

The use of fish otoliths for paleobathymetric evaluation of the Lower to Middle Pleistocene deposits in Southern Italy

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ABSTRACT – A continuous lower and middle Pleistocene succession consisting of clayey-silts and silty-clays, over 400 metres thick, crops out in the southwestern part of the Bradano Trough (Montalbano Jonico area). The bulk samples collected along this section contain otoliths referable to 51 teleost taxa. Eight otolith associations have been recognised and allowed to infer the paleobathymetric changes into the basin. The two associations from the basal part of the succession clearly indicate an upper slope environment (300-500 metres deep). On the other hand, the associations from the middle and the upper parts of the succession indicate some depth variations ranging between the shallow outer shelf and the transitional zone to slope.

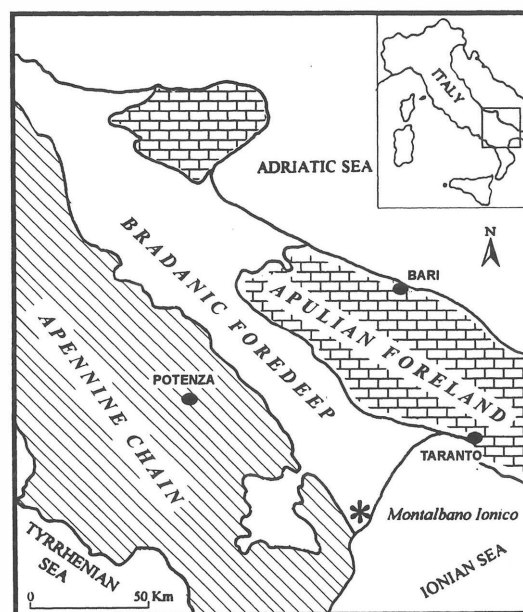
RIASSUNTO – [L'utilizzo degli otoliti per l'interpretazione paleobatimetrica di depositi del Pleistocene inferiore – medio dell'Italia meridionale] – Nel settore sudoccidentale della Fossa Bradanica (Montalbano Jonico) affiora una successione riferibile al Pleistocene inferiore – medio costituita da argille e argille siltose. I bulk samples raccolti lungo alcuni intervalli di questa sezione hanno fornito otoliti riferibili a 51 taxa di teleostei. Le otto associazioni riconosciute hanno permesso di interpretare le variazioni paleobatimetriche del bacino. Le due associazioni della parte inferiore della sezione indicano chiaramente un ambiente di scarpata superiore (profonda 300 – 500 metri). Le associazioni dell'intervallo medio-superiore della stessa successione indicano variazioni di profondità comprese tra la piattaforma esterna e la zona di transizione piattaforma-scarpata.

INTRODUCTION

A succession, over 400 metres thick, has been reconstructed along the internal border of the Southern Apennines Foredeep (Montalbano Jonico area, Text-fig. 1) (Ciaranfi *et al.*, 1997). It mainly consists of terrigenous clayey-silts and silty-clays in the basal and middle part, and of sandy-silts, silty-sands and sand bodies in the upper part. Nine volcanoclastic layers are included at various heights. A marine conglomerate (Text-fig. 2) tops the succession.

According to calcareous nannofossil associations, the succession ranges from the Lower Pleistocene in its basal part (large *Gephyrocapsa* and small *Gephyrocapsa* nannofossil biozones) to the Middle Pleistocene (*Pseudoemiliana lacunosa* nannofossil Biozone) in the upper part (Ciaranfi *et al.*, 1997).

