

Project for the preparation of a Strategic Action Plan for the conservation of
biological Diversity in the Mediterranean Region
(SAP BIO)

The "white coral community", canyon and seamount faunas of the deep Mediterranean Sea

Distribution, biological richness and interest of the « white coral » community,
canyons and seamounts of the deep mediterranean



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March 2003

Cover photo
Lophelia pertusa
D'après Riedl, 1966

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1. INTRODUCTION

The presentation of the so-called "white coral" community by Pérès & Picard (1964) remains an essential reference for studies of the bathyal hard ground fauna in the Mediterranean Sea. Pérès & Picard's understanding of the Mediterranean fauna below roughly 300 m depth, on the rocky substrate, was largely influenced by earlier investigations of deep-water coral communities done in the north-eastern Atlantic, especially by Joubin (1922) and Le Danois (1948). But Pérès & Picard also relied on personal experience gained from deep dredging and trawling in various parts of the Mediterranean Basin, especially when in the 1950/60s J.Y. Cousteau's "Calypso" was occasionally used for scientific cruises. According to Pérès & Picard, the bathyal rock community at a few hundred meters' depth is characterised by two colonial, branching, scleractinian species, *Madrepora oculata* and *Lophelia pertusa* [synonymy: *Lophelia prolifera*]. In common use, both species are called "white corals" for reasons of an approximate perception of colour, that will be explained below.

As a rule, both species are able to produce large colonies and even (at least in the Atlantic Ocean) to produce extended, thick, build-ups. They can thus be community-structuring species, providing a biogenic hard substrate habitat and a complex network of biogenic interstices for many other organisms. Hence the notion of a "white coral" community that is traditionally and widely referred to in Mediterranean benthos literature although rather little original work was done subsequent to Pérès & Picard's (1964) influential presentation.

Consequently, the Mediterranean "white coral" community still remains somewhat hypothetical. The reason is that it is of difficult access for conventional gear in deep water on more or less broken-up rocky bottoms and that with modern gear (submersibles, remote-operated vehicles) it has never been studied on a large scale and subject to detailed comparison in various areas. On the contrary, recent research has been intensive in the north-eastern Atlantic.

Principal physical conditions

Hard ground-inhabiting deep-water corals as the basis for an associated diversified community cannot thrive everywhere in the deep Mediterranean. Certain physical conditions must be satisfied.

- ✍ The first is that of an adequate substrate being available, i.e., rock surfaces steep enough to crop out permanently from the surrounding areas of bathyal mud.
- ✍ Stronger bottom currents plus steep substrate will help to prevent a sediment cover being established.
- ✍ Enough organic matter input arriving from the euphotic layer is another self-evident prerequisite for the existence of a deep-water community of presumably locally-increased biodiversity and production.

The "white coral" community can thus be expected to occur along a narrow zone of steep rocky outcrops beyond the shelf break at adequate depths, as well as in physically

similar areas within the Mediterranean basins away from the continental coastline (seamounts and ridges). Steep-walled underwater canyons bringing the great depths closer to the coastline and canalising flows and turbulence from shallow to deeper water, with the concomitant transfer of organic matter, may be even more suitable places for the "white coral" community.

Given these premises, the present report aims at compiling and updating information on the "white coral" community in the Mediterranean, and for the purposes of comparison also refers to more substantial information on this type of community available from the north-eastern Atlantic. Underwater canyons and seamounts were visited, too, to obtain additional information on deep faunas, whether "white coral" community or other.

2. WHITE CORAL COMMUNITY _____

2.1 Why are these corals called « white » ?

A few remarks may be appropriate to explain the traditional use of the terms "white coral"/"yellow coral".

This use survives particularly well among Mediterranean scientists, who may have less opportunity than their Atlantic-based colleagues to ever encounter these organisms. As explained by Joubin (1922), this was originally a distinction made by Atlantic professional fishermen. Joubin used it himself, followed by other scientific authors, among them Le Danois (1948) and Pérès & Picard (1964). This conventional distinction is based on an approximate perception of colour, since the "white" *Madrepora oculata* and *Lophelia pertusa* are perceived as unlike two also large-sized, colonial, branching, "yellow corals", i.e. two species of the genus *Dendrophyllia*, *D. cornigera* (Lamarck, 1816) and *D. ramea* (Linnaeus, 1758). When using the colour-based categorization, both fishermen and scientists refer to a general impression.

Which color?

The calcareous skeleton itself is typically not pigmented (i.e. white), in all these corals. But in live *Dendrophyllia cornigera* and *D. ramea*, the white skeleton is fully masked by the soft tissues of a deep yellow colour (and with orange tones). A deep yellow colour is also typical of various other dendrophylliids and other bright colours also occur in that family where in live specimens the underlying white skeleton cannot be seen. As for the "white corals" *Madrepora oculata* and *Lophelia pertusa* (to which could be added other species), both fishermen and scientists simply noted the absence of any yellow pigment and the fact that the transparency of the soft tissues allowed the underlying white skeleton to be seen. In these species, the soft tissues are generally not "white". Generally, the soft polyp tissues of *Madrepora oculata* and *Lophelia pertusa* tend to be of a slight pinkish colour, as had been indicated by Le Danois (1948).

Only recently a variety of *Lophelia pertusa* that seems to be totally devoid of pigmentation (again qualified as "white") has reliably been reported from submersible and/or ROV (=remote-operated vehicle) observations in the north-eastern Atlantic.

