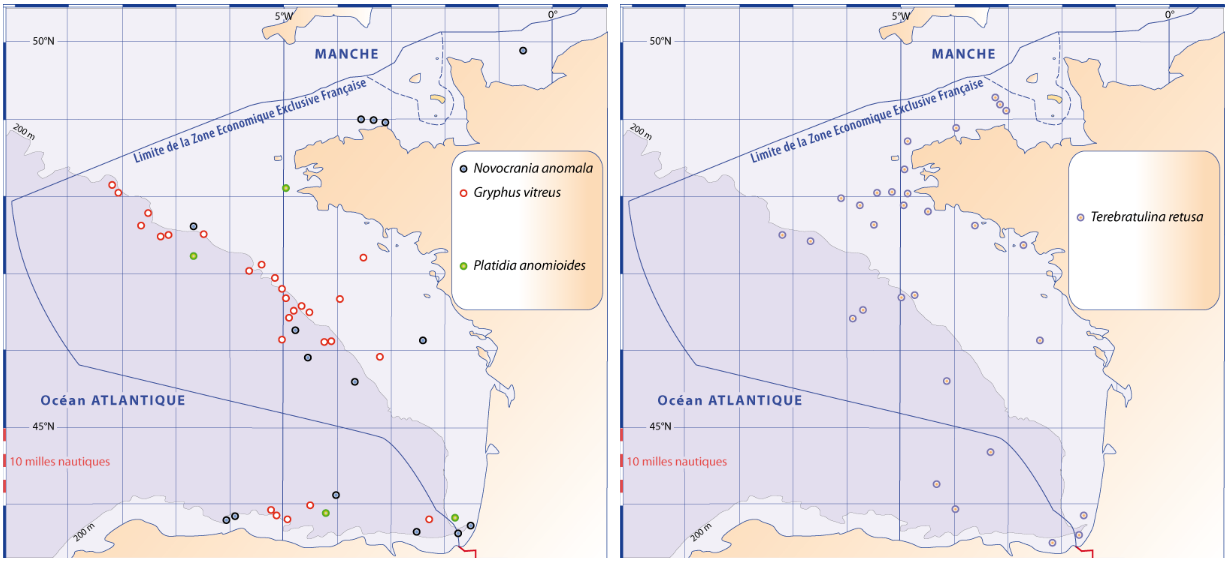
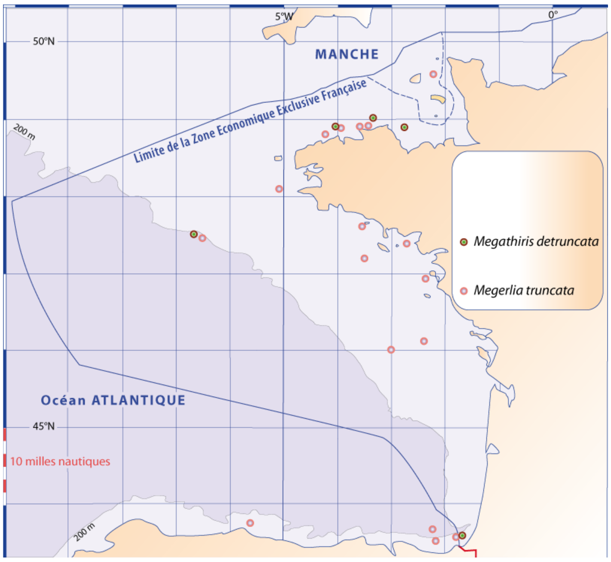


Figure 9-9 : Geographical distribution of the six species of brachiopods off the French mainland coasts in the Atlantic and English Channel (modified, according to Emig, 2016, 2017a).



Thanks

I would like to extend my thanks to all the sailors with whom I have sailed on various oceans and seas. And of course, I have a moved thought for all the sailors and their captains of the CNRS ships: those of Marseille, the N/O Antedon on which I started my career and learned with them and Jacques Picard the work at sea , the N/O Antedon 2 on which I did my last oceanographic mission at sea, the N/O Alciope; those of Villefranche-sur-mer the N/O Catherine-Laurence and the N/O Korotneff. So many moments of sharing, of living together, of pleasure and happiness, also of hard work and heavy weather... a real sailor's life! And send all my regards to all the colleagues who took part in the sea campaigns of RCP n°728, and in particular to all the members of the program, including Fernando Àlvarez (Oviedo), Jean-Henri Delance (Dijon), Italo Di Geronimo (Catania), Bernard Laurin (Dijon), Jean Revert (Pau).

On board the N/O Catherine-Laurence during a BRACORS campaign, from left to right: Italo Di Geronimo, Bernard Laurin, Christian Emig, Jean-Henri Delance, Jean Revert.

My thanks also to Jocelyne Martin (Ifremer, Nantes) and Angélique Jadaud (Ifremer, Sète) for providing me with the data on brachiopods from the Ifremer surveys, cited in this work.

The Commander-in-Chief for the Mediterranean and Maritime Prefect of the Mediterranean (National Navy) has always granted me the authorizations to be able to work in certain areas prohibited to all dredging and above all has granted my requests for diving in a submersible called SMI (sub- Marin d'Intervention de la Marine Nationale) Griffon, let him be warmly thanked. Three dives were made, the pilots were the Lieutenant of the Vessel Roque, the Ensigns of the Vessel 1st Class Gomez and Arnoult. It was with the latter that we dived to a depth of 600 m, the authorized limit and rarely reached by the "Griffon", so it was with particular attention that the mechanic on board monitored any possible intrusion of water ! My thanks also to the help provided by Paul-Henri Nargeolet in equipping the submersible by the Undersea Intervention Group (GISMER) of the French Navy.