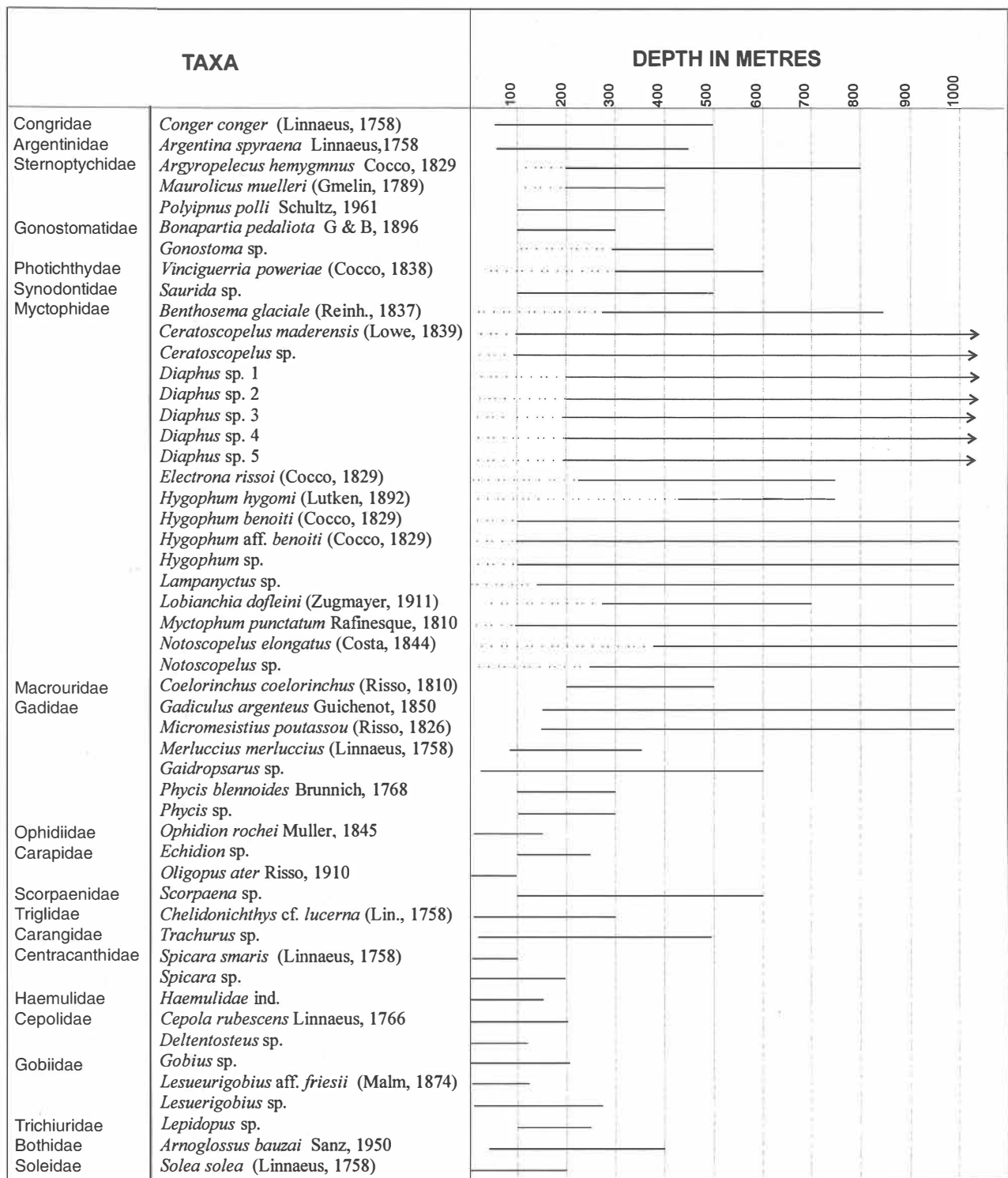
Palaeoecological, taphonomical and sedimentological analyses suggest a general regressive trend from upper slope to shoreface environments. The recognised benthic palaeocommunities can be compared to different recent biocoenoses indicative of a depth ranging from the upper bathyal to the infralittoral zones. The lower part of the succession, up to 150 m (including volcanoclastic layer V1), is characterised by epibathyal fossil communities (*i.e.* from Protobranchs-Siphonodentalids to *Delectopecten*-Semelids communities). Upwards the succession (including the volcanoclastic layers V2 to V9) is characterised by sublittoral paleocommunities (*i.e.* from