The "yellow corals" *Dendrophyllia rama* and *D. cornigera* were considered by Pérès & Picard (1964) as typical (and community-structuring) species on rocky bottoms at lesser depths than *Madrepora oculata* and *Lophelia pertusa*, and their Mediterranean "offshore deep rock community" classed in the circalittoral, and not in the bathyal, stage, as for the "white corals". In fact, Pérès & Picard's schematic view of the *Dendrophyllia* species was biased by the then still imprecise information available, including a certain difficulty about how to distinguish these species. As shown by Zibrowius (1980), the two *Dendrophyllia* species differ in geographical and depth distribution and should not be presented as if they were ecologically equivalent. *Dendrophyllia ramea* is a species of lesser depth and typical of the south-western Mediterranean, whereas *D. cornigera* reaches greater, i.e. bathyal, depths and extends far to the east, i.e. into the Aegean Sea.

2.2- Renewed interest in deep-water coral communities in the Atlantic and their impact on the Mediterranean Sea

In the north-eastern Atlantic, especially in higher latitudes around Ireland, Scotland, the Faeroes and Norway, the "white coral" community has been at the centre of extensive geological and biological research over the last few years. Here, *Lophelia pertusa* is the main deep bio-constructor and community-structuring species, the coexisting *Madrepora oculata* having a lesser role.

Current investigation in the Atlantic covers extremely varied various topics: deep-water calcium carbonate production; age and history of the build-ups; growth rates; concentration of food by internal waves in certain areas with dense coral populations just below the shelf break; community structure including borers and eroders; biodiversity; hypothesis that these deep-water corals and the whole community may benefit from organic matter input derived from methane and other hydrocarbon seeps (chemosynthesis).

Given the constructional potential of (mainly) *Lophelia pertusa* and the high biodiversity, the term deep-water (or cold-water) "coral reef" has even been used in the context of this Atlantic deep-water community. This is contrary to the formerly widely accepted definition of a "coral reef" which, viewed historically, was not easy to have accepted, especially among palaeontologists who had access only to information provided by skeletal structures. The typical coral reef is a near-surface, or at least shallow-water, structure in lower latitudes, where the main coral constructors live in symbiosis with the light-dependent zooxanthellae (main driving physiological factor) and where dead coral structures do not simply crumble into pieces but are incorporated into massive lime deposits by biological and chemical action.

Maybe the new tendency to also see "coral reefs" in deep and cold water can be helpful for fund-raising, given the world-wide concern about the true, tropical, shallow-water coral reefs. Likewise, talk about deep- or cold-water coral "reefs" may help give extra value to work done in the obscure depths of the sea.

The remarkable biodiversity of this Atlantic high latitude deep- and cold-water ecosystem and its role as nurseries for various commercial fish species is well documented,

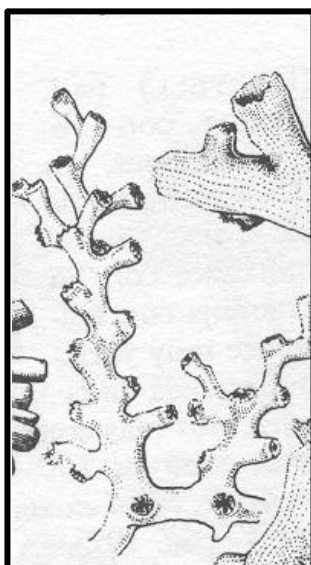
as is the unprecedented destruction caused by modern fishing gear. Accordingly, one major concern has recently been to push government decision-makers to arrange some kind of protection for this key ecosystem. Reasonable, long-term use should be guaranteed. It is significant that in early times, mapping and other studies were done in order to help fishermen avoid areas of mass occurrence of colonial deep-water corals, which represented a danger to their gear (Joubin, 1922; Le Danois, 1948). But in modern times, sophisticated heavy fishing gear represents a danger to these coral grounds, since some types of trawl are designed to break down and flatten the complex habitat, ensuring a one-off catch, but leaving a desert behind.

Now that fisheries activities are extending deeper and deeper everywhere and use more sophisticated and destructive gear, the idea that some type of regulation is needed in order to preserve exemplary key habitats in deep waters has also made its way to the Mediterranean. The problem here is somewhat different from the Atlantic, because the "white coral" community does not seem to occupy a similarly large place as in the North Atlantic.

2.3- Madrepora oculata and Lophelia pertusa in the Mediterranean Sea

Gathering information on the "white coral" community in the Mediterranean Sea requires that the distribution of emblematic coral species be analysed first. There are no fundamental changes with respect to the distribution as summarised by Zibrowius (1980), but updating is possible. The more noteworthy additions are, for both species, the first (even live) record from the Aegean Sea and confirmation of live populations down to at least 800 m in the Ionian Sea. For *Madrepora oculata*, the main addition is new live observations by means of a submersible in the north-western Mediterranean and for *Lophelia pertusa* confirmation that it does not occur in such shallow waters as *Madrepora oculata*.

2.3.1 Records of *Madrepora oculata* (Linnaeus, 1758)



Madrepora oculata
Riedl, 1966

The earliest records of *Madrepora oculata* in the Mediterranean seem to be from commercial red coral fisheries (using tangles) when gear was occasionally lowered into relatively deep water on steep hard bottoms. Branches of *Madrepora oculata* exist in various old museum collections (inherited from former natural history cabinets) together with similar old samples of *Corallium rubrum*, *Caryophyllia cyathus* and *Geardia savaglia*. This type of assemblage points to a red coral fishery origin. Mostly, there is no indication of origin, but southern Italian (Tyrrhenian Sea) and Sicilian waters are the most probable origins.

As indicated by Zibrowius (1980), records using dredging are numerous, from the Strait of Gibraltar to far into the eastern Mediterranean, the easternmost locality being near Kastellorizon, a small Greek island off the coast of south-western Turkey (Anatolia), well outside the Aegean Sea (36°04'10"N, 29°41'E, 366-381m).