Finally, my best wishes to my friends Aleksandra Bitner (Warsaw) and Fernando Álvarez (Oviedo) for their help and comments in the production of this book, for which they are cordially thanked.

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Appendix A.

For a renewal of the taxonomy of current brachiopods.

Among the major zoological groups, the brachiopods have a specificity linked to their age in the fossil records (among the oldest known fossils) and by their relatively small number of current species: they are, with rare exceptions, only paleontologists who study them, to the point of becoming their “private preserve” by and for them (Emig, 2008). Consequently, the taxonomy of the species was made according to a systematic with a paleontological tendency [14] , even stratigraphic and even geographical, that is to say based on the only characters (some without taxonomic value) of the fossil remains which are the shell and its internal structures, sometimes modified by taphonomy (Emig & Rachebœuf, 1990; Emig, 2002). Used to define certain stratigraphic stages, the same fossil species of brachiopod can sometimes change its name by changing stage!

The number of fossil taxa described is of the order of 30,000 species, which today turn out to be very largely overestimated (just like for the genera) - perhaps to be reduced by half? - while it is likely that 5-10% of current so-called valid species are in fact synonyms of species already described (Emig, 2017b). A consequence of the absence of complete diagnoses [10] at all hierarchical levels, which, while the number of characters available is low, has led to variations of a character being used as a criterion to describe new species or genera , sometimes even from a few shell fragments. These tendencies inherited from the 19th century have remained alive for certain paleontologists until today. The six species of brachiopods, collected in the Mediterranean Bathyal, alone attest to all the ambiguities of the systematics currently used. A rapid evolution towards new comparative phylogenetic methods, including cladistics, is necessary, as these have undergone rapid development over the past twenty-five years (Darlu & Tassy, 2018).

The large number of varieties and synonyms (current or fossil) of these six species, often without clear criteria to differentiate them, reflects the problem posed by the lack of diagnosis and studies of character variations within and between the different populations that make up the species. In the present case, it is mainly descriptions by Italian and English-speaking authors. And it is not certain that it is possible to make an exhaustive list of these varieties and synonyms by relating them with certainty to one or other of the valid species, so vague are the descriptions. This trend continues in recent work on fossil forms, it sometimes concerns individuals of small size (millimeter) which should question the authors as to the development during life of certain characters. Indeed, many juvenile forms may not have all the characteristics to determine with certainty the membership of a species.

Based on this observation, the purpose of which here is not to stigmatize authors and discipline, and even less to argue, we must ask ourselves the question “is this systematics still transposable to current species? and the answer is definitely NO. Because the taxonomic and phylogenetic characters go beyond the only fossil remains used until now, that is to say the shell. It is true that paleontologists are neither taught nor equipped to study the morphology and anatomy of the body (also called the soft parts) of brachiopods, nor the ecological and oceanographic means to establish the characteristics of the biotope and biocoenoses. However, it is there that the characters are to be found to define the current species and their populations. How many descriptions provide information on the muscles, the lophophore, the gonads, the larva and its ontogenesis, the spicules, etc. ? However, in recent years, there has been an increase in publications on the biology, anatomy and ecology of current species of brachiopods; but this does not mean that brachiopod systematists have integrated them into their work.

A point often mentioned in publications is the constant decline in the number of brachiopod taxa since the Mesozoic; however, the current number of species, about 400 (Emig *et al* ., 2018), covers a period of at least a million years, and, in the geological past, there is no data on the real number cash valid for a similar period. There remains the habit of conveying concepts that deserve to be reviewed and refined (Emig, 2002, 2017b, Emig *et al* ., 2015).

The systematics of current brachiopod species therefore requires a profound revision in its concepts and methods, as is done in other zoological groups (Zaharias & Sanders, 2018), outside the paleontological context alone. The application of cladistics planned in the project for the revision of part H (Brachiopoda) of the Treatise on Invertebrate Paleontology, never reached the level of genus and species (Williams & Carlson, 2007). Added to this is the genetic tendency which remains incapable of identifying the species which are determined according to classical systematics. In genetic databases, valid species stand alongside synonyms mentioned as valid or treated as such.

Systematics in the life sciences is only a tool, certainly indispensable, but not an end in itself, as is often the case in paleontology. Identifying from a reliable diagnosis is the basis for all subsequent work, as here on the distribution of species in the Bathyal: the presence of species in one or more biocoenoses is a datum to be integrated into the description of the species, or even as a character taxonomic in their systematics.

A species must have an explicit diagnosis, just as the genus to which it belongs must have its own distinct from that of the species it groups together. In the latter case, the diagnosis includes only the taxonomic characters, but all of them, allowing the genus to be identified according to the definition given in the code [10] (ICZN, 1999). These characters in the current forms cannot be reduced to those of the shell alone. The anatomical parts, such as the muscles, the nephridia, the lophophore and the arrangement of the tentacles, the reproduction (from the gonads to the metamorphosis of the larva), are all data that may contain identification criteria, even if they are not available throughout an individual's lifetime. This makes it all the more essential to know all the variations during the life cycle.

Moreover, among brachiopod specialists, there is too often confusion between diagnosis and description, which are two terms with very different meanings and which cannot replace one another. The description concerns all the observations on the specimens collected beyond the diagnosis, by supplementing the knowledge on the way of life, reproduction, the place of life and the surrounding fauna, the ecological conditions, etc. Similarly, there is often confusion between the diagnosis of the genus and that of the species: it is nonsense to write for a monospecific genus: “same diagnosis as for the species” or “as for species”. Not wanting to get angry with my colleagues and not wanting to blame the dead, I leave it to everyone to find these shortcomings in recent work over the last century or more.