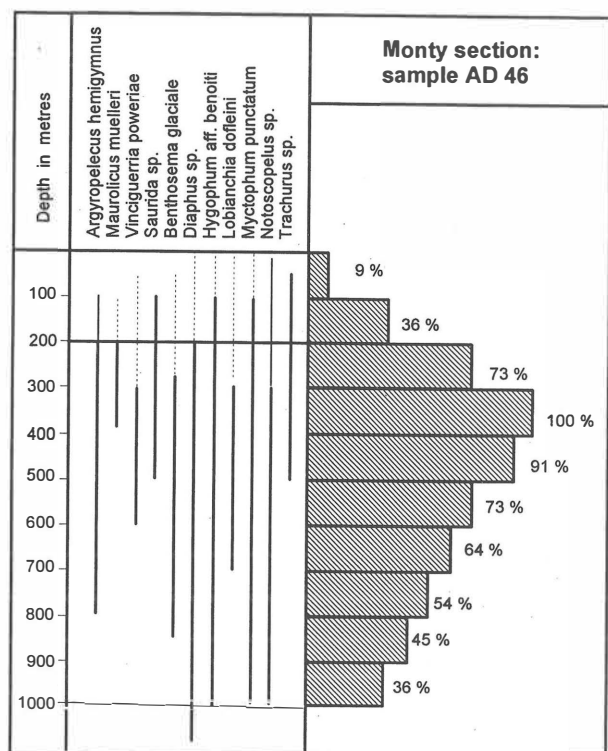
Text-fig. 1 - Location of the study area.

Neopycnodonte-Rissoid up to *Arctica*-Cardids communities) (Ciaranfi *et al.*, 1997).

Several samples have been collected at different stratigraphic intervals in order to evaluate the paleobathymetry of the basin by means of otolith associa-



Text-fig. 3 - Modern bathymetric distribution of all teleost taxa represented in the Montalbano Jonico Section (Lower and Middle Pleistocene) (Whitehead *et al.*, 1986-1989; Choen *et al.*, 1990; Nafpaktitis *et al.*, 1977).