Within this range, the list given in 1980 comprised the following areas: Alboran Sea, Banyuls, Marseilles, Banc de Magaud east of the Hyères Islands, the Gulf of Genoa and the Ligurian Sea, Capraia, Corsica, Asinara north-west of Sardinia, the north of Sicily, the Strait of Sicily near Malta, Pantelleria and Linosa, the Ionian Sea south of Cape Santa Maria di Leuca, and the Jabuka depression in the Central Adriatic Sea.

To this list, we should add the record of *Madrepora oculata* on rocky ridges near la Sentinelle and Resgui bancs (north of Tunisia), at ca 500 m deep by Azouz (1973) during the « Hannoun » campaign to study the physical features and the benthic bionomy of the trawling grounds off the northern tunisian coasts. One sample is still exposed to the public in the Tunisian marine institute (INSTM).

More recently, samples of *Madrepora oculata* have been dredged in the following areas, from various stations:

- ~~✂~~ Alboran Sea, "Cryos" cruise BALGIM, 1984
- ~~✂~~ Along the western side of Corsica, "Suroit" cruise MARCO, 1995
- ~~✂~~ Gulf of Lions, "Europe" cruise DEPRO96, 1996
- ~~✂~~ Tyrrhenian Sea, "Sonne" cruise 41, 1996
- ~~✂~~ Strait of Sicily, "Urania" cruise CS96, 1996/97
- ~~✂~~ Tyrrhenian Sea, "Urania" cruise LM99, 1999/2000.

A more remarkable record, by a commercial trawler, extending the distribution into the north-east Aegean Sea, is from south of Thassos Island (300-350 m), reported by Vafidis et al. (1997).

Altogether there are a great number of stations where *Madrepora oculata* has been obtained by dredging, mainly around the western basin and into the Strait of Sicily. At least in part, this concentration of data in the more western parts of the Mediterranean seems due to the historically more intense research done here, including in the less easily-accessible deeper waters which are the typical habitat of this "white" coral. The scarcity of data further to the east (one station in the Aegean Sea, one off south-west Anatolia) should be interpreted with caution. It may not reflect the true rarity of the coral.

By far the larger part of the data summarised above refers to dead samples (fragments, branches or larger pieces of colonies). For example, whole cruises where special attention was paid to obtaining samples of deep-water coral fauna failed to dredge up even the slightest piece of live *Madrepora oculata*. This was the case during the CS96 and LM99 "Urania" cruises.

Altogether, little information is available on live *Madrepora oculata* in the Mediterranean Sea. Even when broken up and buried in the sediment, coral skeletons are highly persistent and a great many of the dredged samples may be very old, even dating back to the late Pleistocene.

Sediment-buried samples do not even need to look "old", since the dark coating of manganese typical of hard material in deep water forms inside the sediment. One would need to date each dead white branch in order to know its age, whether really contemporary or much older.

Submersible observations on steep rocky bottoms in canyons near Banyuls (Reyss, 1964) and Marseilles (Bourcier & Zibrowius, 1973) provided the first precise information on *Madrepora oculata* living there.

- ✂ In the Banyuls area (Rech Lacaze-Duthiers), live *Madrepora oculata* matter has been obtained by submersible dives (the "Griffon" of the French Navy, in 1986) and by dredging (in 1987).
- ✂ In the Marseilles area (Cassidaigne Canyon), three dives during the CYATOX1 "Suroit" cruise in 1995 provided an opportunity to observe, videotape and photograph live colonies of *Madrepora oculata* between 220 and 510 m. Locally, there were quite a number of colonies, but, remarkably, they mainly occurred under overhangs. Live colonies under overhangs are even more inaccessible to classical sampling gear than those on very steep cliffs, as was previously reported from another submersible observation in the same canyon (Bourcier & Zibrowius, 1973).

Submersible observations in the Cassidaigne Canyon explain why in the Mediterranean live *Madrepora oculata* branches have only exceptionally been obtained by dredging, although the species may locally not be rare. The traditional red coral fisheries of former times may have been proportionally more successful than modern scientific dredging in occasionally obtaining live branches. Indeed, when lowering their gear to more exceptional depths of at least ca. 200 m, red coral fishermen managed to get their gear (tangles attached to bars or crosses) onto broken-up bottoms and under overhangs.

There are rare records of live material from elsewhere, obtained by classic gear, from the following areas:

- ✂ "North of Sicily" (branches received by the British Museum (no. 1922.10.16.9) in 1922, from E.P. Ramsay, possibly from the traditional red coral fisheries);
- ✂ From off Cap Santa Maria di Leuca in the Ionian Sea (Mastrototaro et al., 2001, Taviani et al., 2001)
- ✂ From south Thassos in the Aegean Sea (Vafidis et al., 1997). The live record from Thassos is unexpected, but previously *Dendrophyllia cornigera* had already been obtained live from bathyal depths in the Aegean Sea, causing similar surprise (Zibrowius, 1979, 1980).

Considering the depth of occurrence in the Mediterranean Sea, submersible observations in the Cassidaigne Canyon near Marseilles indicate an interval of approximately 210 to 510 m. Zibrowius (1980) had already extrapolated a minimum depth of possibly 200 m, referring to the shallowest colonies previously observed by submersible (Bourcier & Zibrowius, 1973) and a series of dredgings. This was a correction of a previous estimate of a minimal depth of 130 m that had first been advanced by Bourcier & Zibrowius (1973) on the basis of dredgings. Given the preferred location of colonies on steep cliffs and under overhangs, it is probable that broken off branches will accumulate a few or many meters deeper on less steep areas, where they are more easily accessible to dredging.

