

## IS THE MEDITERRANEAN CORAL *CLADOCORA CAESPITOSA* AN INDICATOR OF CLIMATIC CHANGE?

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### INTRODUCTION

*Cladocora caespitosa* (L.) is a colonial and zooxanthellate scleractinian coral belonging to the family Faviidae. It occurs throughout the Mediterranean and can be locally abundant (Zibrowius, 1980). Colonies occasionally grow to large sizes and build-ups, both living and fossil, have been reported from several sites in the Mediterranean Sea (Peirano *et al.*, 1998). As a fossil, *C. caespitosa* is frequent in terraced deposits of Middle to Late Pleistocene age, providing evidence that it was more abundant during warmer climatic phases.

According to Laborel (1987), the present geographical range of *Cladocora caespitosa* build-ups in the Mediterranean has decreased with respect to their fossil distribution. Reasons for this impoverishment are not known but might be related to climatic change. There are also clues that such a reduction is still in progress. Augier (1982) included *C. caespitosa* in a list of marine species in danger of disappearance.

Where abundant, *C. caespitosa* occurs in two ways, either as: 1) a great number of distinct subspherical colonies (10 to 30 cm in diameter); or 2) large formations reaching some decimetres in height and covering several square meters in surface area. For the latter type of occurrence, Peirano *et al.* (1998) proposed the term "bank", for the former they preferred the rather general and inclusive term "bed".

Both types of occurrence are relatively common in the coastal region around La Spezia. They are presently under study with the following goals: 1) to quantify the importance of the species as a builder during the present time; 2) to understand the influence of major environmental factors upon the build-ups accretion; 3) to correlate the growth of the species with climatic data.

### BUILDING PATTERNS

Living banks of *C. caespitosa* are known especially in the SE Mediterranean (Peirano *et al.*, 1998). Laborel (1961) gave an accurate description of such banks in

the Gulf of Atalanta, Aegean Sea. He reported banks 1 to 3 m high covering up to 100 % of the bottom, from 5 to 18 m depth according to specific sites.

The only living banks of *C. caespitosa* presently known in the NW Mediterranean seem to be those discovered in 1992 near La Spezia (Morri *et al.*, 1994). Banks living in the Gulf of Marseilles during the 18th and 19th centuries, are not longer found nowadays (Zibrowius, 1980). Another bank on the French coast has recently died due to overgrowth by the invasive alga *Caulerpa taxifolia* (Meinesz, pers. comm.).

Photomosaic techniques and *in situ* observations by diving on one the La Spezia banks showed the importance of modular growth strategies for the build-up accretion. Three main mechanisms were recognised: i) fusion of adjacent colonies; ii) "pouring" of the mass due to gravity; and iii) inclusion of satellite colonies. Peirano *et al.* (1998) assumed that this bank, which reaches a total length of over 3.5 m, started as a bed. As neighbouring colonies grew up, they came into contact with each other, eventually merging into a larger mass. In the absence of physical disturbance by storms, due to depth (27 to 29 m), this mass keeps on growing. It progresses chiefly in a horizontal way, "pouring" by gravity down the groove in which it is developing: maximum accretion is thus observed at the lower end of the groove. During this process, other portions of the bank may be met and then added by fusion; or the bank may incorporate smaller satellite colonies occurring nearby. Satellite colonies derive from larvae or originate asexually, by fragmentation.

#### ROLE OF ENVIRONMENTAL FACTORS

Peirano *et al.* (1998) hypothesised that the abundance of *C. caespitosa* is mainly controlled by competition with soft frondose algae. Therefore, shallow beds only develop on rock made nearly bare by sea-urchin grazing.

The capability of combining autotrophy (thanks to the symbiotic zooxanthellae) with plankton ingestion, gives *C. caespitosa* an advantage over algae in deeper locations (i.e., near the compensation depth for photophilic algae) or in turbid water (Laborel, 1961; Tur & Pere Godall, 1982). This may explain occurrence of beds and banks at depths below 20 m or near the mouth of the Magra River.

The formation of large banks in shallow water is probably prevented by physical disturbance by storms, as observed by Schiller (1993) in the Bay of Piran (N Adriatic). On the contrary, building in deeper or sheltered water might be enhanced by higher sedimentation: fine sediments fill interstices among corallites, giving the build-up more strength and compactness.