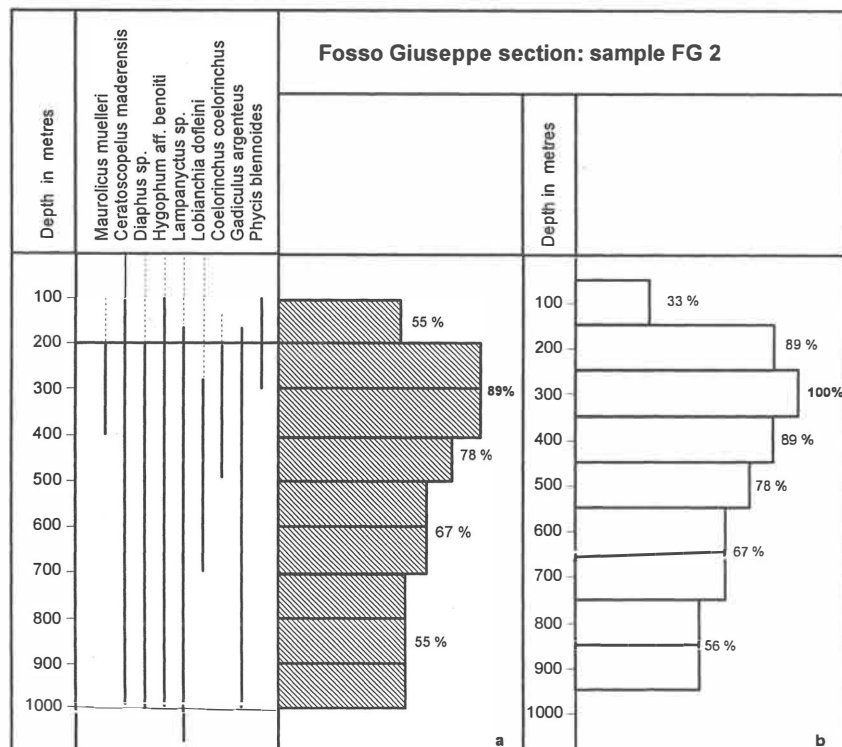


Text-fig. 4 - Modern bathymetric distribution of the teleost taxa represented in AD 46 association; dotted lines represent nightly presence of mesopelagic species at the surface.

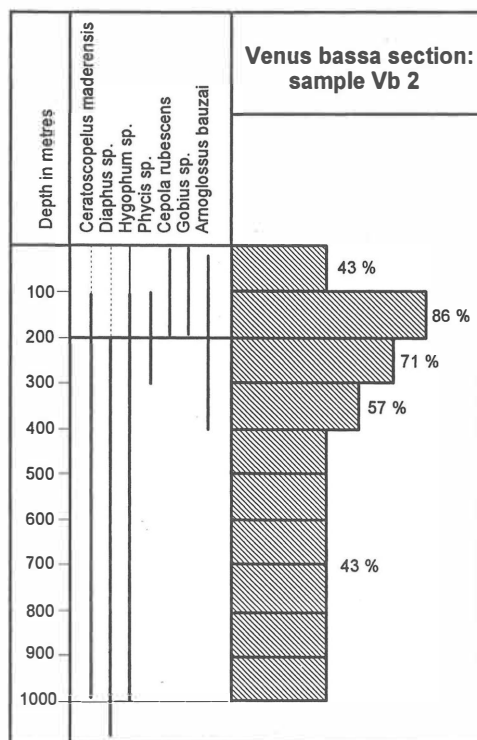
and FG2-4) have been collected in the epibathyal interval (fossil communities comparable with Bathyal Mud biocenosis of Mediterranean). Along the middle-upper part of the succession, the bulk samples Vb1, Va1 and VCT1 have been collected where macrobenthic associations suggested shallower facies (fossil communities comparable with the Terrigenous Mud and the Coastal Detritic biocenoses of the Mediterranean) and the bulk samples Vb2, I1-4 and VCT2 where the paleocommunities indicated deeper facies (fossil communities comparable with deep Terrigenous Mud/Heterogeneous Community, Muddy Detritic/Bathyal Mud and Shelf-Edge Detritic biocenoses of the Mediterranean) (Ciaranfi *et al.*, 1997).

PALEOBATHYMETRIC ANALYSIS

Paleobathymetric interpretations are based on the Monty and Fosso Giuseppe sections for the basal part of the succession, and on the Venus bassa, Dito del Diavolo, Ideale, Vecchietto sections, for the middle and upper part of the succession (Text-fig. 2). The modern bathymetric distributions (Whitehead *et al.*, 1986-1989; Choen *et al.*, 1990; Nafpaktitis *et al.*, 1977) of all the taxa from Montalbano are reported (Text-fig. 3). In the case of extinct species, the traced distribution is the total of the Recent species of the genus concerned (Nolf & Brzobohaty, 1994).



Text-fig. 5 - a) Modern bathymetric distribution of teleost taxa represented in FG2 association. b) Manipulated graph obtained changing the limits of the 100 m intervals: 50-150 m, 150-250 m, etc. instead of 0-100 m, 100-200 m, etc. See Text-fig. 4 for explanation.



Text-fig. 6 - Modern bathymetric distribution of teleost taxa represented in Vb2 association. See Text-fig. 4 for explanation.