2.3.2- Records of *Lophelia pertusa* (Linnaeus, 1758) [synonym: *Lophelia prolifera* (Pallas, 1766)]

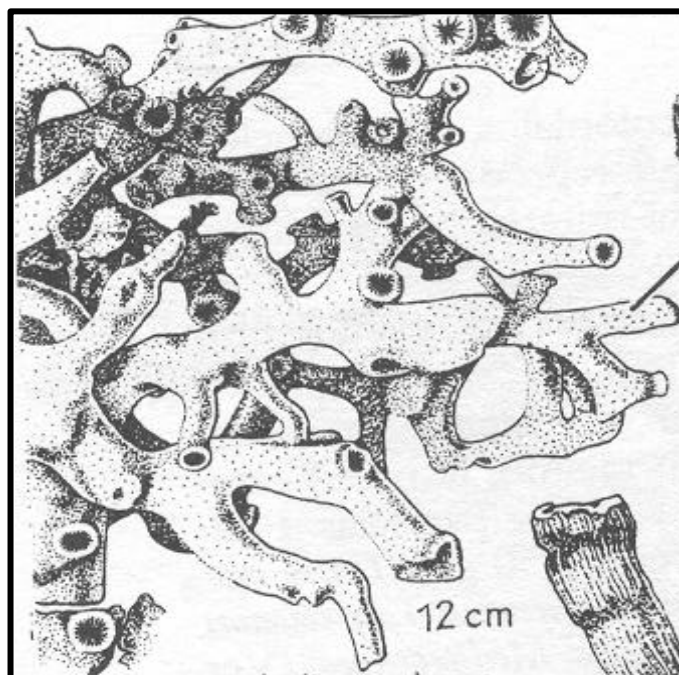
Confirmed live occurrence in a canyon near Banyuls (Rech Lacaze-Duthiers) fits the depth interval obtained in the Cassidaigne Canyon, which may include a widely representative depth interval for present-day live occurrence in the Mediterranean. However, even in the Cassidaigne Canyon, 510 m should not be understood as an absolute limit. If the species extends there into even greater depths, it is probably more rare there, since no such observation has been made. Simply put, dives along steep rock formations possibly suitable for *Madrepora oculata* are still too rare. So far, submersible observations in other parts of the Mediterranean on steep rocky bottoms have not yet revealed live populations of *Madrepora oculata*. Documents from the CYLICE "Cyana" cruise along the western margin of Corsica in 1997 seem to show only accumulations of dead coral. Nevertheless, *Madrepora* occurs in

even deeper water in the area off Cape Santa Maria di Leuca, in the Ionian Sea (Mastrototaro et al., 2001; Taviani et al., 2001). That "white corals" occurred in that area had already been noticed during a "Pola" cruise in 1891 (Steindachner, 1891; Marenzeller, 1893) and more recently was known to fishermen. The INTERREG4 Italia-Grecia cruise in 2000 finally did some dredging and found live *Madrepora oculata* down to at least 800 m. This area off Cape Santa Maria di Leuca seems special and a cruise programmed for August 2002 on board the Italian research vessel "Urania" is expected to provide substantial, precise new information.

This species, widely considered as the other typical species in the bathyal hard ground community, is dealt with second in order here because we have even less information at present on its live occurrence in the Mediterranean Sea. In general, in matters of general distribution (dredged samples) its situation is similar to that of *Madrepora oculata*. Both species commonly co-occur over a wide range.

Again, as indicated by Zibrowius (1980), records by dredging are numerous, from the Strait of Gibraltar to far into the eastern Mediterranean, the easternmost locality being near Kastellorizon, a small Greek island off the coast of south-western Turkey (Anatolia), well outside the Aegean Sea (36°04'10"N, 29°41'E, 366-381m). Within this range, the 1980 list contained the following areas: the Alboran Sea, Banyuls, Marseilles, the Gulf of Genoa and the Ligurian Sea, Capraia, Asinara north-west of Sardinia, the Naples area, seamounts in the southern Tyrrhenian Sea, near the Egadi Islands west of Sicily, the Strait of Sicily, the Strait of Sicily near Pantelleria, the Ionian Sea south of Cape Santa Maria di Leuca, the Jabuka depression and the south-east of Pelagruza in the Central Adriatic Sea.

To this list, we should add the record of *Madrepora oculata* on rocky ridges near la Sentinelle and Resgui bancs (north of Tunisia), at ca 500 m deep by Azouz (1973) during the « Hannoun » campaign to study the physical features and the benthic bionomy of the trawling grounds off the northern tunisian coasts, with one sample exposed in the Tunisian marine institute (INSTM).



Lophelia pertusa
Riedl, 1966

More recent cruises dredged *Lophelia pertusa*, often together with *Madrepora oculata*, in the following areas, from various stations:

- ~~///~~ Alboran Sea, the BALGIM "Cryos" cruise, 1984
- ~~///~~ Along the western margin of Corsica, the MARCO "Suroit" cruise, 1995
- ~~///~~ Gulf of Lions, the DEPRO96 "Europe" cruise, 1996
- ~~///~~ Tyrrhenian Sea, 41 "Sonne" cruise, 1996
- ~~///~~ Strait of Sicily, the CS96 "Urania" cruise, 1996/97
- ~~///~~ Tyrrhenian Sea, the LM99 "Urania" cruise, 1999/2000.

Again, a more remarkable record, extending the distribution into the north-eastern Aegean Sea, is from the south of Thassos Island (300-350 m), as reported by Vafidis et al. (1997).

The same remarks as for *Madrepora oculata* may be made for *Lophelia pertusa* concerning the many stations in the western parts of the Mediterranean and the few stations in the east. As for records of live samples, these are proportionally even scarcer for this species.