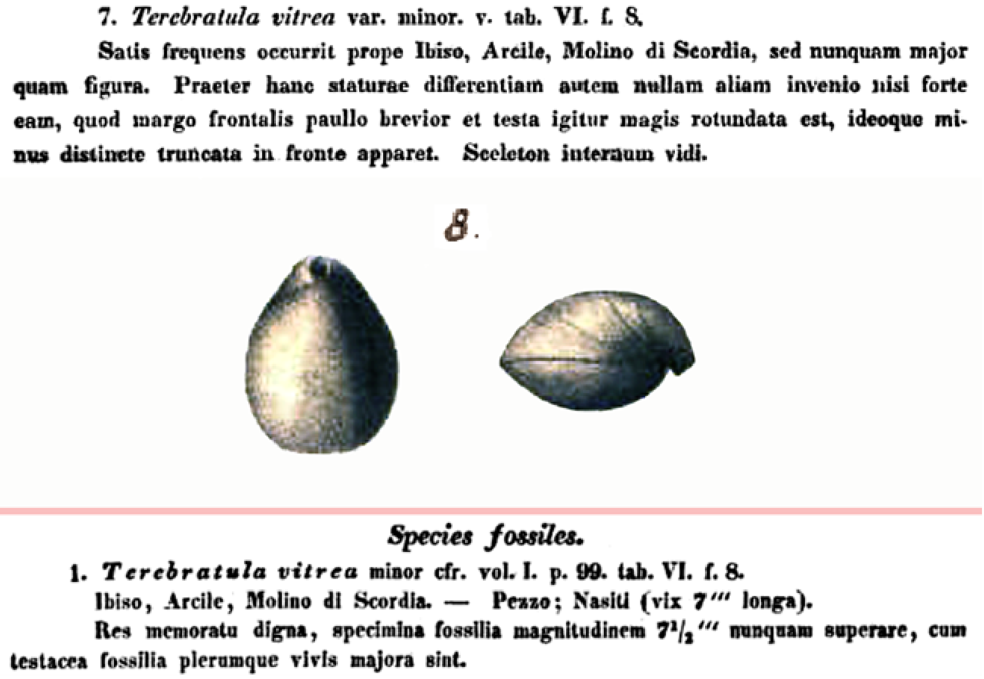
The time has come for a new approach in a phylogenetic context for current brachiopod species.

[14] In France, paleontology is considered to belong to both Life Sciences and Earth Sciences (more in an environmental sense).

Appendix B.

History of the systematics of *Terebratula minor* Philippi, 1836

Philippi (1836) created a fossil variety named *minor* from the species *Terebratula vitrea* , from which it is distinguished only by the small size of the shell (Fig. B-1): it indicates a maximum size of 7.5''' (or lines - i.e. 17 mm, knowing that a line corresponds to 2.256 mm in French units). The specimens came from Calabria (Southern Italy) notably from Ibiso, Arcile and Moline di Scordia (Philippi, 1836, 1844).



7. *Terebratula vitrea* var. minor. v. tab. VI. f. 8.

Satis frequens occurrit prope Ibiso, Arcile, Molino di Scordia, sed nunquam major quam figura. Praeter hanc staturae differentiam autem nullam aliam invenio nisi forte eam, quod margo frontalis paullo brevior et testa igitur magis rotundata est, ideoque minus distincte truncata in fronte apparet. Sceleton internum vidi.

Species fossiles.

1. *Terebratula vitrea* minor cfr. vol. I. p. 99. tab. VI. f. 8.

Ibiso, Arcile, Molino di Scordia. — Pezzo; Nasiti (vix 7''' longa).

Res memoratu digna, specimina fossilia magnitudinem $7^{1}/_{2}$''' nunquam superare, cum testacea fossilia plerumque vivis majora sint.

Figure B-1 : Facsimile of Philippi's description (1836 and 1844) of the variety *minor* . Line (or ''') = 2.256 mm in French units. *Terebratula vitrea* is *Gryphus vitreus* (Born, 1778).

Suess (1859) distinguished *Terebratula minor* from *T. vitrea* because "kleinere Art mit stumpfen Bändern und stärkerer Schal" and named its living specimens *T. vitrea minor* or *T. minor* from around the island of Lipari (north - eastern Sicily, Italy), now *Gryphus vitreus.* Reeve (1861a) placed *T. minor* in synonymy with *T. vitrea* , which prompted the following response from Suess (1861): " Nor do I approve the altered generic position of several species, or the uniting of *T. minor* with *T. vitrea* . In his reply, Reeve (1861b) will not answer this point.

