

ALMA MATER STUDIORUM
UNIVERSITA' DI BOLOGNA

FACOLTÀ DI SCIENZE MM. FF. NN.

Corso di laurea magistrale in BIOLOGIA MARINA

Effects of *Eunicella cavolinii* (Koch, 1887)
(Anthozoa: Plexauridae) on settlement and
recruitment of benthic species:
an experimental approach

Tesi di laurea in Metodologie della ricerca subacquea

Relatore

Prof. Marco Abbiati

Presentata da

Vincenzo Ventra

Correlatori

Dott. Massimo Ponti

Dott. Carlo Cerrano

(III sessione)

Anno Accademico 2009/10

Dedicata al senso di libertà che trovo nel mare...

The important thing is not to stop questioning. Curiosity has its own reason for existing. One cannot help but be in awe when he contemplates the mysteries of eternity, of life, of the marvellous structure of reality. It is enough if one tries merely to comprehend a little of this mystery every day. Never lose a holy curiosity...

INDEX

1. Introduction.....	5
1.1. The coralligenous habitats.....	6
1.2. Biology and ecology of <i>Eunicella cavolinii</i>	14
1.3. Threats and mass mortality events.....	17
1.4. Are gorgonians ecosystem engineers?.....	19
2. Materials and Methods.....	21
2.1. Experimental design.....	21
2.2. Study area.....	22
2.3. Field work.....	27
2.4. Laboratory analysis.....	33
2.5. Statistical analysis.....	35
3. Results.....	37
3.1. Effects of gorgonian forest on the epibenthic assemblages structure.....	37
3.2. Effects of gorgonian forest at Tavolara site.....	43
3.3. Effects of gorgonian forest at Portofino site.....	48
3.4. Effects of gorgonian forest on the ecological groups.....	53
3.5. Effects of gorgonian forest on the species diversity.....	57
4. Discussion.....	61
4.1. Forest effect on community and single species.....	62
4.2. Forest effect on ecological group.....	63
4.3. Forest effect on species diversity.....	64
5. Acknowledgements.....	67
6. References.....	69

1. Introduction

The coralligenous habitat is one of most important environments in Mediterranean shallow-costal water, not only for its extraordinary beauty (admired by many divers), but also for the richness of species and the large species diversity who characterised it (Balata et al. 2005; Ballesteros, 2006). But define a coralligenous habitat is not a simple thing. There is no real consensus among scientists studying benthic communities in the Mediterranean Sea about what a coralligenous habitat is. Someone considered it like a hard substratum of biogenic origin that is mainly produced by the accumulation of calcareous encrusting algae growing in dim light conditions. Others included in this definition some habitats that present only a little stratum of coralline algae near the sea surface (like *Lithophyllum byssoides*), or those are found in shallow water at the upper limit of coralligenous habitat, defined by some authors like “pre-coralligenous”. Anyway all this communities present the same characteristic: a biogenic hard substrate suitable for the settlement and develop of a variety of benthic species that create a mosaic of environmental micro-conditions promoting life’s development.

The aim of this work is to assess the importance of the gorgonian *Eunicella cavolinii* in this complex. Particularly we have been focalised our attention to the importance of the presence of this species in the settlement and recruitment of other sessile organisms. We try to measure a typical “forest effect” (made by high density development of this erect species), that is the capacity of a population of the same species to modify the physical and biological environmental conditions in comparison to their absence. Even though there are many studies made on *E. cavolinii*, the importance of this species like a “habitat modifiers” is little known: many of these studies concern only to the biological features and the relationship of *E. cavolinii* with the surrounding habitat (Cimino, De Rosa, & De Stefano 1984; Velimirov 1976; Weinbauer MG 1996; Weinbauer & Velimirov 1995b). This work is part of a larger experiment that also involves another important species of gorgonian, the *Paramuricea clavata*. The experiment considers for the first time how this species may influence the colonization processes occurring in the coralligenous habitat. These processes can be analysed only through an

experimental manipulative approach (Glasby 2001; Piazzì et al. 2004). Nevertheless the ecological experiments involve many operative problems: first the capacity to check all the environmental factors involved and to keep under control (or measure) the natural intrinsic variability. This “modus operandi” leads us to a hypothesis of functioning model of the ecosystem, through the assessment of variables that determine a natural process. The last mortality mass events of gorgonians in the north-western Mediterranean Sea has had many negative repercussions on the ecosystem functioning (Cerrano et al. 2000; Cerrano & Bavestrello 2008; Coma et al. 2004; Linares et al. 2005) and the aim of the present work is to predict an eventual diversity shifting due to lack of gorgonians.

1.1. The coralligenous habitats.

Coralligenous habitats are biogenic hard substrate, mainly produced by the accumulation of calcareous encrusting algae growing in dim light conditions, and characterised by a diversified community (Ballesteros, 2006). In recent years has been given increasing importance to this habitat, considered like the coral reefs of the Mediterranean Sea (Fig. 1.1-1). The seasonality affect considerably the development and the diversity of this habitat, that presents a marked spatial and temporal variability (Piazzì et al. 2004; Virgilio, Airoldi, & Abbiati 2006). The Mediterranean coralligenous habitat has a low growth rate: it was estimated about 0.11–0.42 mm yr⁻¹ in most recent reef (about 5000 yr. BP with radiocarbon dating) at the depth range of 10-35 m but seems to be different depending on depth and physical conditions (Ballesteros 2006).

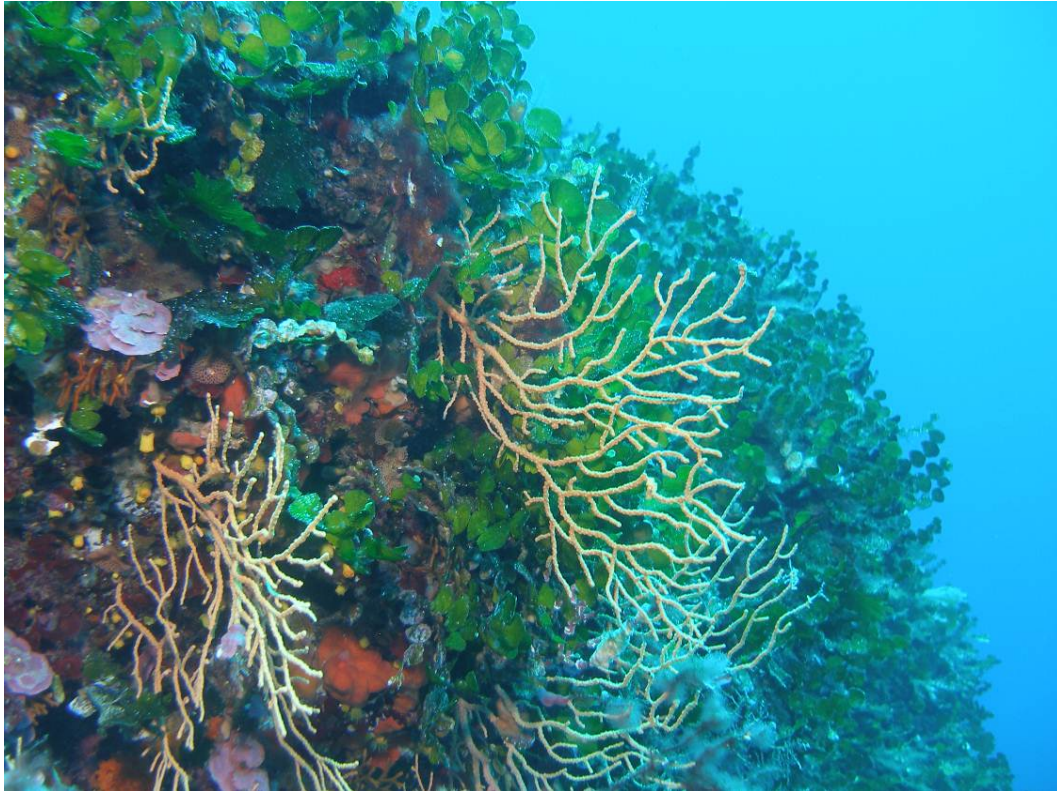


Fig. 1.1-1 Example of a coralligenous habitat (Cala Cicale, Tavolara).

Some physical characteristic typical of coralligenous habitat and that contribute to its development, are listed below:

Light

Light probably is the most important limiting factor in the coralligenous development. Ballesteros (2006) sustain that two characteristic are important for coralligenous development, the light intensity and the wavelengths. Of the two, the former appears to be more important, as seen in several studies on the depth distribution range, conducted in different areas of the Mediterranean Sea: difference were found both in the north-western Mediterranean Sea and in Adriatic Sea where its distribution is limited to light penetration (Casellato & Stefanon 2008). However, Ballesteros (2006) remarks the importance of the light quality, because the red algae capture light in the 'green window' thanks to the phycobilines. In addition, the complexity of the coralligenous framework creates different local condition of light penetration as well as other factors can contribute to coralligenous development. For instance, the substratum topography (crevices or the entrance to a cave) can recreate the same light conditions of deeper habitats

even at shallow depth. Similarly, light reduction in shallow water can be due to terrigenous input.

Nutrients, POC and DOC

Nutrients (both nitrates and phosphates) are also important for coralligenous habitat and, with some exception, their average concentration in the water column depend on several factors that can show seasonality changes. Generally, the peak of nutrients was reached in winter and spring due to water remixing movement. The coralligenous algal communities are adapted to low concentrations but, despite this, there are species with different growth characteristics. High nutrients concentration can affect the specific composition and calcareous construction rates (in some instances may increase also the destruction rates) (Ballesteros 2006). Nutrients, can also affect the plankton growth (primary production) and, consequently, the abundance of coralligenous suspensions feeders.

POC and DOC are also important for suspension feeders, and their concentrations are main related to terrestrial input, as well the recycling of the organic matter. The peak of concentrations for POC is higher during winter and spring, while DOC is higher in spring and summer. Both present high seasonal variations.

Sedimentation

Sedimentation was considered generally as a threat for coralligenous habitat, but we will discuss this aspect in more detail later. The accumulation of sediment is related to water movement and with the inclination of substrata (Airoldi 2003). Sedimentation leads to the creation of patches of sediment in cavity holes and crevices within coralligenous framework. These patches contribute to the development of typical soft bottom communities. The result is a general fragmentation of the coralligenous habitat increasing diversity and trophic relationship between species (Ballesteros 2006). Sedimentation is also important for the lithification processes involving fine particles that contribute to the coralligenous build-up.

Conversely, high sedimentation rates can alter the normal development of coralligenous habitat. Some effects are the reduction of light irradiance and the choking of coralligenous assemblages (mainly sessile species), as well the inhibition of settlement of new plants (Ballesteros 2006).