There are no submersible observations of live colonies in situ either in the canyons near Banyuls or those near Marseilles or apparently on the western margin of Corsica (accumulation of dead coral only, the CYLICE CYANA cruise in 1997). However, live branches have been dredged in the Banyuls area (by D. Reyss) and in larger quantities in the area off Cape Santa Maria di Leuca, in the Ionian Sea (Mastrototaro et al., 2001). The fact that *Lophelia pertusa* occurred in that area had already been noticed during a "Pola" cruise in 1891 (Steindachner, 1891; Marenzeller, 1893) and more recently the area was known to fishermen for the occurrence of "white coral". The INTERREG4 Italia-Grecia cruise in 2000 finally did some dredging and found live *Lophelia pertusa* at least down to 800 m. As for the co-occurring *Madrepora oculata*, this area in the Ionian Sea seems to be very special and a cruise programmed for August 2002 on board the Italian research vessel "Urania" is expected to provide substantial, precise new information.

A sample obtained live from a telegraph cable and deposited in the British Museum (no. 1910.4.21.1) is said to have come from off Gata Cape, 183-366 m. That would be at the western limit of the Alboran Sea, but the real collecting locality may be far away from that Cape, which perhaps was referred to only because the cable started there. Both the locality and the depth (probably a rough extrapolation meaning simply "deep water") should be treated with circumspection.

As in the case of *Madrepora oculata*, the depth range of samples collected dead by far exceeds the depth range inhabited by confirmed live populations.

In fact, dead branches of both species were occasionally reported from a trawl by the Prince of Monaco, off Monaco, at more than 2000 m depth (Gravier, 1920; Zibrowius, 1980). The explanation may be dumped material. Depth is less well elucidated for live populations than in the case of *Madrepora oculata*: down to at least 800 m off Cape Santa Maria di Leuca in the Ionian Sea, considerably less (some 300 m) in the Banyuls area. It is probably significant that there seem to be no dredged dead samples of *Lophelia pertusa* from depths as shallow as the shallowest records of *Madrepora oculata* that had been extrapolated to about 200 m. *Lophelia pertusa* may be expected starting well below 200 m.

2.4- Statut of Mediterranean *Madrepora oculata* and *Lophelia pertusa* populations

Pérès & Picard (1964) were already aware that in the Mediterranean the present-day "white coral" community was less thriving than in the north-eastern Atlantic, and that this community, the two colonial corals included, seems to represent a more residual stage, on a geological age scale, compared with its former prosperity.

However, they erred in attributing the more prosperous ancient "white coral" community to a warmer interglacial stage of the Pleistocene Mediterranean (Tyrrhenian, now known to have occurred at ca. 130,000 B.P.). It is not the deep-water counterpart of a well-known littoral fauna characterised by the presence of *Strombus bubonius* (see also Blanc et al. 1959). On the contrary, the prosperity of the colonial "white corals" was a feature of a cold Mediterranean, the last cold stage of the Pleistocene (Wuermian). Likewise, this cold stage is also characterised by an abundance of big solitary corals down into the great depths of the Mediterranean, on deep scarps and in canyons where similar populations of big live corals no longer exist.

In the north-eastern Atlantic, the large deep-water build-ups (not to be called coral reefs!) mainly on the basis of *Lophelia pertusa*, with their rich, diversified fauna, thrive in temperatures lower than those of the present-day deep Mediterranean. The lower temperature of the Pleistocene deep Mediterranean was more suited to this fauna than the present temperature. Further, it seems normal that *Lophelia pertusa*, which along Norway extends to higher latitudes than *Madrepora oculata*, shows a larger regression in the Mediterranean than other species, with respect to the ancient fauna, and that it does not seem to live in the Mediterranean at such shallow depths as only ca. 200 m.

Even though *Madrepora oculata* and *Lophelia pertusa* frequently occur together in the north-eastern Atlantic, *Madrepora oculata* seems to tolerate slightly higher temperatures, which are close to the limit for *Lophelia pertusa*. It is particularly interesting that both species seem to occur in larger quantities in the Ionian Sea, south of Cape Santa Maria di Leuca, in depths around 800 m.

This may be the only area far inside in the Mediterranean where the two colonial corals and possibly the whole community may show signs of a more "Atlantic" prosperity. Perhaps the dense cold water formed in winter in the Adriatic Sea and flowing southwards into the Ionian Sea is one cause of this more exceptional situation. Anyway, speculation needs to be confronted with observation during and results from the "Urania" cruise to this area planned for August 2002.

We stress that we have no information on the existence of major *Madrepora* and *Lophelia* formations (build-ups) similar to those, famous for their large size, volume and thickness, reported from higher latitudes in the north-east Atlantic. On the contrary, with possibly an exception off Cape Santa Maria di Leuca, where we may expect a more "Atlantic" feel to the community, it seems that *Madrepora oculata* and *Lophelia pertusa* mainly occur as isolated colonies on steep, rocky bottoms rather than as a dense, thick cover on larger surfaces.

The Mediterranean is a very special basin, with its relatively high deep-water temperature conditioned by the temperature at the Gibraltar threshold, and there is a risk that by exaggeratedly transposing an Atlantic situation, an undeserved hypothesis will be reinforced.

Together with Pérès & Picard (1964), but now having access to additional information, we may consider that the Mediterranean "white coral" community is a reduced version of the Atlantic one.

Even during the lower Pleistocene, when the fauna (many groups investigated) of the deep Mediterranean had a much more "Atlantic" feel and included many species that later disappeared from the basin but still exist in the Atlantic, the Mediterranean fauna was not fully "Atlantic".

This was illustrated, for example, by the case of the colonial scleractinian *Solenosmilia variabilis* (Duncan, 1873). In the Atlantic, this species occurs over a wide range of latitudes, at a depth greater than that typical for *Madrepora oculata* and *Lophelia pertusa*, i.e. at lower temperatures. It also has a potential of producing larger build-ups that shelter a complex community and it commonly has its colonies altered in shape by the incorporated tubes of the associated polychaete *Eunice norvegica*. *Solenosmilia variabilis* could have been the ideal third "white coral" for older writers interested in the mass occurrence of colonial deep-water corals (Joubin, Le Danois) – had they been aware of its existence and had fishermen already trawled deep enough to find it dangerous to their gear. *Solenosmilia variabilis* was never found in the Pleistocene Mediterranean, possibly because the temperature was never low enough.