Seguenza (1865b, 1870) pointed out that *Terebratula minor* is not distinct from *T. vitrea* (Table 11); his comparison remains ambiguous: " Dalle esposte osservazioni conchiudiamo, che le *T. minor* può ritenersi como specie differente dall *T. vitrea* , ma essa non no è ben distinta . In his table I, this author shows the similarities between the three species which in fact are variations all leading to *Gryphus vitreus* , therefore to be compared with Boullier *et al* . (1986), Huault (1990) (Fig. 5-5). Other forms, such as *T. leylliana* (Table 11; see Davidson, 1870), have little difference from the shell of *T. minor* and which Seguenza (1871) referred to as *T. minor* . Davidson (1880) recognizes that: " *T. vitrea* varies much, and several of its varieties or modifications in shape have been described as distinct species. Nevertheless a few lines later he maintains *Terebratula vitrea,* var . *minor* while emphasizing: "it is often difficult to distinguish from the young shell of *T. vitrea* . *The localities* are in the Atlantic Ocean (from the Arctic to the Cape of Good Hope), in the Mediterranean Sea, and fossils in southern Italy. And he adds: " The question may, indeed, be further mooted, whether Philippi was not correct in considering *Ter. minor* or *affinis* as merely a small variety of *Ter. vitrea* . Professor Suess, however, believes the former shell to be specifically distinct from *Ter.vitrea* . Dr Gwyn Jeffreys and my self were also at one time disposed to consider the *Ter. davidsoni* , A. Adams (Annals and Mag. Nat. Hist., 3d ser., vol. vp 12, 1860, dredged at Satanomoski, Japan), as identical with *Ter. vitrea* or *affinis* . This view is not, however, shared by our distinguished contemporary, Mr Dall. Nevertheless, in 1886, Davidson wrote: " I have compared species of the fossil shell with species dredge alive by Prof. Seguenza in the bay of Messina, and found them to be identical I cannot, however, get rid of the idea that *Liothyris minor* is more than a small race or variety of *Liothyris vitrea* ; it occurs, associated with the last-named shell, in the same beds and localities in Calabria and in Sicily. Kowalevski (*in Œhlert* & Deniker, 1883) makes some observations on the embryology of *Terebratula minor* . Carus (1893) cites numerous localities of the living form of *Terebratula affinis* (= *minor*) (Table 11) in the Mediterranean Sea (Adriatic, Aegean Sea, Sicily, Corsica, Algiers, Tunis, Marseille…) which are to be attributed to *Gryphus vitreus* .

Maugeri Patanè (1929) considers *Terebratula* (*Liothyrina*) *minor* as distinct from *Gryphus vitreus* : " ha una linea di commessura fortemete accentuata (quasi aussente nella *vitrea*), nonchè apparicchio brachiale puitosto parallelo, che nella *vitrea* è quasi triangolare com'ebbero un osservare Aradas e Benoit (1870) "; and it describes three varieties, named *depressa* , *globosa* , and *rotundata* , based primarily on shell shape, noting that *T. minor* occurs in the western Mediterranean basin. Its figures 1 to 3, pl. 28, confirm the similarity with G. *vitreus* (compare with Fig. 5-5). Lipparini *et al* . (1981) reported *Terebratula* (*Liothyrina*) *sphenoidea* and *T.* (*Liothyrina*) *vitrea* var. *minor* in the Pliocene at Cape Milazzo (Sicily).

Creating the new genus *Eurysina* based on the following diagnosis: " *Tichosina* with a loop angle greater than 25° ", Cooper (1983) transferred *Terebratula minor* Philippi to it. But, this position has never been accepted by recent authors. Finally, *Eurysina* has been placed in synonymy with *Tichosina* by Lee & Smirnova (2006): the diagnoses published by these last two authors of the genera *Tichosina* and *Stenosarina* appear very similar, possibly leading to a synonymy.

Gaetani (1986), Gaetani & Saccà (1983, 1984), Saccà (1985) described *Gryphus minor* in the Late Miocene and Pleistocene in Sicily and Calabria, considering the species distinct by external shell characteristics. Scattered valves of *G. minor* and *Terebratula scillae* Seguenza, 1871 are reported from Pleistocene deposits in Sicily by Borghi *et al* . (2005).

According to Taddei Ruggiero (1994), *Gryphus minor* has been known from the Miocene and at least until the Late Pleistocene; but she notices that today a form similar to *G. minor* is still associated with *G. vitreus* . In the fossil record, *G. minor* lived on vaso-detrital bottoms referred to the Circalittoral (around 70 to 120 m deep). According to Taddei-Ruggiero & Bitner (2008), Lower Pleistocene brachiopods in Calabria are represented by seven species, the most common of which are *Terebratula scillae* , *Gryphus vitreus* and *G. minor* , with other species like *Terebratulina retusa* , *Megerlia truncata* , *Dallina septigera* and *Macandrevia cranium* .

Ruggiero & Raia (2010) described *G. minor* in great abundance in siliciclastic-carbonate sand about 1 m thick: the muddy fraction increases at the top of the layer and could be responsible for the fossilization. They consider this species to be a valid extinct Mediterranean species, having been variously assigned to separate species or subspecies, including *dilatatus* (Jeffreys), *elongatus* (Jeffreys) depending on whether the shells are wider, narrower or more elongated. Other authors, including Logan (1979), Boullier *et al* . (1986) and Huault (1990) have shown, even demonstrated, that the variability of forms is a characteristic of *Gryphus vitreus* that must necessarily be taken into account, just like the geographical and biocoenotic distribution of the populations.

During numerous recent expeditions to the Mediterranean, *Gryphus minor* has never been formally identified, nor considered as a juvenile form of *G. vitreus* , because of the great variations in the characters of the latter species (Boullier *et al* ., 1986; Huault , 1990).

Table 11 : List of species or varieties (since the Miocene) relating to *Terebratula minor* , considered today as a synonym of *Gryphus vitreus* . This list is not exhaustive, but reflects the complexity and ambiguity due to the absence of real taxonomic characters to relate individuals to an identifiable species with certainty.