MONTY SECTION

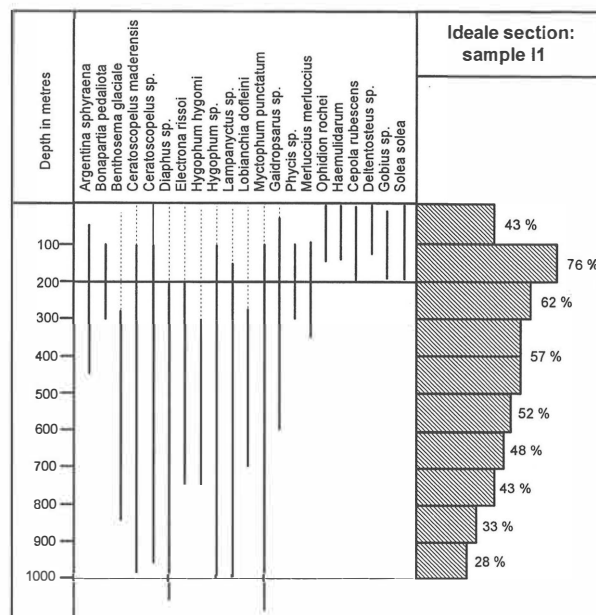
(long. 16° 32' 45"; lat. 40° 17' 51" from M. Mario)

The bulk sample AD46 contains the most significant association of the whole stratigraphic interval investigated. It is composed mostly of mesopelagic fishes of the families Myctophidae, Sternoptychidae and Photichthyidae. Otoliths of macrourids, benthic fishes that live on the bottom of the continental slope, have been gathered during the field but do not occur in the bulk sample. According to the bathymetric distribution chart (Text-fig. 4), this association is the deepest of the whole Montalbano Jonico section. The depth range is 300 – 400 metres.

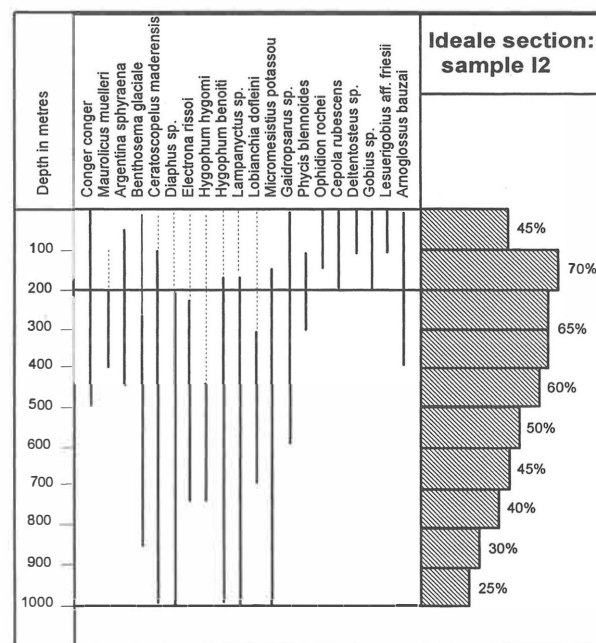
FOSSO GIUSEPPE SECTION

(long. 16° 32' 56"; lat. 40° 18' 37" from M. Mario)

In Fosso Giuseppe section four samples have been collected; only sample FG2 contains an amount of otoliths providing a significant association. The association is composed of five myctophid taxa, the macrourid *Coelorinchus coelorhincus*, gadids (*Gadiculus argenteus* and *Phycis blennoides*) and the sternoptychid *Maurolucus muelleri*. *Coelorinchus coelorhincus* is the only benthopelagic taxon that characterises the association. This association suggests a depth interval probably ranging between 200 and 400 metres (Text-