#### GROWTH AND CLIMATE

Schiller (1993), using Alizarin Red S, calculated a growth rate for *C. caespitosa* of 2.9-5.2 mm·year<sup>-1</sup>. In an aquarium, with a water temperature of 18-20° C all year

round, Oliver Valls (1989) observed a growth rate of about  $5 \text{ mm}\cdot\text{year}^{-1}$ . Based on X-radiography (a technique widely used on corals), average growth rate of corallites from La Spezia region resulted comprised between  $1.3$  and  $4.0 \text{ mm}\cdot\text{year}^{-1}$  (Peirano *et al.*, 1999).

X-radiographs of corallites show a clear banding pattern. *C. caespitosa* deposits two bands per year: a high-density band during the winter, a low-density band in the summer. No differences in deposition timing were found between shallow and deep colonies. Deposition timing proved to be correlated to monthly temperature and irradiance trends (Peirano *et al.*, 1999).

Year-to-year variations in band width are obvious on X-radiographs, and we started to correlate band width with temperature data. As an example, the skeletal growth of a colony more than 20 years old showed some positive correlation with annual mean temperature in the late '70s to first '80s and possibly in the late '80s to first '90s, but showed no correlation in other periods (Fig. 1). Retrospective analysis of a larger colony, more than 60 years old, showed that higher growth rates coincided with a warmer period in the '40s, and lower ones with a colder period in the '70s (Bianchi, 1997).

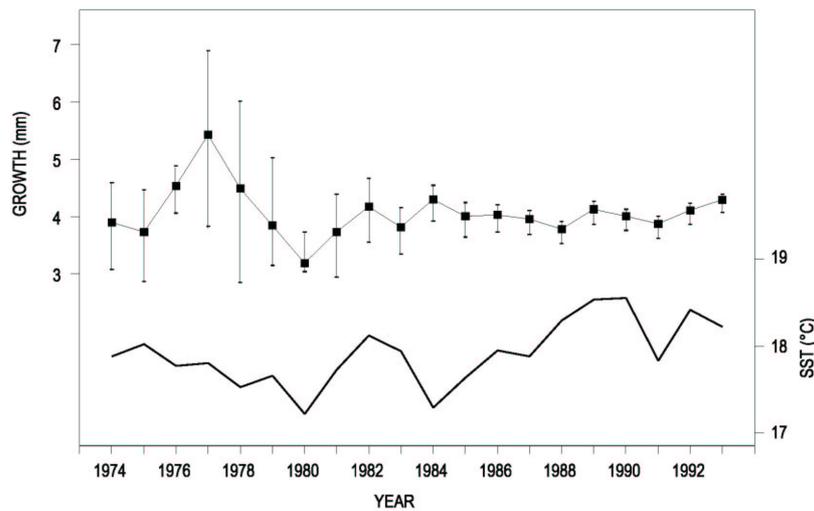


FIG. 1 Annual growth (mean  $\pm$  95 % confidence limits) of a colony of *Cladocora caespitosa* from La Spezia region, and mean annual sea surface temperature in the Ligurian Sea, 1974 to 1993.

The use of annual density bands in corals as a tool to understand past climatic variations is well known. Growth over one year is represented by the above-mentioned banding pattern (Knutson *et al.*, 1972; Barnes & Lough, 1993). Average annual calcification for *Porites* colonies provided a proxy for variations of sea surface temperature on the Great Barrier Reef back to the 18th century (Lough & Barnes, 1997), notwithstanding some distortion of environmental information during

coral growth and for intrusion into the environmental signal of information associated with skeletal architecture. Being a plocoid coral and thus having distinct and separate corallites, *C. caespitosa* may provide clearer results. Another advantage of *C. caespitosa* is that in the Mediterranean Sea the seasonal signal is stronger. Shallow water temperatures in the region of La Spezia, for example, range from winter values of slightly less than 13° C to summer values of about 23° C.

If band width proves to be related to mean annual temperature, the comparison of living and fossil growth rates in *Cladocora caespitosa* will help to reconstruct the conditions under which major banks were built in the past, and will make possible to predict the response of the present-day formations to climatic change.

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