Terebratula vitrea var. *Minor* , Philippi, 1836		Philippi (1836)
Terebratula affinis Calcara, 1845		Calcara (1845)
Terebratula miocenica Michelotti, 1847	**has**	Michelotti (1847)
Terebratula vitrea (*Anomia*)		Aradas (1847), Reeve (1861a), Seguenza (1870)
Terebratula minor		Suess (1859, 1861)
Terebratula affinis		Seguenza (1862a, 1862b)
Terebratula miocenica	**has**	Seguenza (1862b)
Terebratula minor	*	Seguenza (1863, 1865a, 1865b, 1871)
Terebratula minor		Davidson (1864, 1880)
Terebratula minor		Davidson (1864)
Terebratula lyelliala Seguenza, 1865		Seguenza, 1865a)
Terebratula rovasendianus Seguenza, 1866		Seguenza, (1866)
Terebratula minor = *T. affinis*		Aradas & Benoit (1870)
Terebratula lyelliala		Davidson (1870)
Terebratula minor		Seguenza (1871-1874)
Terebratula vitrea var. *minor*		Davidson (1886)
Terebratula vitrea var. *minor* = *T. affinis*	*	Davidson (1880)
Terebratula vitrea var. *minor* = *T. affinis*	*	Jeffreys (1878)
Terebratula affinis	*	Carus (1893)
Terebratula minor		Sacco (1902)
Terebratula (Liothyrina) minor		Maugeri Patane (1929)
Terebratula (Liothyrina) minor var. *depressed*		Maugeri Patane (1929)
Terebratula (Liothyrina) minor var. *globosa*		Maugeri Patane (1929)
Terebratula (Liothyrina) minor var. *rotundata*		Maugeri Patane (1929)
Terebratula vitrea var. *minor*	*	Granier (1978)
Gryphus miocaenicus	**has**	Meznerics (1943)
Terebratula (Liothyrina) vitrea var. *minor*		Lipparini *et al* . (nineteen eighty one)
Eurysina minor	*	Cooper (1983)
Gryphus minor		Gaetani (1986), Gaetani & Saccà (1983, 1984), Saccà (1985)
Liothyrina agulhasensis Helmcke, 1939	**b***	Helmcke (1939, 1940)
Gryphus minor		Taddei Ruggiero (1988), Taddei Ruggiero (1994),
Gryphus minor		Borghi *et al* . (2005)
Gryphus minor		Taddei-Ruggiero & Bitner (2008), Ruggiero & Raia (2010)
Gryphus miocaenicus	**has**	Bitner & Dulai (2004)

***** Current specimens have been reported under this species name by the author.

has. *Terebratula miocenica* was described by Michelotti (1847, p. 76) from Serravalle Scrivia, located about 50 km north of Genoa (Italy), emphasizing that: " the front finally, which in the case of the English author is cut in a straight line, is rounded in our species. This last character is sufficient in itself to distinguish it also from Lamarck's *Terebratula vitrea* . It should be emphasized that the correct name of the species is *miocenica* or *miocenicus* . Meznerics (1943) describes this species under *Gryphus* , but does not mention *T. minor* in his long list of *Terebratula* in Tertiary sites in Hungary. Recently, Bitner & Dulai (2004) confirm that this species, small in size, does indeed belong to the genus *Gryphus* with a rectimarginate anterior commissure as in *Gryphus vitreus* : it is known from the Eocene to the present day. In the absence of a description of the internal structures of the shell, it is impossible to identify specimens that could refer to *G. miocenicus* .

b. Specimens of this species, named *Liothyrina agulhasensis* by Helmcke in 1939, had been mentioned and figured by Blochmann (1906) under " *Liothyrina* n. sp. von Agulhasbank ". Helmcke (1940) places them as a synonym of this new species *Terebratula vitrea* var. *minor* Philippi described and figured by Davidson (1880) and collected at the Cape of Good Hope (South Africa); he also makes a comparison with *Liothyrella affinis* (Calcara). *Liothyrina agulhasensis* was classified under *Xenobrochus agulhasensis* (Helmcke, 1939). Note that the publication date of Helmcke's work is indeed 1939, and not, as sometimes mistakenly indicated, 1938.

To close this presentation, it is interesting to reproduce plate 1 from Seguenza (1871) with the characteristics of the shells of *Terebratella minor* Philippi and *T. sphenoidea* Philippi; these species considered here as synonyms respectively of *Gryphus vitreus* (Born, 1778) and of *Stenosarina sphenoidea* (Philippi, 1844) that Logan (1998) had renamed under *S. davidsoni* Logan, 1998.

To consult the descriptions of the numerous species of fossil brachiopods by the authors quoted in Table 11, it is necessary to broaden the question of the validity of all these species of brachiopods described since the Eocene in the Mediterranean area: how many are really identifiable by re-examining all taxonomic characters and their variations. At the same time, it is necessary to verify, based on their variations, that the characters available on the fossil forms are sufficient to discriminate individuals up to the species, especially when these forms are still alive in the marine environment (see Appendix A). . The revision of the taxonomy of brachiopods is not an understatement, but a necessity, in particular to be able to apprehend the true biodiversity and its evolution through geological times up to the present day.