Water movement

The currents can contribute to several processes like sedimentation and nutrients availability. The horizontal water movements (currents) are considered more important than the vertical component (waves) for the coralligenous habitats, because the greater depth. But Ballesteros (2006) in his review show that waves are very important even at big depth in some north-western Mediterranean areas well exposed, pointing on the role of vertical movement to influence some physical processes. Generally, the intensity of water movement tends to decrease with depth and this affect the spatial distribution of coralligenous assemblages. In addition, it depends on the bottom profile and the morphology of the coast, as well as large-scale movement of Mediterranean circulations currents (Doglioli, Griffa, & Magaldi 2004). For instance some species are better adapted to high water intensity and their spatial arrangement reflects this phenomenon, as we will see later in gorgonians (Burlando et al. 1991; Velimirov 1973; Weinbauer & Velimirov 1995a). However, due to the intricate morphology of coralligenous frameworks, water movement can differ greatly between various microenvironments, in a similar way to that reported for light levels (Ballesteros 2006).

Temperature

Another important factor in structuring benthic coralligenous habitat is the water temperature. The marked seasonality of the physical conditions of the Mediterranean Sea includes high temperature changes in the superficial waters, related with the variation of the seasonal thermocline (Fig. 1.1-2). Temperature range differs from 10° to 23° C in superficial water (between 10-20 m). Despite several organisms can tolerate these variations, others are influenced in functioning and distribution.

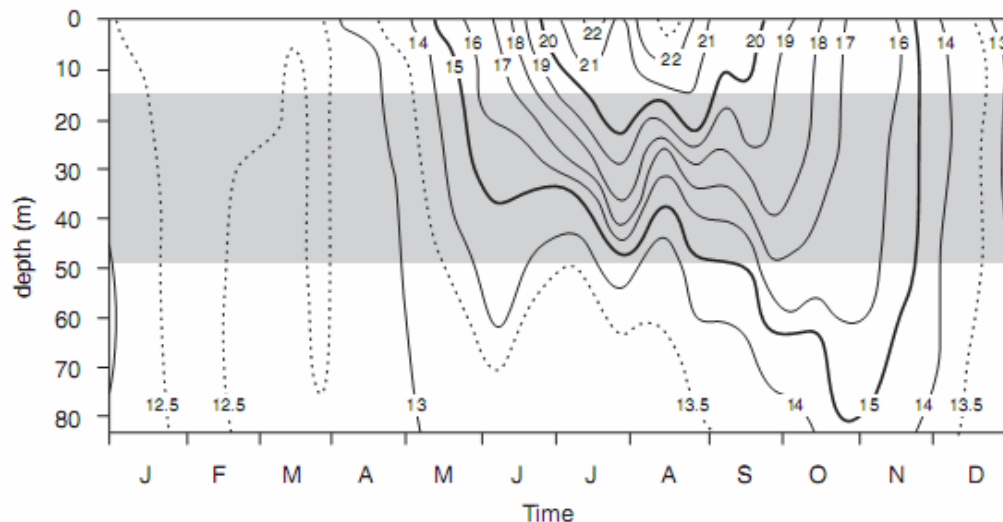


Fig. 1.1-2 Mean annual T variations at Medes Island (NW Mediterranean) from Ballesteros (2006).

Some organisms living in coralligenous assemblages from deep waters seem to be highly stenothermal, as they are never found in shallow waters. In recent year, peaks of 22° C were registered in summer at the depth over 40 m, causing health problems of these species (Ballesteros 2006). For instance the mass mortality events of *P. clavata*, as well other gorgonians species, seem to be related to periods of high temperatures during summer (Cerrano et al. 2000; Fava & Valisano 2007), although the ultimate cause of these mortalities remains unclear (seems related to other factors like pathogens or food availability see Martin 2002; Vezzulli et al. 2010).

Ballesteros (2006) summarises the Mediterranean distribution of coralligenous habitat and the relatively depth range according to some studies conducted during last decades. The coralligenous habitats are developed in all the Mediterranean Sea, except for the most south-eastern part (Lebanon and Israel). The depth range distribution depends on several factors. The nature of algal builders and the light irradiance influence the minimal depth of formation, which is in turn conditioned by other factor as water clarity and topography. The maximum depth varies from region and depends on the presence of historical formations dating from earlier periods. The general pattern is related with latitude, with the deepest distributions in the southern Mediterranean Sea than the northern part, where the coralligenous habitats are present in shallow water (Ballesteros 2006).

Within this depth distribution, the coralligenous framework can be present in two main morphology: banks, which are flat frameworks with a variable thickness (can reach a few meters) that have numerous holes and often surrounded by sediments in patches, and rims, which develop in the outer part of marine caves and on vertical cliffs, usually in shallower waters than banks (its thickness is smaller than banks). This two main type of bioconstruction and their general complexity are due to different species compositions.

The general distribution of living organism is described below. Algae, both encrusting corallines and green algae, usually dominate in horizontal to sub-horizontal surfaces, although their abundance decreases with depth or in dim light. The corallines algae that mainly contribute to the coralligenous build-up belong to few species of the *Mesophyllum* genus, while the green calcareous algae are the *Halimeda tuna* and *Flabellia petiolata*. At greater depths, the density of these erect algae decreases and other corallines dominate the community (*Rodriguezelletum strafforellii*). The fauna was represented by many different species of suspensions feeders, vagile and sessile predators, many herbivorous, fishes and other organism from many phyla.

However, the invertebrates characterising coralligenous habitats can be grouped in four categories, according to their function and position in coralligenous structure (Ballesteros 2006):

- Builder, contributing to build-up, which helps develop and consolidate the framework created by the calcareous algae. Several bryozoans, polychaetes (serpulids), corals and sponges constitute this category. They include 24% of the total species number.
- Cryptofauna colonising the small holes and crevices of the coralligenous structure. They represent around 7% of the species, including different molluscs, crustaceans and polychaetes.
- Epifauna (living over the concretions) and endofauna (living inside the sediments retained by the buildup), which represent a great number of species of almost all phyla (nearly 67%).
- Eroding species, accounting for only around 1%, distinguished in microborers (mainly cyanobacteria and fungi) and macroborers (echinoderms, the bivalve *Lithopaga lithopaga* and some sponges).

The general framework is a very complex community that presents a high spatial variability (Abbiati, Virgilio, & Querci 1996; Fava, Ponti, & Abbiati 2008). On a very small scale, the coralligenous framework can alter physical conditions, creating a series of micro-habitats with high different features. The result is a great heterogeneity of species composition even on few metres. In fact the Mediterranean coralligenous habitats are the one of the most important environments in terms of diversity of species (Boudoresque 2004), second only to *Posidonia oceanica* meadows. Moreover, the total number of identified species seems to be underestimated, because their complex structure and the paucity of studies dealing with coralligenous diversity. We have also to consider that the majority of these studies are carried out in the north-western Mediterranean Sea, with little exception from other area. At the moment this exceptional diversity of species was numbered of about 1600 species and continues to grow (Ballesteros 2006).

This high species diversity brings to light an intense and complicated network of trophic relationships and spatial interactions. The general processes involve the coralline algae and the invertebrates that contribute to the construction of coralligenous, on the one hand, the borers that continuously change the structure, from the other. The final result is the framework as we know it (Fig. 1.1-3).



Fig. 1.1-3 Diagrammatic section of a coralligenous bank, showing the high small-scale environmental heterogeneity and the different microhabitats from Ballesteros (2006).

The largest part of the living biomass in coralligenous assemblages consists of algae and suspension feeders, which suggest that herbivory and carnivory are not as important as in other marine Mediterranean environments. The low dynamism of coralligenous habitats also supports this suggestion. Despite this, there are many herbivores (like sea urchins) and most carnivores fishes that thrive in coralligenous communities, as well as most prosobranchs, echinoderms, vagile polychaetes and crustaceans. Although feeding by most animals is not selective, there are some noteworthy examples of animals that have a strong prey selection. Trophic relationships are especially interesting in coralligenous communities because the main organisms are not easily edible. Most of them have skeletons that deter feeding. Others may have chemical defenses that make them unpalatable or even toxic. The chemical defenses are also used for space competition and several organisms, including many gorgonians (Ioannou et al. 2009), produce active substances to avoid proliferation. Finally, but not less important, the coralligenous habitats are characterised by innumerable relationship like epibiosis, mutualism, commensalism and parasitism. Among these, the epibiosis are important because they directly affect gorgonian's growth. Several benthic species can tolerate different degrees of epibiosis, but excessive growths can alter the normal development of the host. This is due to precarious states of health or shifting of physical conditions. There is an epibiosis overgrowth when gorgonians population are threatened or when the habitat suitability is low (Weinbauer & Velimirov 1996).

For our purpose, we will argue some aspects of gorgonians communities and the surrounding habitat. In areas rich in nutrients (e.g., Gulf of Lions, Marseilles area) gorgonians can dominate the community. True (1970) studied a benthic assemblage dominated by *Eunicella cavolinii*. He reports a basal layer of encrusting algae accompanied by erect algae were the *E. cavolinii* is the most abundant species, followed by bryozoans, some serpulids and other smaller groups. The main biomass corresponded to the phylum Bryozoa, closely followed by Cnidaria, and, with much lower values, Annelida, Porifera, Tunicates and Mollusca. He also studies an assemblages dominated by *P. clavata*, that are most abundant on steep rocky walls at major depth, and found similar results, with the exception of the algae that are little represented. The main biomass corresponds to Cnidarian, followed by Annelidae, Bryozoans and other small ones (True 1970).

Studies are carried out by some authors about other gorgonians as the *Eunicella singularis* (Gori et al. 2007; Linares et al. 2008; Skoufas 2006), *Leptogorgia sermentosa* (Cocito, Bedulli, & Sgorbini 2002; Gori et al. 2010; PLAN 2008) and the gold coral *Savalia savaglia* (Cerrano et al. 2009). Other studies show that sea fans are normally colonized by a multitude of organisms, such as bryozoans (*Pentapora fascialis* or *Turbicellepora avicularis*), hydrozoans (*Eundendrinum sp.*, *Sertularella sp.*) or sponges (*Dysidea sp.*, *Hemimycale columella*). Few studies focused on the role of gorgonians as habitat modifiers. In general, they are recognized in the coralligenous biocenosis as “facies”, an area that is characterized by a dominant species with high density populations and homogeneous ecological conditions. Tunesi (2009) described a series of gorgonians facies of the coralligenous habitats present in Italy. He points that the facies of *E. cavolinii* are developed in the circalittoral zone at the average depth of 10 to 30 m, creating an environment with three-dimensional development. He emphasises the role of this gorgonians as an important structuring species, creating areas of concentrations for many other species. It is found widely on hard bottoms in dim light conditions and are sensitive to high temperature values (>27°C) and human fishing impacts. Particularly, the assemblages dominated by *E. cavolinii* tolerate values of irradiance higher than those tolerated by assemblages with other gorgonians (as *P. clavata*). Assemblages dominated by *E. cavolinii* is characterised by a higher algal component, composed mainly of soft algae. All the colonies have the same orientation of the branches, perpendicular to prevalent current (Tunesi 2009).