A unique record reported in the literature from the Pleistocene in Calabria (Collela & D'Alessandro, 1988) has been shown to be a misidentification of a misshapen branch of *Lophelia pertusa* (Zibrowius, 1991).

2.5- Biodiversity of the "white coral" community

What can be said of the biodiversity of the "white coral" habitat or community in the Mediterranean? Is it be a "hot spot" of biodiversity in the deep, as in the Atlantic?

On the basis of a rough comparison (literature for the Atlantic, limited own dredging experience for the Mediterranean) Pérès & Picard (1964) concluded that the Mediterranean "white coral" community was considerably impoverished. In the meantime there has been intensive research done on its Atlantic counterpart, not least because the oil industry was involved. Lists from the Atlantic, increased and refined, tend to reinforce the impression of a general impoverishment in the Mediterranean. However, it should be remembered that no similar research has been done on the Mediterranean "white coral" habitat or on deep hard bottoms in general.

Occasional biological results, in most cases obtained "commensally" from cruises focusing on other fields (in general geological) point to a fauna that is more diversified than commonly expected and that includes higher taxa that were considered as typical of the oceans but not present in the Mediterranean. For example, in recent years the Italian research vessel "Urania" dredged the first Mediterranean psolid holothurian (Massin, 1997) and the first Mediterranean *Dendrobrachia* (unpublished). The latter is a strange gorgonian devoid of sclerites (formerly described as a strange antipatharian) had been known only from

a few deep stations in the Atlantic ("Challenger" and Prince of Monaco expeditions) before being rediscovered recently, also in deep water, off southern Australia.

These more spectacular occasional additions to the Mediterranean deep, hard bottom fauna (not found attached to "white corals" but to other substrates) from hard ground where "white corals" can be expected (maybe the dredge simply missed them) suggest that many more discoveries can be made, in particular when groups comprising small organisms are critically investigated on the basis of larger series.

It would be unrealistic, at this stage of investigation of the deep, hard bottom fauna, on the basis of presently available lists (how reliable are they?) to evaluate the comparative richness (or poverty) of the Mediterranean and Atlantic faunas.

Although an advanced representative inventory of its biodiversity has never been made, it is reasonable to assume that the Mediterranean version of the "white coral" community is not poor in species, especially if the "white coral" community is given a somewhat wider sense: the community of deep hard bottoms where "white corals" occur (even as a minor element, since total cover by thick build-ups seems to be at least exceptional at sea).

As larger colonial organisms with persistent calcareous skeletons, *Madrepora oculata* and *Lophelia pertusa* provide additional hard substrate that extends into mid-water, thereby structuring the community. The same effect can be observed when steep rock surfaces at bathyal depths are covered by in situ fossilised sponges and build-ups of large ancient oyster shells. In situ fossilised sponges were commonly dredged in certain areas of the Strait of Sicily during the CS96 "Urania" cruise, sometimes together with large fossilised oyster shells broken off the rock. These large shells, probably from the Pleistocene to the Holocene age, occur widely throughout at least the western Mediterranean and the Strait of Sicily, forming belts on steep rock surfaces at several hundred meters' depth.

A diversified fauna of generally small organisms has been found attached to these substrates that to some extent are equivalent to the substrate provided by the main coral species of the "white coral" community. On escarpments at even greater depths (down to 2000 m or even 2500 m) throughout the western Mediterranean and into the eastern basin (south of Crete), no *Madrepora* and *Lophelia* can be expected. Here, another type of biogenic substrate exists: in situ fossilised large, calciform (but filled in) hexactinellid sponges and in situ fossilised large solitary scleractinians (*Desmophyllum cristagalli*, *Caryophyllia sarsiae*) that typically occur superposed in clusters. The incrustated fauna on these substrates is mixed, both late Pleistocene and recent (Zibrowius, 1983).

3.CANYONS

Underwater canyons, like deep-cut valleys in the continental margin, exist in various parts of the Mediterranean, a situation that is well illustrated in Le Pichon's map "Les fonds de la Méditerranée". Canyons held the attention of many geologists.

The canyons off the Mediterranean coast of France may be those best documented. Geological publications, especially those reporting on submersible cruises, occasionally provide biological information, although captions to photographs may not always correctly identify the organisms illustrated. Biologists have also worked in canyons, occasionally using

submersibles for direct observation. Some pioneer work by biologists was thus done with J.Y. Cousteau's SP 350 ("diving saucer") as early as the late 1950s in the Cassidaigne Canyon near Marseilles and subsequently also in the Banyuls area (Rech Lacaze-Duthiers). Precise information on the "white coral" community was obtained from in situ observation in canyons. Investigation of soft bottom fauna, bioturbation, anthropogenic and telluric particle input was also done in this deep environment.

Is biodiversity higher in canyons than elsewhere on the Mediterranean slope and margin at similar depths? The literature may give this impression, which, at least in part, does not reflect reality. Major old marine laboratories (Banyuls, Marseilles) are situated in areas where marine biologists have always had rather easy access to the bathyal depths in the nearby canyons. The use of the Cassidaigne canyon near Marseilles for dumping alkaline "red mud", waste resulting from the aluminium industry, made various studies of soft and hard bottom communities necessary. Thus it is normal that fauna data from canyons is proportionally better represented than fauna data from similar bathyal depths along the more distant outer and "regular" part of the margin between the canyons. In fact, no representative study seems to exist that compares in detail the fauna of canyons and that of equivalent other bathyal bottoms. One could argue that there are reasons why canyons should have a richer fauna. For example, in the north-western Mediterranean, canyon morphology may contribute to canalizing cascades of more dense water in winter. On the other hand, it largely conditions upwelling. The strong Mistral-induced upwelling at Cassis, near Marseilles, is related to the Cassidaigne canyon.