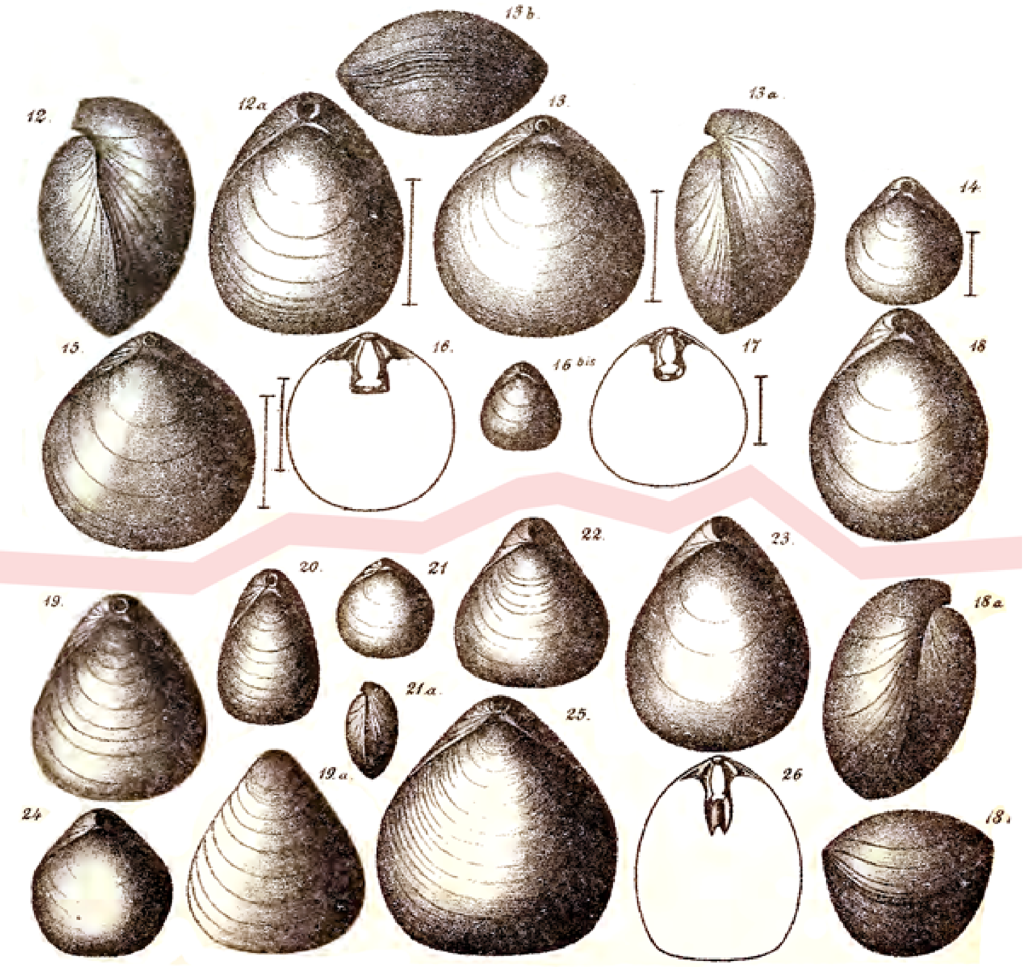


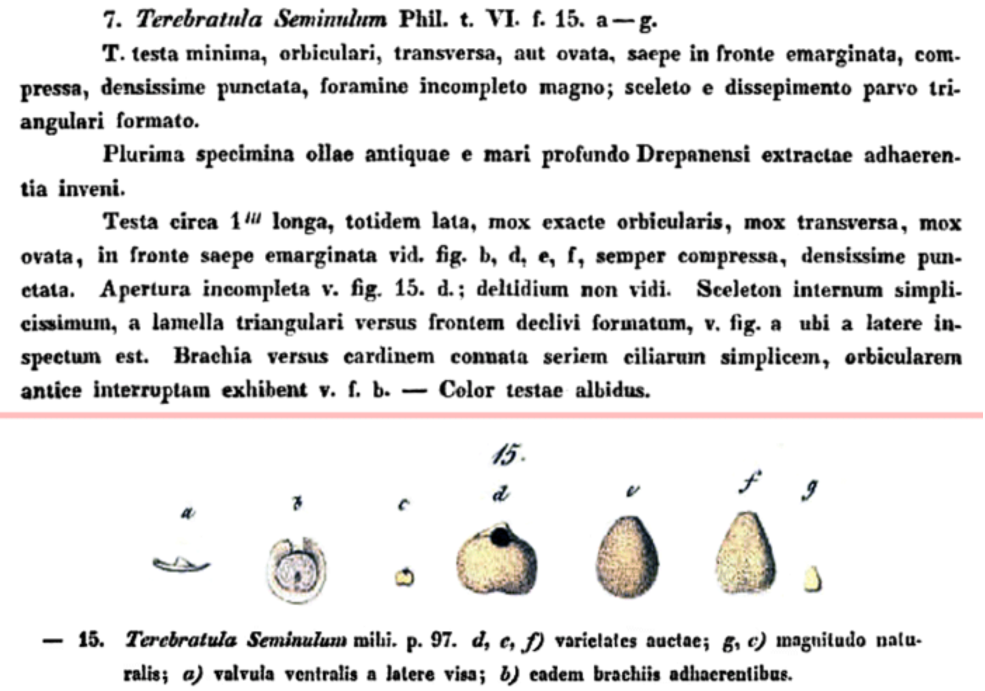
Figure B-2 : Extract in facsimile of plate I (*species fossili*) from Seguenza (1871).