1.2. *Biology and ecology of Eunicella cavolinii*

Eunicella cavolinii (Koch, 1887) is a yellow sea fan typical of Mediterranean coastal waters (Fig. 1.2-1), with high depth range distribution (5-150 m), but more abundant from 10 to 30 m in depth (Russo 1985). It is very common in the western Mediterranean Sea and in the Adriatic Sea, while is more rare in the eastern basin. *E. cavolinii* lives mainly on rocky hard substrata in the coralligenous and pre-coralligenous habitat, where the light irradiance is not too low, often associated with colonies of *Paramuricea clavata*. *E. cavolinii* prefers moderately exposed sites, like cliffs or underwater channel, but it also found on

the entrance of subtidal caves. It is a member of the genus *Eunicella* (Verrill, 1869), that in Mediterranean Sea is represented by other two species: the *E. singularis* (Esper, 1791) and the *E. verrucosa* (Pallas, 1766). Belongs to the family of Plexauridae, order Alcyonacea, subclass Octocorallia of the class of Anthozoa.

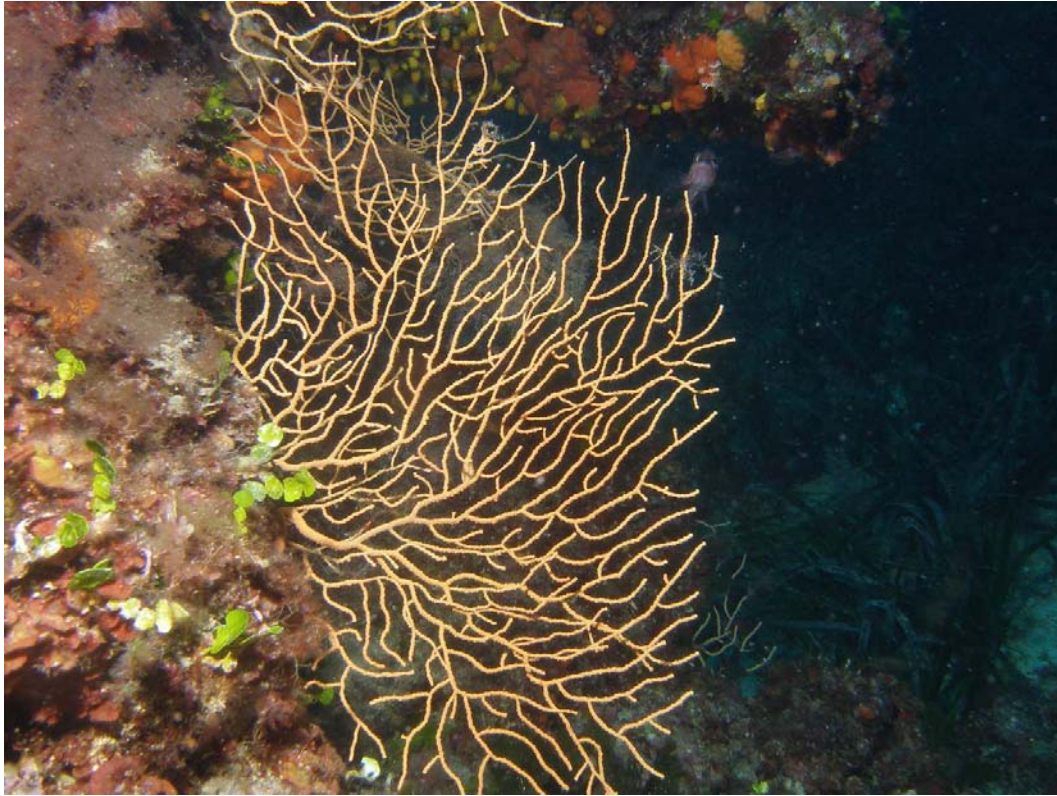


Fig. 1.2-1 The yellow sea fan *E. cavolinii*

Little is known about the biology of this species and most of the previous studies dealt with its ecological role (Velimirov 1976; Weinbauer MG 1996; Weinbauer & Velimirov 1996). It is an azoxanthellate gorgonian that form fan-shaped colonies of about 30-40 cm, but can reach higher dimensions (Trainito 2005). The colonies present a hard skeleton, known as sclera. The sclera can be divided into an inner part, called medulla, and an outer cortex that consists in a substance called “gorgonina”. The gorgonina is an organic compound made up of proteins, carbohydrates and halogens (iodine and bromine) and it is produced by epithelial specialized cells of the axis (Tidball 1982). All the central axis is surrounded by the coenenchyme: this gives a partial elasticity to the branches, to avoid currents damages (Fig. 1.2-2).

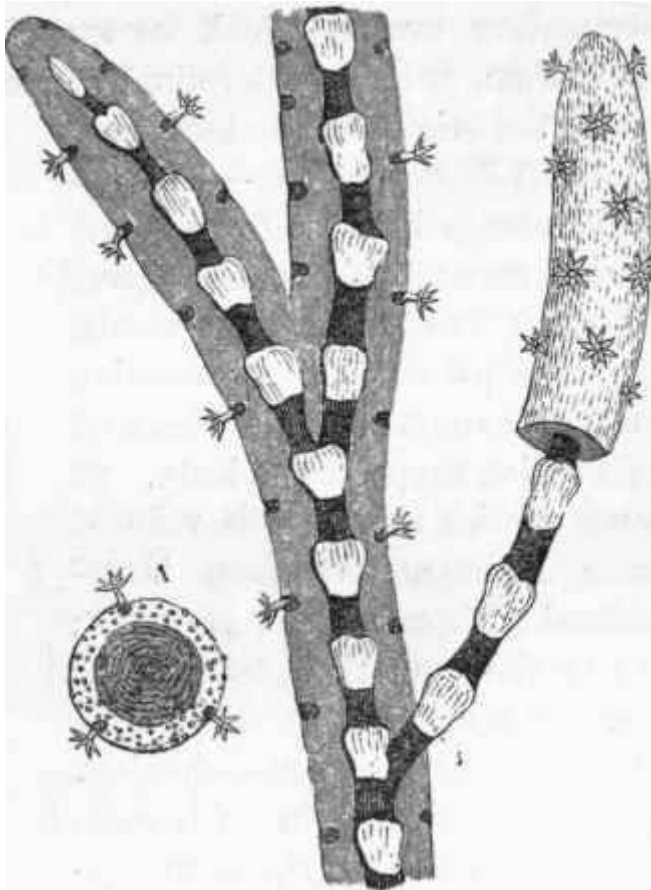


Fig. 1.2-2 Schematically section of a gorgonian from (Jones 1861).

The coenenchyme is secreted by the polyps during growth and allow communication within single polyps. It is formed by epidermis and mesoglea: the latter is made from a mixture of polymer matrix and fibrils. Immersed in coenenchyme there are numerous calcareous spicules that confer great resistance and deter feeding. They are composed of an inorganic fraction and an organic matrix (containing amino acids as Ala, Glu and Asp) and are produced by differentiated cells (scleroblasts) that are aggregate during the formation of spicule (Kingsley et al. 1990). The single polyps are situated in the coenenchyme. They are passive suspension feeders and generally feed on little plankton. A system of tubules joins the stomach cavity of each polyp. Despite the polyps can live independently, some area of the colony are specialized for defense (Lang & Chornesky 1990) and other for the reproduction (Harrison & Wallace 1990). Reproduction is external and the sexes are separated (gonochorism). This species is described as oviparous and begins to reproduce after a few years of the colony settlement. In oviparous, when the eggs hatch, there are ciliated larvas called

planula that have planktonic life (usually several days) until it settles in the substrate and originates a new colony (Barnes, Ruppert, & Litvaitis 1974).

Their growth was estimated about few cm for year, and was larger in periphery branches than in the central part (Weinbauer & Velimirov 1995a). The estimated maximum age was 21 years, but on average the *E. cavolinii* rarely exceeds a dozen years (Weinbauer MG 1996). The growth represents a compromise between the need for maximize the surface area exposed to metabolic exchange and to minimize the resistance to hydrodynamic forces (Velimirov 1976). In the central axis, the growth of the colony is reported as a series of concentric rings, like tree, because the growth follows the seasonal deposition of cortex matrix (Mistri & Ceccherelli 1994). The count at the microscope of the rings present in the basal central axis of the gorgonians is still the most accurate and secure way, even if destructive, to know the age of a colony (Velimirov 1975).

Important, also for our study, is the capacity of this sea fan to synthetize some biological active compound: it has been found many antiviral agents (Cimino, De Rosa, & De Stefano 1984). Some of these are important for human health and are processed in medical research for their anti-proliferative activity (Ioannou, Abdel-Razik, Alexi, et al. 2009). This effect, although not directly, was taken into account in our experiment.

1.3. *Threats and mass mortality events*

In the last decades, big mass mortality events involved gorgonians occurred in the north-western Mediterranean Sea (Cerrano & Bavestrello 2008; Fava & Valisano 2007; Martin 2002; PLAN 2008). In the summer of 1999, coinciding with high water temperature up to more than 40 meters in depth, there was a large-scale death of Anthozoan and other animals (molluscs, bryozoans, tunicates and sponges) in the Ligurian Sea and along the coasts of Provence in France. Several species were affected: the gorgonians *L. sermentosa*, red gorgonians (*P. clavata*), white gorgonians (*E. singularis*), yellow sea fans (*E. cavolinii*), *E. verrucosa*, red corals (*Corallium rubrum*), corals loaves (*Cladocora caespitosa*) and yellow cluster anemones (*Parazoanthus axinellae*) (Fig. 1.3-1).



Fig. 1.3-1 Effects of mass mortality events on colonies of *E. cavolinii* (from Cerrano et al. 2000)

In some areas, the mortality of existing colonies was between 60 and 100%. Millions of sea fans and others Anthozoa were died (Cerrano et al. 2000). For reasons still unknown, in *P. clavata*, death has hit principally the polyps of female colonies (Cerrano et al. 2005). Studies have shown that, due to the high temperatures, the fans were subjected to a severe stress and ended up being damaged by a wide variety of microorganisms (Cerrano et al. 2000; Martin 2002) or mucilage (Fig. 1.3-2). In 2003 there were other mass deaths of Anthozoa in the Mediterranean Sea, this time not only on the coasts of France and Italy (Fava & Valisano 2007), but also in Spain (Garrabou et al. 2009). These events have inspired studies focused on some aspect of mass mortality consequences, as the loss of diversity (Cerrano & Bavestrello 2008; Coma et al. 2007), natural recovery strategies (Cerrano et al. 2005) and physiological response (Ferrier-Pagès et al. 2009). Another study shows that the species of the genus *Eunicella* are more resistant and resilient to other gorgonians, as *P. clavata* (Fava et al. 2010). Repeated mass mortality events may have far reaching consequences for populations and communities and urgently requires attentions from marine scientists and environmental managers (Cerrano 2000).