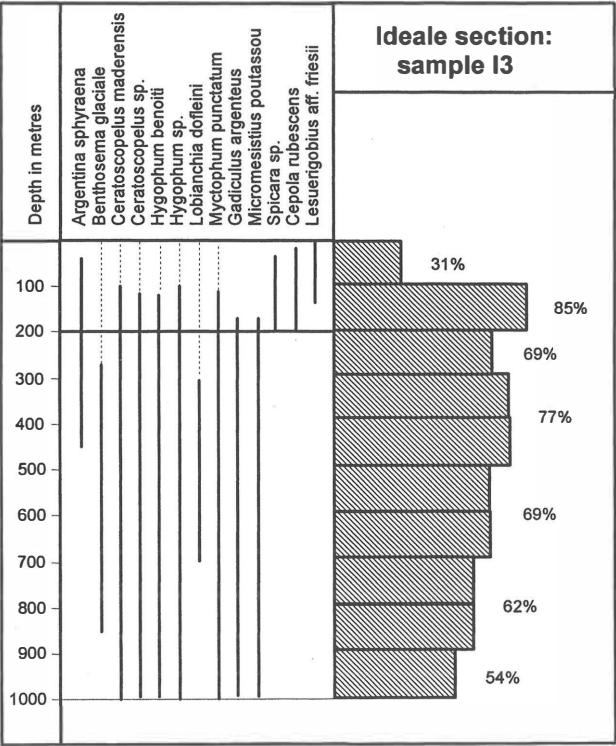


Text-fig. 7 - Modern bathymetric distribution of teleost taxa represented in I1 association. See Text-fig. 4 for explanation.



Text-fig. 8 - Modern bathymetric distribution of teleost taxa represented in I2 association. See Text-fig. 4 for explanation.

fig. 5a). The manipulated graph indicates for this association a depth range of 250 – 350 metres (Text-fig. 5b).



Text-fig. 9 - Modern bathymetric distribution of teleost taxa represented in I3 association. See Text-fig. 4 for explanation.

VENUS BASSA SECTION AND DITO DEL DIAVOLO SECTION

Two bulk samples (Vb1 and Vb2) and one sample (VA1) have been collected from the Venus bassa (long. 16° 32' 54"; lat. 40° 17' 37" from M. Mario) and Dito del Diavolo (long. 16° 33' 20"; lat. 40° 17' 40" from M. Mario) sections, respectively. Samples Vb1 and VA1, corresponding to a shallowing trend, contain few otoliths. The recognised associations are not significant to apply the quantitative method for the paleobathymetric interpretations; they are composed of benthic neritic taxa (gobiids) and benthopelagic fishes like *Gadiculus* sp. and *Phycis blennoides*.

Sample Vb2, collected in a deeper setting, contains otoliths referable to 7 taxa. The association is composed of myctophids (*Diaphus* sp., *Hygophum* sp., *Ceratoscopelus maderensis*), benthic neritic fishes (*Cepola rubescens*, *Gobius* sp.), gadids (*Phycis* sp.) and the bothid *Arnoglossus bauzai*. Although only a few otoliths for each taxon occur (1 or 2 specimens for taxon), the graph suggests a depth ranging between 100 and 200 metres (Text-fig. 6).

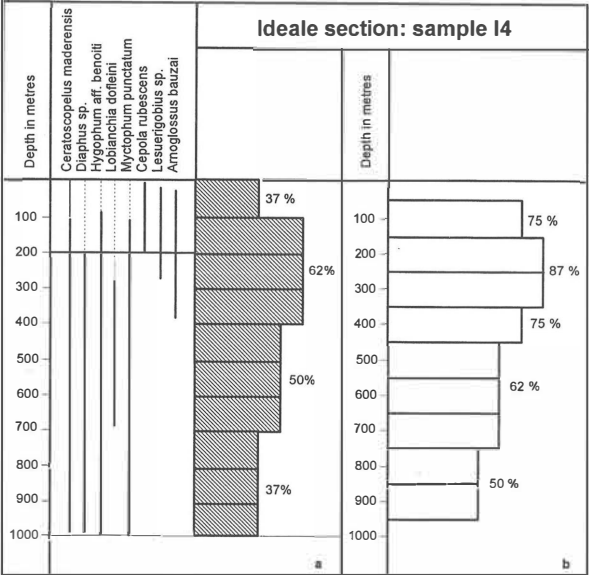
IDEALE SECTION
(long. 16° 33' 14"; lat. 40° 17' 42" from M. Mario)