Terebratula minor , Philippi (ingrandita).
12. Example of the Pliocene Superiore of Catanzaro.
13. (ingrandita). Un individuo del pliocene superiore di Gravitelli presso Messina.
14. Example of the Pliocene of Gravitelli della var. *Lyel liana* (ingrandito).
15. Un individuo dello Zancleano sup. di cui sono più appa riscenti le pieghe della contrada Pietrazza presso Messina (ingrandito).
16. Apparecchio apofisario ingrandito del pliocene superiore di S. Filippo presso Messina.
16a. Varietà truncata ed elargato alla fronte, pliocene superiore di S. Filippo.
17. Apparecchio apofisario ingrandito della *T. Lyelliana* di Gravitelli.
Terebratula sphenoidea , Philippi.
18. Un esemplare ristretto alla fronte dello Zancleano superiore della contrada Pietrazza: presso Mess.
19. Un esemplare di forma tipica, contrada Pietrazza.
20. Forma allungata dello stesso luogo e terreno.
21. A giovane dello Miocene medio di Scirpi presso Mess.
22. Una forma breve e larga di Scirpi nello Zancleano medio.
23. Un esemplare colla truncation frontale meno distinta, SCIRPI.
24. Un altro assai breve colla maggior larghezza verso la metà del medesimo luogo e terreno.
25. Un grande esemplare e largo, dello Zancleano superiore di Trapani presso Messina.
26. Apparecchio apofisario de un esemplare della Contrada Pietrazza.

Appendix C.

History of the systematics of *Terebratula seminulum* Philippi, 1836

Terebratula seminulum was harvested in the deep sea off Drépane today Trapani (*Tràpani* in Sicilian, Drépanon *in* ancient Greek or *Drepanum* in Latin), a port located at the western end of Sicily (Italy). It was described by Philippi in 1836 and depicted on his pl. VI, fig. 15 (Fig. C-1).



7. *Terebratula Seminulum* Phil. t. VI. f. 15. a—g.

T. testa minima, orbiculari, transversa, aut ovata, saepe in fronte emarginata, compressa, densissime punctata, foramine incompleto magno; sceleto e dissepimento parvo triangulari formato.

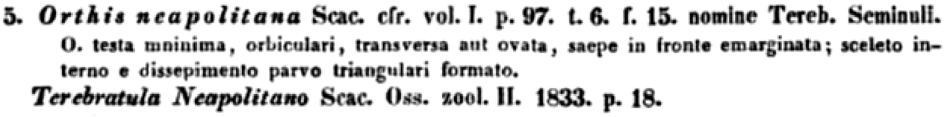
Plurima specimina ollae antiquae e mari profundo Drepanensi extractae adhaerentia inveni.

Testa circa 1''' longa, totidem lata, mox exacte orbicularis, mox transversa, mox ovata, in fronte saepe emarginata vid. fig. b, d, e, f, semper compressa, densissime punctata. Apertura incompleta v. fig. 15. d.; deltidium non vidi. Sceleton internum simplicissimum, a lamella triangulari versus frontem declivi formatum, v. fig. a ubi a latere inspectum est. Brachia versus cardinem connata seriem ciliarum simplicem, orbicularem antice interruptam exhibent v. f. b. — Color testae albidus.

— 15. *Terebratula Seminulum* mihi. p. 97. *d, e, f)* varietates auctae; *g, c)* magnitudo naturalis; *a)* valvula ventralis a latere visa; *b)* eadem brachiis adhaerentibus.

Figure C-1 : Facsimile of the original description of *Terebratula seminulum* and fig. 15 pl. VI by Philippi (1836), representing *Terebratula seminulum* , with the extract from the legend corresponding to fig. 15 (see text below). The length of the shell is about a line (or '''), or about 2.3 mm.

Philippi (1844) considers *T. seminulum* to be a synonym of *Orthis neapolitana* Scacchi, today *Joania cordata* (Risso, 1826) (Fig. C-2). Indeed, by observing Fig. C-1, we can only conclude that two distinct species are represented: ad - which may well correspond to *Platidia* (or *Amphithyris* ?) and ef - to *Joania* (?) (Fig. C-2).): this ambiguity is then found in the debate on the identity of the specimens represented by referring them all to the same species, which is probably erroneous.



5. *Orthis neapolitana* Scac. cfr. vol. I. p. 97. t. 6. f. 15. nomine Tereb. Seminuli.
O. testa mninima, orbiculari, transversa aut ovata, saepe in fronte emarginata; sceleto interno e dissepimento parvo triangulari formato.
Terebratula Neapolitano Scac. Oss. zool. II. 1833. p. 18.

Figure C-2 : Facsimile of extract from Philippi (1844) classifying *T. seminulum* with *Orthis neapolitana* , described by Scacchi in 1833 – now *Joania cordata* .

Davidson (1852, 1887) considered *Terebratula seminulum* to belong to the genus *Platidia* , stating that *T. appressa* Forbes, 1844, collected from the Aegean Sea was synonymous. However, in 1852 (p. 371), Davidson observed that: ‟ Philippi's species has been mistaken by Sowerby, who gave the name *seminulm* to another form which we have called *Argiope Forbesii* . *A. forbesii* Davidson , 1852 is a synonym of *Joania cordata* . In neither of his two works does he refer to the change made by Philippi (1844).

Fischer & Œhlert (1891) estimate that the shape of the lophophore is not that of *Platidia* , but perhaps that of *Cistella* (genus which currently corresponds to *Argyrotheca* Dall, 1900 and to *Joania* Álvarez, Brunton and Long, 2008). They also refer to a figure by Monterosato (1879) (Fig. C-4); now this last author considers that *seminulum* is a *Platidia* and he writes that Philippi (1844) ‟ relates it, inadvertently, to *T. Neapolitana* , Scacchi . » Thomson (1927) places *T. seminulum* in the genus *Amphythyris* Thomson, 1918 considering that in Davidson (1887, pl. 20, fig. 20-22): « Philippi's figures reproduced by Davidson leaves no doubt as to distinct characters of the lophophore . (Fig. C-3) and therefore that Davidson (1887) and then Dall (1920) mistakenly assigned this species to *Platidia* . Atkins (1959, fig. 23, p. 126) compares the figures of Philippi (1836) with an individual of *Platidia anomioides* of the same size, i.e. about 2 mm. She concludes that *T. seminulum* is a juvenile form of *P. anomioides* , as already mentioned by Jeffreys (1878). Note that the shape of the lophophore is only definitive in a mature adult, since during the development of an individual, this shape evolves, as also pointed out by Atkins (1959). Thus, it cannot be considered as a taxonomic character, but only as an additional character (in its adult form), as demonstrated in the neighboring group Phoronida by Emig (1985b).