Fig. 1.3-2 Mucilage on *P. clavata* colonies.

1.4. *Are gorgonians ecosystem engineers?*

Ecologists have long recognised that organisms can have important impacts on physical and chemical processes occurring in the environment (Wright & Jones 2006). Some ecological processes have great importance in structuring ecosystem as disturbance (Dayton & Hessler 1972) and facilitation (Bruno & Bertness 2001). The latter was often due to some species that are recognised as ecosystem engineers. Jones et al. (1994) defined ecosystem engineers as “organisms that directly or indirectly modulate the availability of resources (other than themselves) to other species by causing...state changes in biotic or abiotic materials. In so doing they modify, maintain and/or create habitats”. Many species have been recognized to be ecosystem engineering (Boer 2007; Castilla, Lagos, & Cerda 2004; Cerrano et al. 2006; Gaylord et al. 2007; Shashar et al. 1996; Wright, Jones, & Flecker 2002), which typically modify their own habitat increasing the fitness of associated species (Bruno & Bertness 2001). These organisms are defined foundation species. The presence of foundation species can often reduce water flow velocity as demonstrated for algal canopies (Jackson & Winant 1983) and seagrass meadows (Gambi, Nowell, & Jumars 1990) and this physical effect

can reduce re-suspension (Gacia & Duarte 2001) thus stabilising the substrate, increasing the fine sediment fraction (Eckman, Nowell, & Jumars 1981) and the quantity of sediment organic matter (Pusceddu et al. 2007). As a consequence, organisms living in habitats characterised by the presence of these “engineers” can experience a sort of “buffer zone” where environmental modifications occur slower and within narrower ranges with respect to the surrounding ambient.

Some authors have argued that all organisms are in some way ecosystem engineers (Wilby 2002), generating a heated debate. Others have argued that there are several degrees of modification (Reichman & Seabloom 2002).

We could compare the effect created by gorgonian forest to those of the trees in the terrestrial forests, although on a smaller scale. Previously, almost no one has tried to carry out studies on the ecological effect created by the sea fan forests and their significance in settlement and recruitment of benthic species. The only similar study was performed by Cerrano et al. (2009) on the gold coral *Savalia savaglia*, a rare zoanthid that growing a greater depth and, when present at high density, is able to enhance the benthic diversity simulating a forest effect.

The loss of gorgonians forests may affect not only the distribution of the species itself, but also the coralligenous community. If it were true, this would give greater importance to a species, *E. cavolinii* that has not yet protected by conservation measures. The aim of this work was to analyse the possible effects of *E. cavolinii* on the settlement and recruitment of other epibenthic species. These effects were tested by a field experiment carried out using recruitment panels in presence and absence of the gorgonians.

2. Materials and Methods

The experimental design is complex and involves several steps. A good planning is required for the implementation of the work, due to the impossibility to repeat the experiment in short terms. After a little introduction to the experiment, in this section is described the study area and the methods, followed by a short description of the statistical analysis involved.

2.1. *Experimental design*

The experiment involves the use of artificial recruitment panels arranged in plots, to measure the difference on settlement and recruitment of benthic species in the presence or absence of the sea fan *E. cavolinii* in coralligenous habitats (Fig. 2.1-1). It was conducted by SCUBA divers in two different area of the north-western Mediterranean Sea. For each site, four control plot with and four without gorgonians were placed randomly on the substrata, at the same depth range. Every plot presents four replicates of PVC Forex[®] panels (10.5x15 cm), each with three colonies of *E. cavolinii* (sampled before and each of about 15 cm height) implanted on it, with the same orientation (perpendicular to prevalent current). The reached density of sea fan, about 190 colonies/m², was similar to observation made in precedent study in good conditions of growth (Weinbauer MG 1996) to breed a forest effect. The study was carried out from June 2010 to October 2010, for a period of about four months in the summer season. During this period the plots were monitored periodically to check their status.

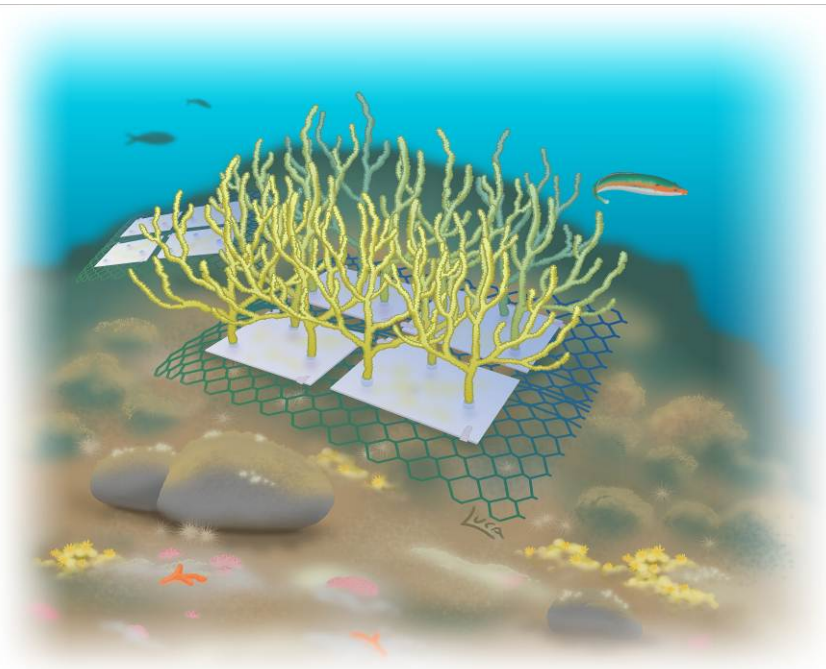


Fig. 2.1-1 Schematic representation of the experimental plots (drawn by Luca Parisi).

2.2. Study area

Two pristine study sites were randomly selected in the north-western Mediterranean Sea for the experiment. The study sites are placed into two of the most important and functional Italian MPA's to prevent the human impact on the experiment: the Tavolara-P.ta Coda Cavallo MPA (Sardinia) and the Portofino MPA (Liguria). In this case the two study sites were selected in correspondence of two diving hot spot, but the presence of diving disturbance didn't affect the experiment (probably the presence of University markers on the plots has avoided this phenomenon). The two sites are far apart about 350 km.

The MPA of Tavolara-P.ta Coda Cavallo, situated in the Tyrrhenian Sea in the north-eastern of Sardinia Island, was established by Decree of the Ministry of Environment on 12 December 1997. It is managed by a consortium between the towns of Olbia, Loiri Porto San Paolo and San Teodoro. It covers an area of about 15'000 ha and includes the islands of Tavolara, Molara, Molarotto and other small ones (Fig. 2.2-1). This MPA is one of the most important and well managed in Italy and presents several endemism.

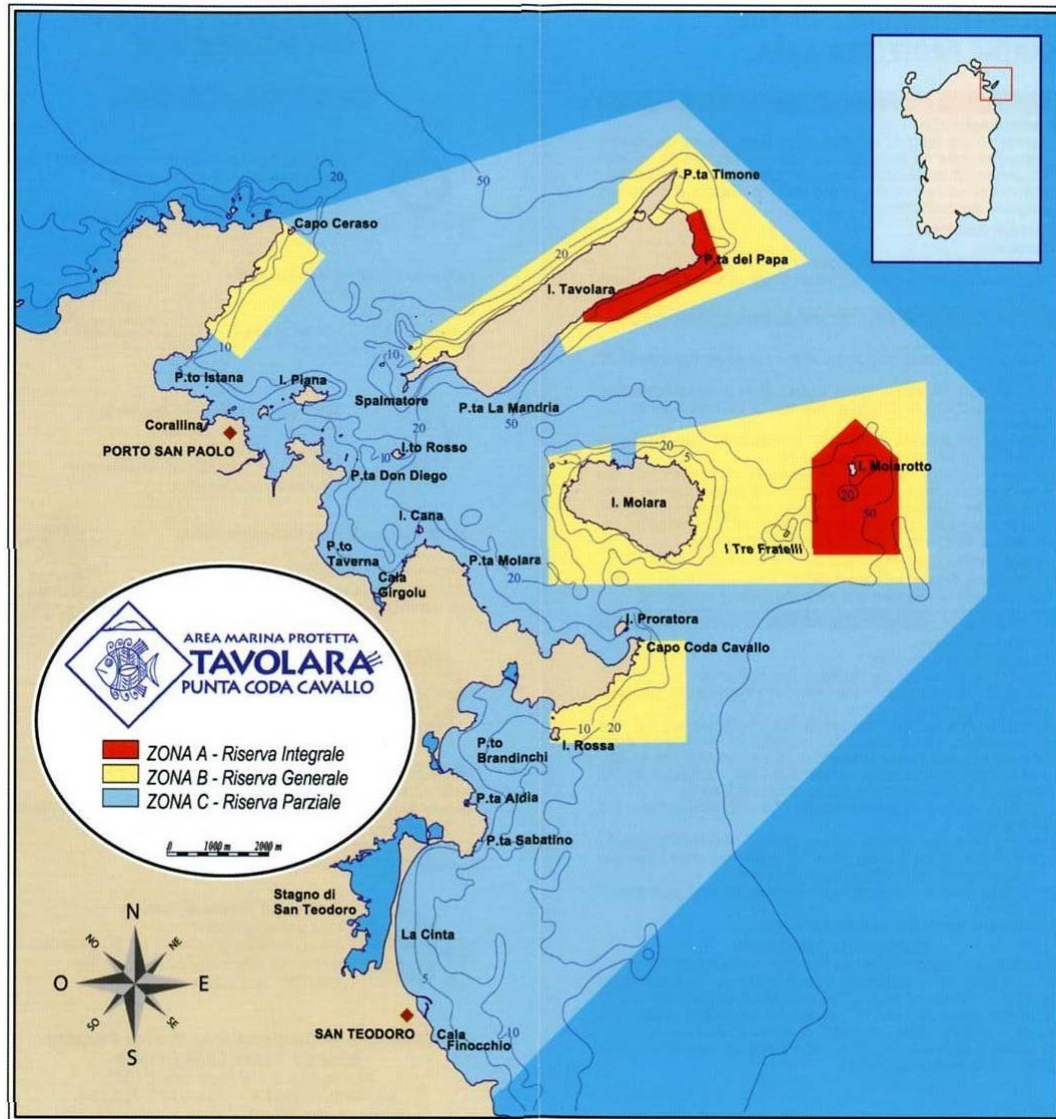


Fig. 2.2-1 The MPA of Tavolara-P.ta Coda Cavallo and their zonation (from MPA website).