4. SEAMOUNTS

Seamounts role

A conventional view sees them as individualized structures that rise above the deeper ocean floor, whereas lower structures that just rise from shelf areas should be called differently.

Biogeographically, seamounts are islands separated by great depths. Consequently they may serve as isolated refuges for relict populations of species that have disappeared from the greater portions of their former ranges, or may be subject to isolating mechanisms for speciation. Seamounts may also be essential stepping stones for range extensions between distant continental margins.

Seamounts are present in all ocean basins, yet their fauna was largely overlooked until the 1960s, when their potential as fishing grounds was first realized and commercially exploited (Keating et al., 1987; Rogers, 1994).

Seamounts have been intensively studied by geologists and biologists in various parts of the world's oceans, for example the north-eastern Atlantic, the south of Tasmania and on the ridges between New Caledonia and New Zealand. Outside the Mediterranean, the number of publications on both seamount geology and biology is large, reflecting an increased interest in these structures. Concerning the Mediterranean, Le Pichon's map "Les fonds de la Méditerranée" suggests that there are a number of structures that, depending on how wide or restrictive the definition of seamount is, could be classed as such. Investigations

of seamounts in the Mediterranean have been mainly geological, with biological studies relatively neglected.

In spite of its seamount title, Perrone's (1985) paper deals with the fauna of a shallow (40-70 m) near-shore structure in the Gulf of Taranto, Ionian Sea. Magaud Bank (in French known as the Banc de Magaud), east of the Ile du Levant, culminates a bit deeper but still at less than 100 m and is just the lower eastern end of a fairly continuous structure without very deep depressions. It is more of a "bank" of the deeper shelf zone than a seamount. Its benthos has been studied in detail (Falconetti, 1980). Various "banks" or "shoals" rather than seamounts in the complex area of the Sicily Strait were visited in 1954 by a "Calypso" cruise, whose first biological results were then summarized by Pérès & Picard (1956) before being worked up in greater detail, at least in part, by other authors. Graham Bank, a shoal of volcanic origin, emerged twice in the 19th century as an island (Julia Island). The area was revisited by the geological-biological cruise CS96 on board the "Urania" in 1996/97 (some of the samples being worked up now).

Earlier geological literature (Blanc, 1964; Blanc & Froget, 1967) provided some first biological information on modest seamounts (if that term is justified here) in the Aegean Sea, with summits of less than 100 m: Johnston Bank and a structure between Crete and Karpathos. From the latter, a strange ascidian and some brachiopods collected by the "Calypso" cruise in 1964 were finally studied a few decades later (Monniot & Zibrowius, 1999; Logan et al., 2002).

On a Mediterranean scale, major seamounts (Marsili, Vavilov and others) occur in the southern Tyrrhenian basin and seem to have been well explored from the geological point of view, including by submersible dives (Genesseeux et al., 1986; Robin et al., 1986; Uchupi & Ballard, 1989; Kaz'min et al., 1990; etc.).

Part of the deep faunas (hexactinellid sponges, scleractinian corals) collected there are Pleistocene in age (Brachert et al., 1987; KELLER, 1991). Some information about recent fauna is provided by Sokolova et al. (2001). Zhuleva (1987) mistakenly attributed dead colonial deep-water scleractinians from Vercelli Seamount, Tyrrhenian Sea (150-250 m), to a former, shallow-water coral reef, which presumably thrived during a warmer period of the Pleistocene and then underwent subsidence. This strange interpretation was corrected by Zibrowius (1989).

A large seamount that in size approaches those of some Atlantic counterparts is the Eratosthenes Seamount in the Levant basin south of Cyprus. It has been intensively studied by geologists (Emery et al., 1966; Ben-Avraham, 1976; Nesteroff & Maurice, 1979; Krasheninnikov et al., 1994; Robertson et al., 1994, 1995; Leg 160 Scientific Party, 1996; etc.). The seamount is a slightly elongated, massive, flat-topped rise (33°40'N, 32°40'E), measuring approximately 120 km in diameter at the base and rising 1,500 m above the adjacent abyssal plain, with a summit 756 m below sea level. The centre of the flat top (surface generally sloping down northward, 33 km wide NE-SW, 28 km NW-SE) lies ca. 100 km south of Cyprus and ca. 220 km off the African and Asian coasts.

The first benthos samples from the Eratosthenes Seamount were collected by the "Poseidon" German research vessel in 1994 (one trawl and box core samples nearby, across the top at 800 m). The muddy substrate was strewn with mostly subfossil scleractinian corals, subfossil polychaete tubes, various bioclasts, pieces of indurated crust formed by superficial cementation of the pelagic sediment, pumice, coal and slag from coal-burning ships. The trawl also collected an aluminium soup-ladle, illustrating the overall presence of

litter at the bottom of the sea. Epifauna was present on the various hard substrates, including the man-made one.

The fauna proved to be relatively rich and diverse (Galil & Zibrowius, 1998). It included two species of scleractinian coral (*Caryophyllia calveri*, *Desmophyllum cristagalli*), which are the first live records from the Levant basin and significantly extend the species' depth range. The "white corals" *Madrepora oculata* and *Lophelia pertusa* were not found, although the depth of 800 m does not seem excessive now for these species (see their occurrence off Cape Santa Maria di Leuca down to at least 800 m). Further records include: two types of encrusting foraminiferans; two species of encrusting porifers; abundant scyphozoan polyps; many individuals of the small actinian *Kadophellia bathyalis*; two species of zoantharian - one encrusting an antipatharian; seven species of bivalve; one species of sipunculan; five species of serpulid polychaete; four species of decapod crustacean; one species of asteroid; and one species of fish. Main hard substrates obtained include dead scleractinians, fossilized polychaete tubes made mainly of agglutinated pelagic foraminiferan tests, and shell fragments of the cephalopod *Argonauta argo* with signs of rapid cementation of the attached sediment crust - altogether a surprising diversity for deep waters in the easternmost Mediterranean. Further research is required to understand the input and origin of the organic matter that sustains the community in its diversity and density.