In this section, four associations (I1, I2, I3 and I4) have been recognised. Associations I1 and I2 show a

similar composition with both mesopelagic and neritic as relevant components. Mostly benthic forms such as *Ophidion rochei*, *Cepola rubescens*, *Deltentosteus* sp., *Lesuerigobius* aff. *friesii*, *Gobius* sp. and *Solea solea* represent the neritic fauna. The gadoids *Merluccius merluccius*, *Phycis blennoides* and *Micromesistius poutassou* are represented by juvenile specimens and, according to the ecological data, the youngs of these species are more coastal dwellers and live on the continental shelf, while the adults migrate downwards along the slope. The mesopelagic fauna is composed mainly of myctophid taxa and subordinately of gonostomatids, argentinids and sternoptychids. The abundance of myctophids suggests a neritic environment exposed to oceanic influence and located in the deeper outer shelf. For these two associations, the peak of maximum frequency corresponds to a bathymetric interval between 100 and 200 metres (Text-figs. 7, 8).

Association I3, collected a few metres under the volcanoclastic layer V4, shows two peaks of maximum frequency (Text-fig. 9), which according to Nolf & Brzobohaty (1994) suggest an allochthonous association. Field data are in agreement with this interpretation.

Association I4 displays a lower diversity than associations I1 and I2, particularly with regard to the frequency of the neritic benthic taxa (*Cepola rubescens* and *Lesuerigobius* sp.). The mesopelagic fishes are represented only by myctophid taxa. The peak of maximum frequency is very wide indicating a bathymetric range between 100 and 400 metres (Text-fig. 10a), while the manipulated graph (Text-fig. 10b) indicates a depth between 150 and 350 metres. Nolf & Cappetta (1988) recognised a comparable association



Text-fig. 10 - a) Modern bathymetric distribution of teleost taxa represented in I4 association; b) manipulated graph. See Text-figs. 4 and 5 for explanation.

from the Pliocene of southern France composed of neritic and epi-mesopelagic fishes, without macrourids. Although the graph suggests a bathymetric interval between 200 – 300 metres, they placed this association between the outer shelf and the upper part of the slope.

VECCHIETTO SECTION

(long. 16° 33' 30"; lat. 40° 17' 39" from M. Mario)

In this section two bulk samples (VCT1 and VCT2) have been investigated; sample VCT1, collected in a shallow facies, is devoid of otoliths.