The island is the biggest of the archipelago: it's well known like the “mountain on the sea” due to 565 m of altitude of Monte Cannone. It is a limestone massif of rectangular shape 5 kilometres long and 1 kilometre wide, with steep cliffs except at its ends. A cove and beach can be found at each end of the island. On the eastern side there is a natural column of rock well known as “Pope’s Rock”, to the similarity with the figure of a Pope. In the past, this island was famous for the institution of a little reign (one of the smallest in the world) by the Bertoleoni family, between 19th and 20th century, annexed to the Italy not formally after the death of the last descendant. Currently, the island is inhabited by only a handful of families, and has a small cemetery and a restaurant active only in summer in the western side of the island (Spalmatore di Terra). On the other side (Spalmatore di

Fuori) there is a small military NATO base, build in the 1962 as radiogoniometric station, now with a VLF-transmitter used to transmitting with submarines. All the eastern half side of the island is restricted to military personal only. The water around the island is popular for recreational activities like boating and diving, despite the restrictions of the MPA in some areas, because clear waters and high diversity of habitat above and below the sea surface. The seabed is characterised by the presence of *P.oceanica* meadows, lower midlittoral rock, semidark cave, dark cave, and coralligenous habitat on seawalls and rocky boulders (Bianchi, Morri, & Navone 2010). The sample area was located in front of the central part of the south side of Tavolara Island at Grottone location (40°54.017' N 9°42.725' E), where the gorgonian colonies was collected at depth of 22-26 m. The settlement area was located near the diving spot of Cala Cicale, not so distant from collection site (40°53.717' N 9°42.327' E), on a single big rocky boulders at depth of 24-25 m (Fig. 2.2-2). All the plots have the same face orientation (120° N) with an inclination of about 45° to the surface.



Fig. 2.2-2 Study site at Tavolara Island.

The Portofino MPA was established by the Decree of the Ministry of Environment of 26 April 1999 and includes the towns of Camogli, Portofino and Santa Margherita Ligure, in the Ligurian Sea (about 20 km far from the big town of Genoa). Besides the cities concerned, the management consortium includes the

University of Genoa and the Province of Genoa. This area covers about 346 ha in front the Promontory of Portofino, and since 2007 waiting to be annexed to the near Regional Park of Portofino to create a National Park (the proposal is being considered by the Senate) and to acquire the title of UNESCO World Heritage (Fig. 2.2-3).



Fig. 2.2-3 The MPA of Portofino and its zonation (from Italian Parks website).

The Promontory is located in one of the most populated coastal areas of Mediterranean Sea and the institution of the MPA has, in some ways, preserved the natural importance of these places. The surrounding area is characterised by many activities such as shipbuilding industries, mariculture, fishing, nautical and underwater tourism (Mangialajo et al. 2007). The Promontory is limited by the Gulf of Tigullio at the eastern side, while at the western side there is the Paradise gulf. This stretch of coast is characterized by a narrow continental shelf with a very steep slope, deepening from 50 to 500 m in a few kilometres. Along this coast, the abrupt headland of the Portofino Promontory extends into the sea for more than 4 km, with a roughly quadrangular shape. The southern side of this

Promontory is characterized by submerged very steep cliffs, while the western and eastern sides descend more gradually. From an oceanographic point of view the Portofino MPA lies within the Ligurian Sea, which is dominated by a well-defined cyclonic gyre, with a seasonal cycle related to the variations of the atmospheric forcing. The Ligurian coastal circulation is part of the general cyclonic circulation of the Mediterranean Sea: the result is general north-westward current that following the coast, with only short period of reversal, associated with northerly winds (Doglioli, Griffa, & Magaldi 2004). The geomorphological features and the hydrodynamic conditions favour the development of a rich and diversified environment: there are some important and protected habitats of the Mediterranean Sea already mentioned about Tavolara (included the coralligenous assemblages). In addition we found a marked presence of pelagic domain and the communities of the deep sea at few km of the coastline. This area has been subject of many ecology studies, as well as for gorgonians mass mortality events occurred in recent year (Cerrano et al. 2005; Cerrano & Bavestrello 2008; Fava & Valisano 2007; Sara et al. 2000; Vezzulli et al. 2010) and related to Sea-Surface Temperature (SST) increased in the north-western Mediterranean Sea (Martin 2002). The collection site was located at P.ta dell'Indiano (44°18.810' N 9°10.207' E) in the Bay of San Fruttuoso (near the famous Christ of the Abyss) at depth of about 24-31 m, while the experiment was placed at P.ta del Faro, in the southern tip of the Promontory (44°17.918' N 9°13.179' E) at depth of 22-24 m (Fig. 2.2-4). The face orientation of the plot was about 130°N, whereas the inclination was the same of Tavolara site (about 45°).

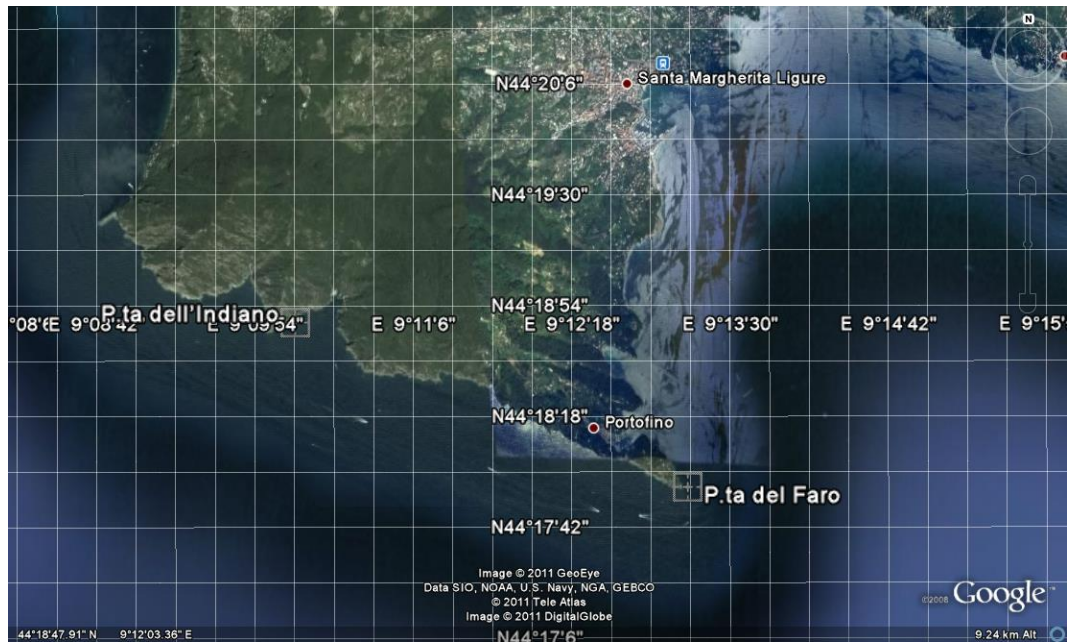


Fig. 2.2-4 Portofino study site.

2.3. *Field work*

The study was designed in order to respect the experimental scientific approach. It was prepared step by step, trying not to leave out any details.

The construction of the experimental plots was performed at the University labs. The plots were made of a rigid plastic net to secure the panels on hard substrata. The plot dimension was about of 40x30 cm (Fig. 2.3-1).

Each plot supports four panels in PVC Forex[®] of 10.5 cm wide and 15 cm long. The Forex[®] was a plastic material of PVC Foam Board that is commercial use in various applications, such as construction and industry, with low cost (Fig. 2.3-2). One of these is the use of this material on underwater slates. The Forex[®] has some qualities for the use and processing: important for our purposes is the ease of cutting and creating holes for the gorgonians transplant, not least the ability to scrape the biofouling for biomass measures, because of the smooth surface. In addition to these important features, the choice of the Forex[®] was made by considering some ecological aspects. There are several studies that have used artificial panels for colonization of free living space in benthic habitats with good results (Benedetti-Cecchi et al. 2001; Rule & Smith 2005; Turner & Tood 1993) as well as some studies have shown that the composition of substrate may affect the benthic recruitment and composition (Bavestrello et al. 2000; Glasby 2000). Naturally the use of natural rocky tiles or other “non-plastic” material gives a

better natural response to the dynamic of benthic population, but we must consider two important issues in ecological experiments: targets and timeframe. In this study we focalized most of the attention to check the difference due to a marine forest effect on the colonization of new free living space, as the first step to be verified in marine ecosystems. In addition the use of PVC panels gives logistic facilities, lower costs and good response, very similar to natural substrates, as well documented by other studies (Bourget, DeGuise, & Daigle 1994; Zeevi Ben-Yosef & Benayahu 1999).

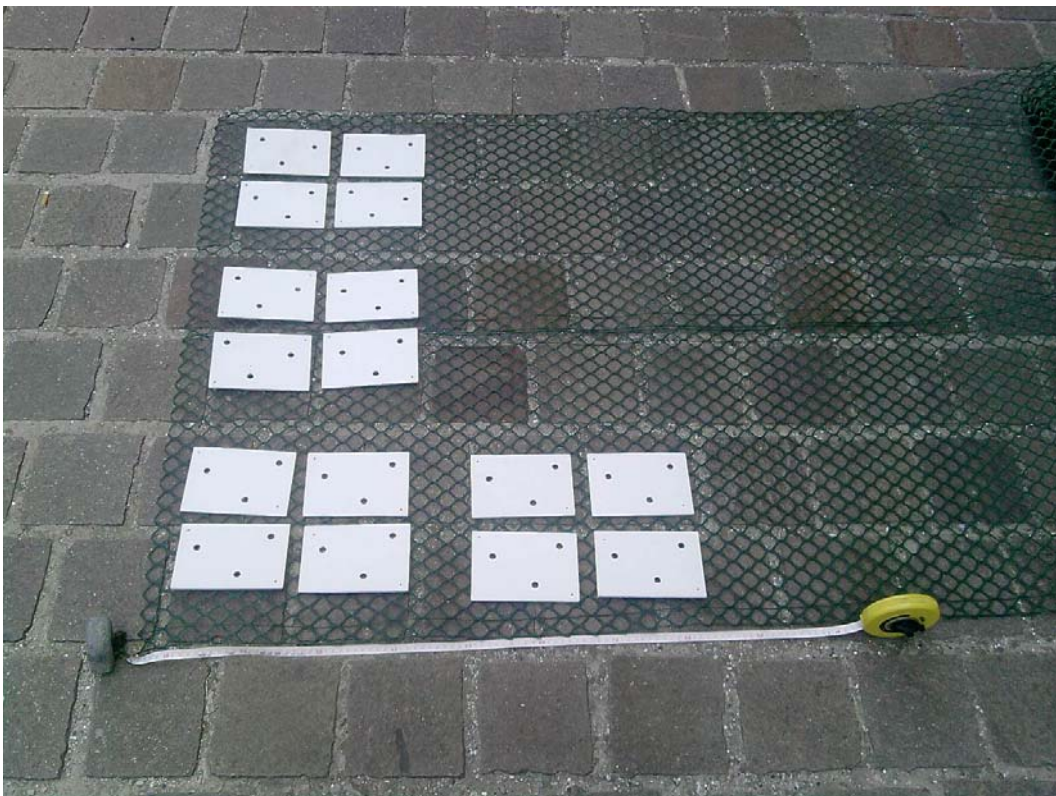


Fig. 2.3-1 Construction of the experimental plots.