As for biodiversity on Mediterranean seamounts in general, no representative study seems to exist that compares in detail the fauna of seamounts and that of other bathyal bottoms at equivalent depths.

7. PROTECTING THE « WHITE CORAL » COMMUNITY AND RELATED BIODIVERSITY

In general there seems to be less danger in the Mediterranean than in the North Atlantic that this kind of bottom will be destroyed by deep-water fisheries (Hall-Spencer et al., 2002). There is simply much less to fish in the deep Mediterranean and it may be economically irrational for fishermen to invest in huge destructive gear when the probability is small that good catches could be obtained from deep, steep and broken-up bottoms. An exception may be the area off Cape Santa Maria di Leuca, where live *Madrepora* and (!) *Lophelia* do not seem to be rare in an area visited by fisheries.

Measures to be adopted

Anyway, establishing special sanctuaries in areas of the deep Mediterranean to be defined would be a wise precautionary measure. It would also stimulate further research, as happened in the case of more littoral sanctuaries. The impression that there are no major areas in the Mediterranean with extended larger build ups of colonial "white corals" should not stop decision makers preparing for some kind of protection for "the little that we have" of these deep particular biota. On the contrary, the relative scarcity of these formations in the present day Mediterranean (compared with the north eastern Atlantic) should be an argument for having it protected from destruction because of its general heritage value. The idea of a general heritage value, widely accepted for the terrestrial domain (for example in the case of relict forests, of rare species at the edge of their zone of distribution, and of disconnected species islands), deserves to be applied even to the less visible (because deep) marine domain. Other, more utilitarian, arguments for rational management can be advanced:

- ~~///~~ possible interactions at species and community level (nurseries etc.) with nearby soft bottoms where species of commercial interest can be caught by means of non destructive means;
- ~~///~~ biodiversity to be investigated in view of potentially bioactive metabolites expected to occur in various groups (sponges, octocorals, ascidians ...).

~~///~~

Deep areas with a seemingly remarkable fauna on steep rocky bottoms, including the (generally reduced) occurrence of "white corals", would have to be selected to be managed as representative reserves. As Mediterranean reserves, they would be complementary to similar zones in the Atlantic where the "white corals" have their "centre of prosperity", contrary to their peripheral "left over" status from a former geological period in the Mediterranean Sea.

8. OUTLOOK

All the information presently available in the Mediterranean on the "white corals" *Madrepora oculata* and *Lophelia pertusa* and the related hard bottom community has been obtained only occasionally, from the Linnean times of emerging marine zoology up to the age of submersible cruises. The last cruise that observed live *Madrepora oculata* in situ in an underwater canyon was the "Cyana" cruise in 1995 along the coast of Provence (France). Unlike the intensive research done in the north-eastern Atlantic in recent years, no special programme has ever been run in the Mediterranean on this subject. However in August 2002 a cruise of the "Urania" Italian research vessel will explore an area off Cape Santa Maria di Leuca (Ionian Sea) that is remarkable for the presence of apparently quite abundant live *Madrepora oculata* and *Lophelia pertusa*. Hopefully, this cruise will obtain substantial new biological data on the occurrence of this particular coral, together with detailed information on the associated community. For a better understanding, elsewhere, of the biology of these corals and the functioning and biodiversity of the community, it would be necessary to visually investigate the most suitable sites: the steepest parts of submarine canyons, the margin in general, and seamounts. Among the major seamounts in the Mediterranean Sea, the Eratosthenes Seamount (south of Cyprus), well known to geologists already, would especially deserve in-depth biological investigation, given that a unique biological trawl on its top has revealed the presence of an unexpectedly diverse fauna.

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Abbreviations:

CAC: canyon currents

CAF: canyon fauna

CAG: canyon geology

DHF: deep hardground fauna

SMF: seamount fauna

SMG: seamount geology

WCC: white coral community

exMed: extra-Mediterranean

fos: fossil

gen: general (reference to older studies, synthesis)

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The Regional Activity Centre for Specially Protected Areas (RAC/SPA) constitutes one of the institutional components of the Mediterranean Action Plan (MAP) of the United Nations Environment Programme (UNEP), co-ordinated under the supervision of the MAP Co-ordinating Unit. The Centre was set up in 1985 to assist Mediterranean countries in implementing the Protocol on specially protected areas and biological diversity. The Centre aims at assisting Mediterranean countries to establish and manage marine and coastal protected areas and to conserve biological diversity.

Among the Centre's activities is a project for preparing a **Strategic Action Plan for the Conservation of Marine and Coastal Biological Diversity in the Mediterranean Region** -SAP BIO Project - (1 January 2001 - 31 December 2003).

Starting from an assessment at national and regional level of the state of marine and coastal biodiversity, based on existing scientific data, and taking into account the Jakarta Mandate (developed within the framework of the Convention on Biological Diversity) and the Protocol on Specially Protected Areas and Biological Diversity, the SAP BIO Project aims at analysing the negative factors that affect marine and coastal biodiversity, or the lack of information, and identifying concrete remedial action. Integration of the actions decided on at national, sub-regional and regional level, along with detailed investment portfolios, involvement of stakeholders, and the development of approaches and principles, will become the Strategic Action Plan for Biodiversity. In addition to this strategy, which is the final document of the processes, within the framework of the SAP BIO Project, a series of national and regional reports is being prepared.

The present document is part of this series.



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