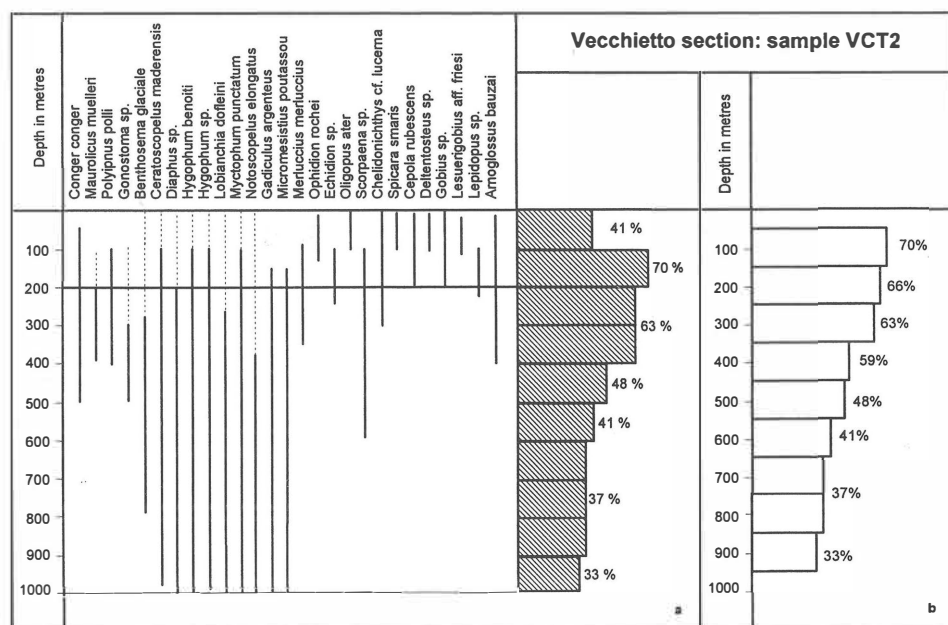
Sample VCT2, collected 6 metres above V5, shows the highest diversity among all the collected samples (twenty-seven taxa). Apart from frequent myctophids, eight taxa (*Ophidion rochei*, *Chelidonichthys cf. lucerna*, *Spicara smarini*, *Cepola rubescens*, *Deltentosteus* sp., *Gobius* sp., *Lesuerigobius aff. friesii*, *Lepidopus* sp.) are benthic neritics and two taxa (*Conger conger* and *Scorpaena* sp.) are fishes living on the bottom of the shelf and the upper continental slope. The gadiforms (*Merluccius merluccius*, *Micromesistius poutassou* and *Gadiculus argenteus*) are all juvenile specimens that, as mentioned above, live on the continental shelf. The graph suggests a depth ranging between 100 and 200 metres (Text-fig. 11a) or from 50 to 150 metres, according to the manipulated graph (Text-fig. 11b).

CONCLUSIONS

The teleost fauna of the Montalbano Jonico area is mainly characterised by myctophids, gadoids and neritic taxa. The macrourids are represented only by

Coelorinchus coelorhincus that inhabits the upper part of the slope. The conspicuous presence of myctophids suggests a basin influenced by oceanic waters. Today, in the modern Mediterranean basin, the myctophids are more abundant in the western area than in the eastern area; near the Alboran Sea this group displays the highest specific diversity. In the Montalbano fauna, the oceanic influence is demonstrated by the presence of two taxa (*Polyipnus polli*, *Bonapartia pedaliota*) that presently live in the subtropical – tropical eastern Atlantic Ocean, but not in the Mediterranean.

As far as bathymetric interpretations is concerned, the two lowermost associations (AD46 and FG2) are indicative of the upper continental slope with maximum depth of 400m decreasing upward to about 250 metres. The six associations (Vb2, I1, I2, I3, I4 and VCT) from the middle and the upper part of the succession are indicative of a neritic environment. The samples (Vb1, VA1 and VCT1) collected in the intervals referable to shallower environments according to the macrobenthic associations (*i.e.* fossil communities comparable with shallow Coastal Detritic biocenosis of Mediterranean) do not contain enough otoliths for applying the quantitative method. These rare otoliths are from fishes living on the continental shelf as well as juvenile specimens of fishes that migrate down to the upper part of the slope in their adult stage. However, the associations of shelf environments point out three deeper settings: the lowest association (Vb2) suggests deep outer shelf environment, the middle associations (I1, I2, I4) indicate an increase of depth from outer shelf to transitional zone to slope, the uppermost association (VCT2) is referable to the shallow outer shelf. The succession shows a deepen-



Text-fig. 11 - a) Modern bathymetric distribution of teleost taxa represented in VCT2 association; b) manipulated graph. See Text-figs. 4 and 5 for explanation.

ing – shallowing cycle with a maximum depth close to layer V4 (Text-fig. 2). This interpretation inferred by otolith associations are in agreement with the fourth order cycle pointed out by macrobenthic associations (Ciaranfi *et al.*, 1997).

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