Fig. 2.3-2 Example of Forex[®] panels of various dimensions.

Each panel was perforated with three holes about 1 cm in diameter with an electric drill. Then they are filled with plastic Eppendorf tubes of 1.5 ml, to house the sea fans for transplanting. The replicates were identified on the underside of the panels with permanent marker, and then connected to the network plot using cable ties. All the plots have been previously assembled and loaded with small fishing weights (30 g) to give it a slightly negative buoyancy to facilitate underwater operations (Fig. 2.3-3).

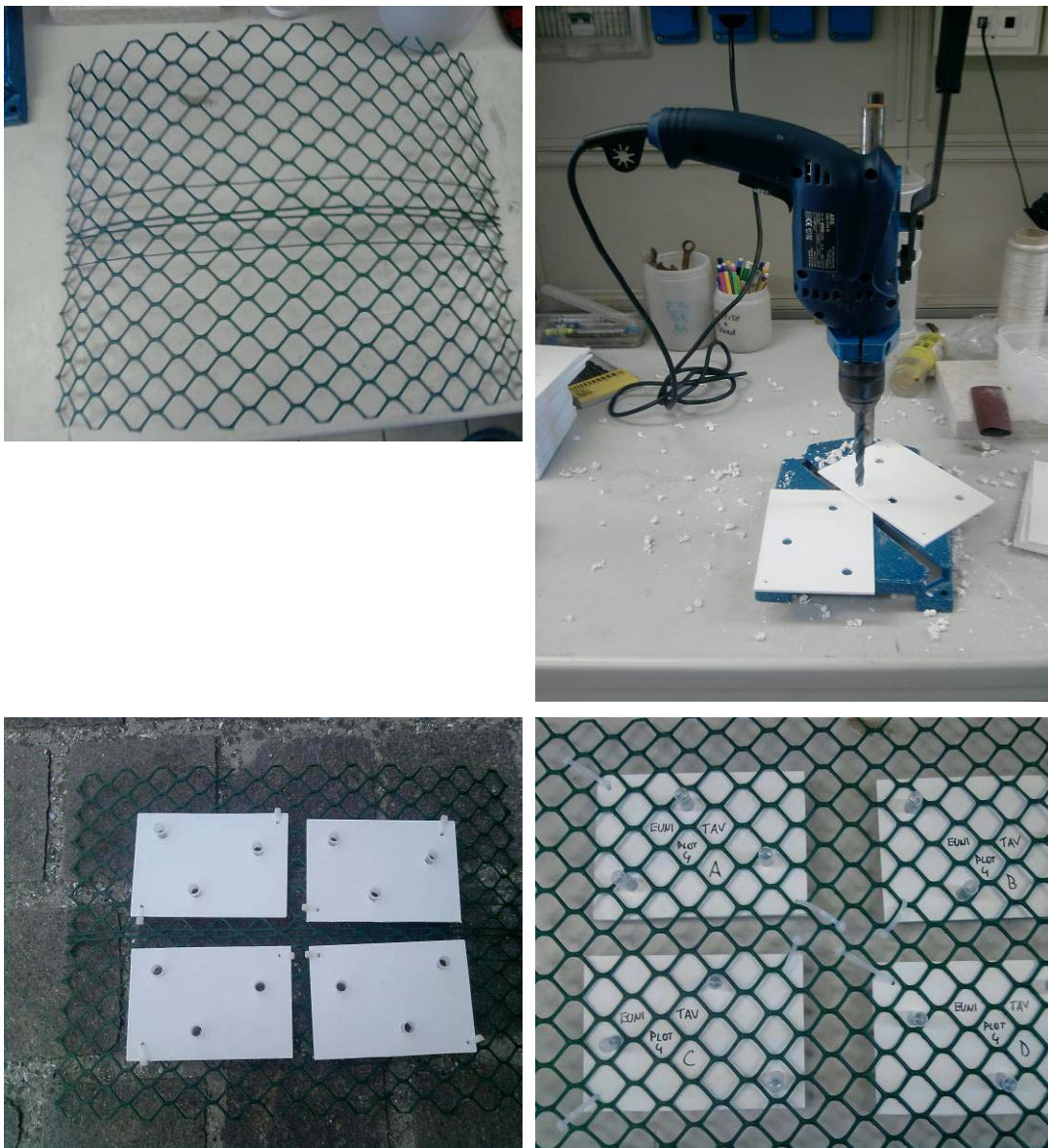


Fig. 2.3-3 Some stages of materials preparation.

The field installation of the experiment at Tavolara Island was carried out 7th June, after a previously check dive for the choice of the study site and gorgonians density measures. During the field work the MPA provides the support boats with the overseen of their staff. Two main dives are planned in the day: one for the collection of the living *E. cavolinii* branches and the second for the plots placement on substrata. The dives are separated by a short surface interval in which the plots with gorgonians are prepared.

Four SCUBA divers were equipped with shears and fishing nets to collect the gorgonians. The branches collected were up on average 15 cm. Once rises to the surface, the fishing nets with gorgonians were placed in large water tank previously prepared on the boat: this phase was very complex because it was necessary to keep alive the sea fans during the transplantation on the panels avoiding contact with air and providing continuous water supply from the sea (Fig. 2.3-4).

Four of the eight plots were prepared with gorgonians, the remaining are the control treatment. For fastening to the Eppendorf tubes was used an epoxy filler Subcoat S[®]. It is water-resistant glue widely used for small repairs on boats, because fast curing and easy to prepare. It consists of a mix of two equal parts of components (blue base and white hardener) that was prepared at the occurrence simply working with hands. Once mixed, a little of Subcoat S[®] was placed in the Eppendorf tubes with gorgonians and left to harden up, constantly in the water tank. Then all the plots were placed by SCUBA divers at the study site of Grottone, randomly distributed on the rocky boulder at the same depth (24-25 m). Steel nails were used to fix the plots to the substrate also with cable ties, and the University warning labels are placed around the study area. Further check dive was performed the next day to assess the experiment and the survival of the gorgonians (Fig. 2.3-5).



Fig. 2.3-4 Some phases of the experimental set-up.

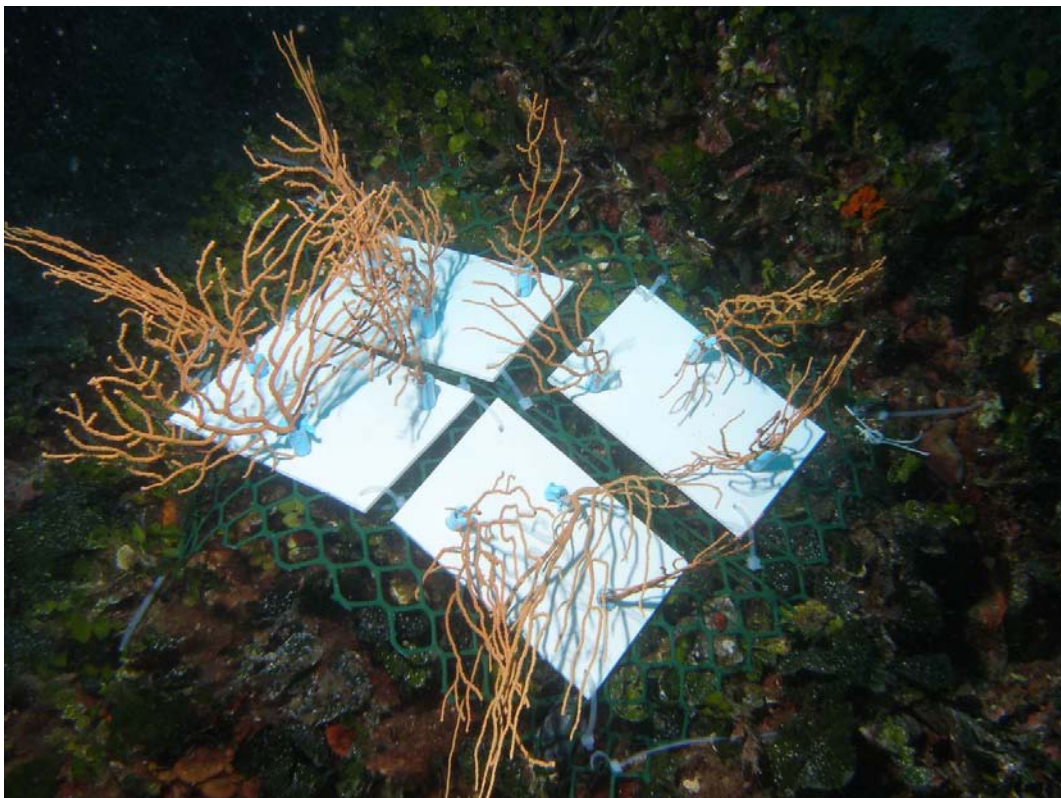


Fig. 2.3-5 One of experimental plots with gorgonians

The June 11 was the turn of the Portofino site. The gorgonian were collected at P.ta dell'Indiano of the same average size of Tavolara Island and then transplanted: the followed procedure was the same. The plots were placed at P.ta del Faro at 22-24 m of depth: this site was well recognized for ecological investigation in previous study (Cerrano et al. 2009).

During the three next months the plots are monitored periodically and the eventually gorgonians lost are replaced. The experiment was recovered 14th October from Tavolara Island and 17th October from Portofino. The procedure was the same and was done with a single dive (except two dives in Portofino to shoot a documentary video). Previously sealed plastic bags are prepared to storage the gorgonian and the panels to the surface, so as not to lose the organic material or contaminate the samples. During dive the panels (replicates) were sampled one by one and storage separately from gorgonians by cutting them at the insertion of the Eppendorf tubes (Fig. 2.3-6). The panels and the gorgonian were identified by some label markers placed at the moment into the sealed plastic bags.