Figure C-3 : Facsimile of figures 20-22 from pl. 21 from Davidson (1887, after Philippi, 1836) depicting *Terebratula seminulum* . They correspond respectively to figures 15 d, e, b of Philippi (1836) (Fig. C-1).

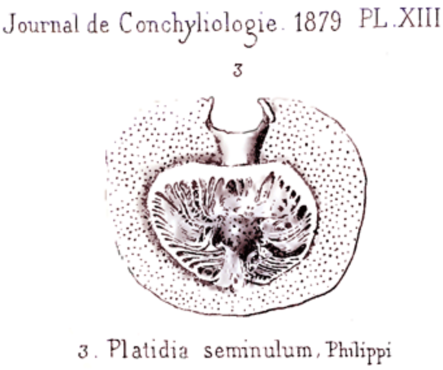


Figure C-4 : Facsimile of figure 3, pl. 13 of Monterosato (1879).

In the collection of the Museum für Naturkunde (Berlin, Germany), Lüter & Sieben (2005) discovered a small box with several copies labeled: " *Terebratula seminulum* Ph., Sicilia, Dr. Ph. " On examining them, they found that these specimens corresponded to two different species and to conclude that, on the original figure of Philippi (1836), the shells ad corresponded to *Platidia anomioides* and those eg to *Joania cordata* (Fig. C-1). One can wonder if this box was not forgotten by Rudolph Amandus Philippi (1808-1904) when he emigrated to Chile in 1854; indeed, according to an Eyzaguirre-Philippi descendant (2008; and personal communication), he had taken his personal library and collections to Santiago in Chile.

It is in Davidson's collection at the British Museum in London that MacKinnon *et al* . (2008) found five specimens labeled " *Platidia seminulum* : specimens described and given to me by Marquis of Monterosato as belonging to Philippi's species, Journ. of Conchology " from the Mediterranean, as well as another individual marked " *P. anomioides*, Canon Norman Collection, Naples ": their examination led these authors to identify them as *Amphithyris seminula* (Philippi, 1836), confirming this species in this kind by Thomson (1927). But they do not cite the publication of Lüter & Sieben (2005). Moreover, it is all the same curious that Davidson never mentioned the possession of these specimens in his collection, especially since he died in 1885 even before the publication of his monograph 1886-1888, in which he reproduced the three figures by Philippi (1836) (Fig. C-2, C-3) without mentioning the specimens donated by de Monterosato. Moreover, during his trip to Nice (with contacts with Italian colleagues) at the request of JG Jeffreys, Davidson (1869) does not mention any relationship with de Monterosato. This trip was initiated in order to thoroughly verify the validity of the brachiopod species described by Antonio Risso (1777-1845), an Italian naturalist pharmacist (Emig, 2012). His work had hardly satisfied these English authors, as Davidson (1869) wrote: " consequently we must not be surprised to find so large an amount of error in the work above specified . It is not sure that the Italian scientific community appreciated!

Nauendorf *et al* . (2014) describe *Terebratula seminulum* under *Amphithyris seminula* (Philippi, 1836) considering that all references to another genus made by the various authors are erroneous and that their specimens are to be put under the name of genus *Amphithyris* . The type of this species was chosen from the specimens of Philippi, cited under *Platidia anomioides* by Lüter & Sieben (2005). However, these copies, at least some, would have been included in Helmcke's collection (1940); however, this author did not work on Mediterranean brachiopods but on the contrary Antarctic ones. In the inventory of the Zoologischen Museum zu Berlin, drawn up by Helmcke in 1939, we find *Argyrotheca cistellula* under the mention " Trapani (Philippi) " and " Palermo (Monterosato) ", *Joania cordata* under " Trapani (Monterosato) ", *Megathiris detruncata* under " Trapani (Philippi) ", *Platidia anomioides* under " Palermo (Monterosato) ".

Recently, Tréguier and Álvarez (*in* Álvarez *et al* ., 2016, 2017) studied the collection of the Marquis de Monterosato (1841-1927), belonging to the Musée des Sciences de Laval (France). This collection of living shells from the Mediterranean Sea, determined by de Monterosato, had been purchased in 1893 by Daniel Œhlert, paleontologist and brachiopod specialist (Emig, 2013). The brachiopods all come from the Mediterranean Sea, near the west coast of Italy and around the islands of Corsica, Sardinia and Sicily. Among these specimens of *Argyrotheca cuneata* , *Joania cordata* and *Megerlia truncata* collected in Trapani, but not of *Platidia* .

Difficult to conclude with certainty, because the contradictions remain and appear through this history, to which must be added the fact that no signaling of the genus *Amphithyris* has ever been made in the Mediterranean Sea during centuries of harvesting, especially for individuals referable to *Platidia* (Fig. 5-8), that the genus *Amphithyris* is restricted to the South Pacific, South Africa and Antarctica. It is not a question of questioning the identification of the specimens, but of wondering about their origin. The solution probably lies off the coast of Sicily, and more broadly the Mediterranean. In the meantime, the presence of *Amphithyris* in the Mediterranean Sea appears highly unlikely.

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Translation to 🇺🇸 and other languages

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