Fig. 2.3-6 The recovery of the experimental panels.

At the work ends the plots without panels were removed form substrate and disposed on land. Once on land the panels were slightly washed with sea water, photographed on both sides and preserved by a buffered solution of 4% 32

formaldehyde, after removing the Eppendorf tubes. The rinse water was filtered in a 0.5 mm mesh sieve to recover the vagile fauna and then put into a jar with formaldehyde. The same procedure was made with vagile fauna on gorgonian branches. The latter were stored separately without water to be dried in a lab oven (Fig. 2.3-7).



Fig. 2.3-7 Some scenes of stowage work.

2.4. Laboratory analysis

The analysis was carried out in the laboratories of ecology at the Interdepartmental Centre of Environmental Sciences placed in Ravenna. Principally we focused on the benthic settlement analysis, while the gorgonians biometrical measures were carried out by some colleagues of the Polytechnic University of Marche, in Ancona. For the measures were considered four parameters: dry weight, mean area, average height and width.

For the settlement analysis an artificial grid was used in order to determine quantitatively the colonization: the total panel area was divided into 400 cells (Fig.

2.4-2). The grid was realized manually by an artificial sized PVC frame and fishing line. All the panels were analysed under a stereomicroscope to facilitate the measures after being rinsed under fume hood to remove the formaldehyde. Photographic analysis was used to support the direct identification, also through the superimposition of a 400 cells grid drawn with software (Fig. 2.4-1).

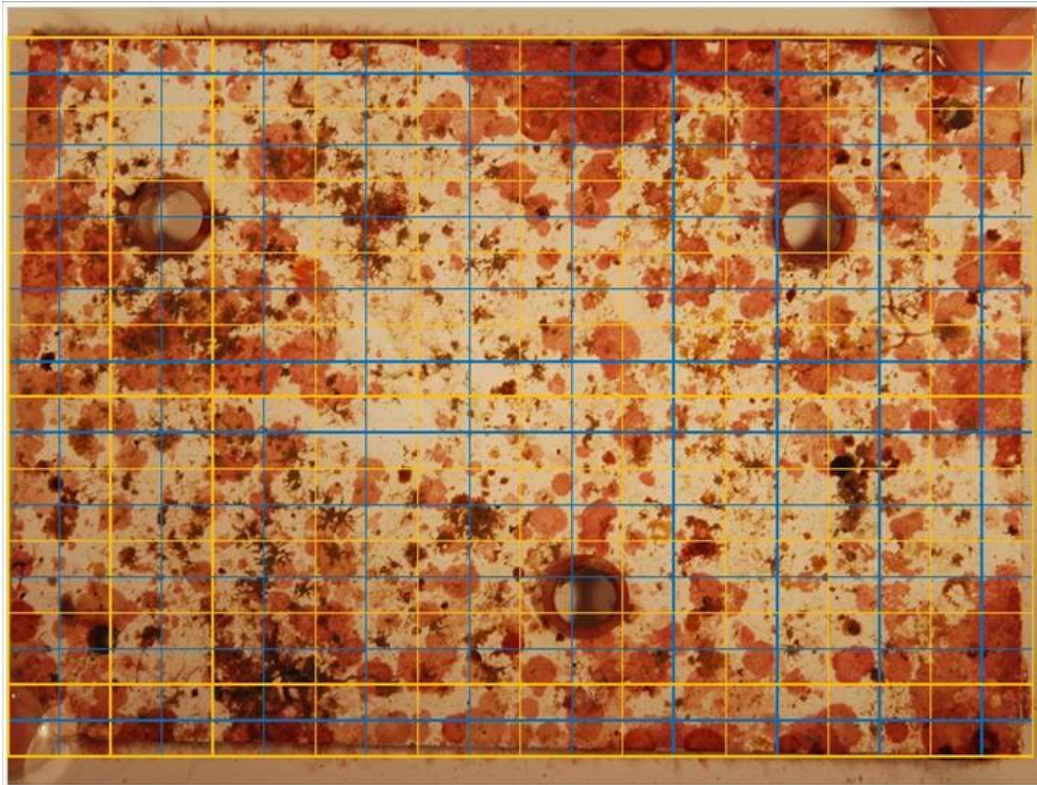


Fig. 2.4-1 Example of photographic analysis of a panel.

Voucher specimens were archived together with their microscopically photograph (Huber 1998). The identification and classification of the species was made with the use of specific dichotomous keys where possible, and with the help of some taxonomic specialists. Per cent covers were obtained from frequency measurement: when using a very dense grid, with many small squares, the two measures tend to converge (Bianchi et al. 2003). The counting results were plotted into an Excel[®] datasheet. All the frequencies are previously divided for the 400 cells to obtain percentage measure of coverage.

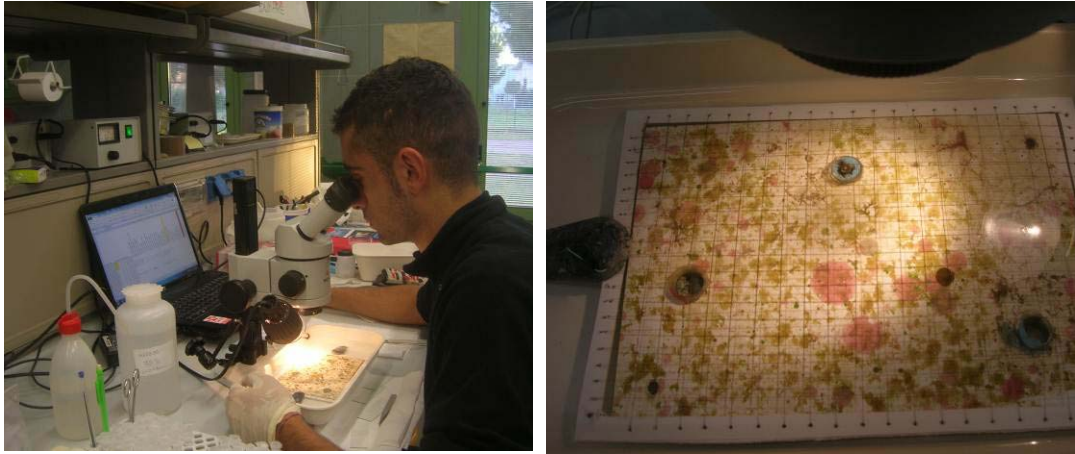


Fig. 2.4-2 Quantitative measurements of cover with microscope and the artificial grid.

2.5. Statistical analysis

The statistical analysis was performed with the software PRIMER v6[®] and PERMANOVA+[®]. The data were also processed through Microsoft Excel[®]. The null hypothesis tested was that there are no differences in the two experimental treatments. Differences in community structures between gorgonian forest treatment (Fo: fixed factor with 2 levels: presence/absence), sites (Si: random factor with 2 levels: Tavolara/Portofino), and plots (Pl: random factor nested in FoSi with 4 levels) were assessed by permutational non-parametric multivariate analysis of variance. The analyses were performed using principal coordinate analysis (PCO, i.e. metric multidimensional scaling) based on Bray-Curtis dissimilarities of square root-transformed data (Anderson & Robinson 2001). When less than 999 unique values in the permutation distribution were available, asymptotical Monte Carlo P-values were used instead of permutational P-values (Anderson 2001). A post-hoc Pair-wise Test was performed for significant results ($P < 0.05$). The final results are plotted in an Excel[®] datasheet together with graphical representations. Then the analysis was performed for each site to test separately the forest effect with a two-way analysis of variance (PERMANOVA): forest (Fo: fixed with 2 levels: presence/absence) and plots (Pl: random factors nested in Fo with 4 levels). Three-way analysis of variance was applied also for single taxon and ecologic group, after a Euclidean distance resemblance for dissimilarity matrix of not transformed data. This analysis was also performed separately for each site to test principal variations in species composition. The

design has two factors: forest (Fo: fixed with 2 level: presence/absence) and plot (Pl: random factor nested in Fo with 4 levels). The most abundant e significant species results are supported by a graphical representation with the mean coverage values and standard error, to assess the differences.

Some diversity index was calculated to test the differences between treatments and plots: Hill's diversity number $N1 = \text{Exp } H'$ where H' is the Shannon index, $N10 = N1/S$, and the inverse Simpson index $(1/\lambda')$, also with species richness S . Combinations of several indices take advantages of the strengths of each and develop a more complete understanding of community structure. In addition they better represent a population with high heterogeneity giving more power to taxa that are well represented. The results are plotted in a graphical representation together with the results of the statistical analysis of variance.

3. Results

3.1. Effects of gorgonian forest on the epibenthic assemblages structure

During the recovery of the plots, differences between sites in panels' colonization were recognized, even at first sight (Fig. 3.1-1). Furthermore an entire plot without gorgonians in Portofino (plot N1) was lost during the last period. The loss of this experimental plot makes the experimental design unbalanced. Despite these, it is still possible perform statistical permutation tests (PERMANOVA). The collected forested panels didn't show differences in population density of *E. cavolinii* at the end of the experiment. The results show that the average density of about 190 colonies/m² remains the same and were in accordance with maximum densities reached by this species in previous results (Weinbauer & Velimirov 1996). Measures carried out at the end of the experiment didn't show significant differences among the biomass of gorgonians present on the forested panels: the average biomass was of 4.21 g DM m⁻².

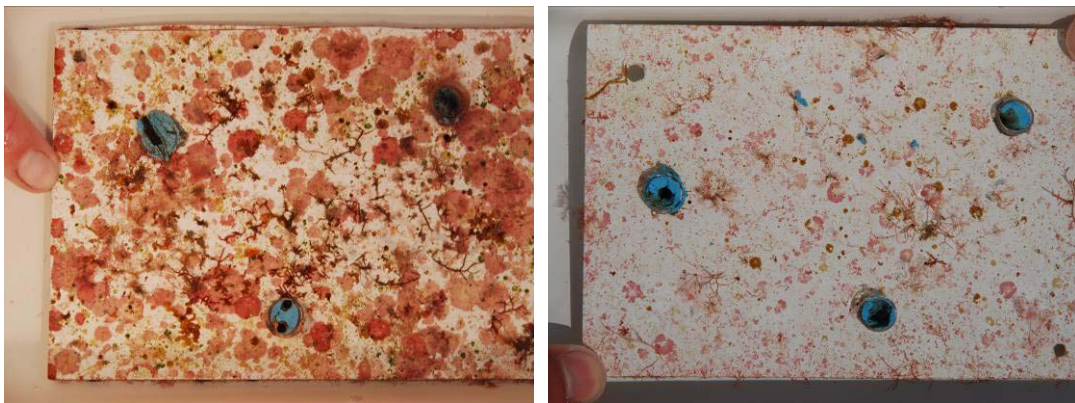


Fig. 3.1-1 Examples of Portofino (left) and Tavolara (right) panels: note the differences in colonization.

Overall, 149 different taxa have been found. Some taxa have been found in both sites, but with different abundances (see Table 10 and Table 16). As expected, the algae were the most represented group (with a predominance of Rhodophyta)

(Balata, Acunto, & Cinelli 2006), followed by Foraminiferans, Cnidarians, Polychaetes, Bryozoans and finally Molluscs and Sponges (Fig. 3.1-2). Most of the algae remain unidentified because the early stage of development made it difficult to identify. Conversely, the majority of Polychaetes and Bryozoans have been identified; as well other groups are recognised to the lowest possible taxonomic level. The classification is still under way by specialists.



Fig. 3.1-2 Examples of species belonging from different taxa. Clockwise from top right: *Champia parvula* (Rhodophyta), *Dyctiota* sp.1 (Phaeophyta), *Dexiospira pagenstecheri* (Spirorbidae) and *Schizoporella magna* (Bryozoa).

The PCO ordination plot, which represents the similarities among assemblages, show a clear separation of the epibenthic assemblages between sites. It is possible to observe a little difference between with and without gorgonian forest, and these differences are more evident in Tavolara (Fig. 3.1-3). The three-way PERMANOVA test has confirmed this great difference between assemblages

found in the two sites, but didn't show any forest effect (Table 1). The differences between plots are also very significant as can be observed on the PCO graph.

Table 1 PERMANOVA analysis for differences of epibenthic assemblages (in bold the significant results).

Source	df	SS	MS	Pseudo-F	P(perm)	Unique perms	P(MC)
Fo	1	2061.80	2061.80	1.2975	0.5058	6	0.3229
Si	1	21538.00	21538.00	19.0800	0.0003	9938	0.0001
FoxSi	1	1589.10	1589.10	1.4077	0.1446	9914	0.1468
Pl(SixFo)	11	12417.00	1128.80	3.7130	0.0001	9734	0.0001
Res	45	13681.00	304.01				
Total	59	51392.00					

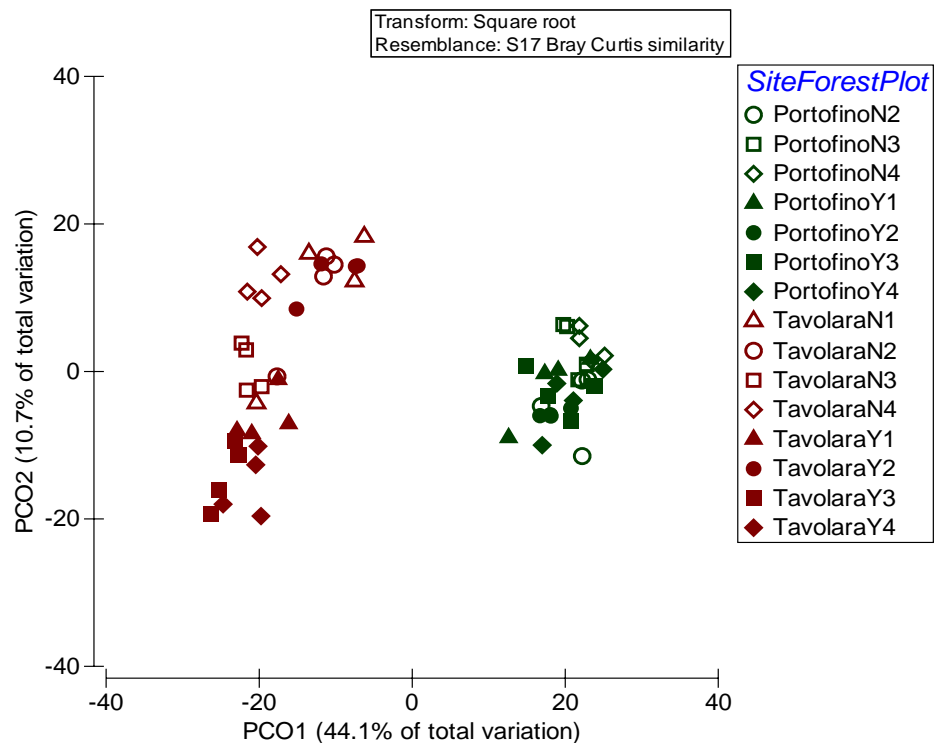


Fig. 3.1-3 PCO ordination plot showing similarities among assemblages found in each recruitment panel, grouped by plot (1..4), site (Tavolara vs Portofino) and presence of the gorgonian forest (Y/N).

Taxa that more contribute to the pattern of similarity among assemblages are reported on the PCO ordination plot as correlation vectors (Fig. 3.1-4).

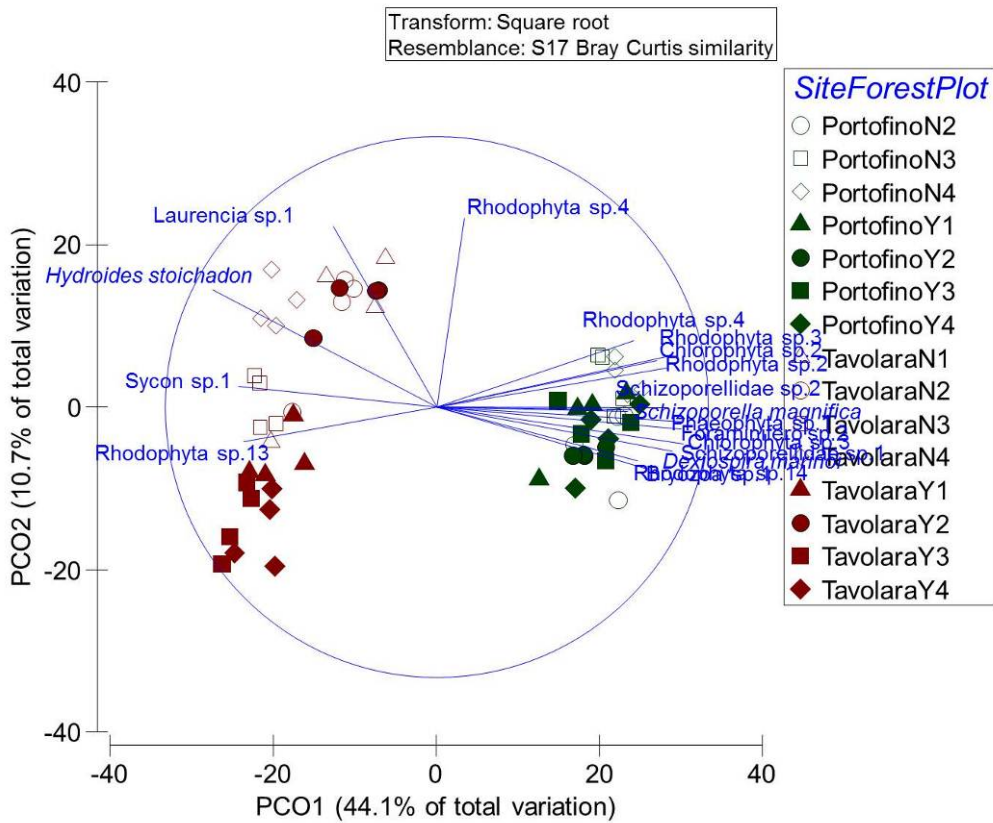


Fig. 3.1-4 Correlation vectors of the taxa that more contribute to the similarity patterns (Pearson correlation coefficient > 0.7), superimposed on the PCO ordination plot.

The Corallinacea sp.1 was the most abundant species at both sites. It showed high heterogeneity at small spatial scale (i.e. significant differences among plots) and it was significantly more abundant at Portofino (Fig. 3.1-5). The following most abundant taxa were Rhodophyta sp. 1 and Chlorophyta sp. 1, which showed high heterogeneity at small spatial scale (i.e. significant differences among plots) but they didn't differ between sites (Table 3 and Table 4 - Fig. 3.1-6 and Fig. 3.1-7).

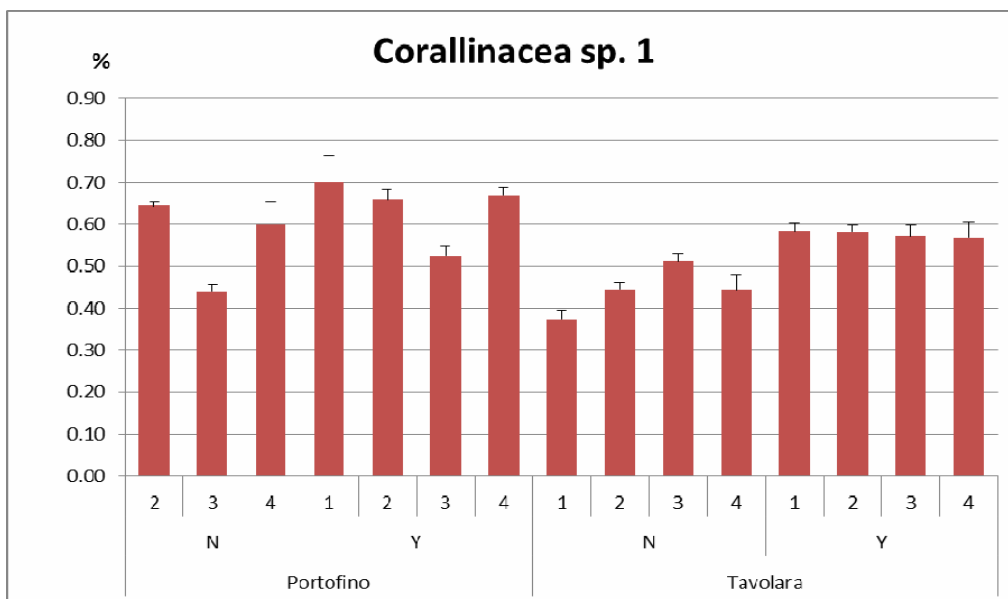


Fig. 3.1-5 Mean per cent cover of Corallinacea sp.1 (\pm s.e.).

Table 2 Results from PERMANOVA on epibenthic per cent cover data of Corallinacea sp.1.

Source	df	SS	MS	Pseudo-F	P(perm)	Unique perms	P(MC)
Fo	1	0.0775	0.0775	11.2410	0.5044	6	0.1814
Si	1	0.0540	0.0540	6.3033	0.0267	9792	0.0300
FoxSi	1	0.0069	0.0069	0.8043	0.3906	9816	0.3923
Pl(SixFo)	11	0.0943	0.0086	5.0803	0.0002	9928	0.0001
Res	45	0.0759	0.0017				
Total	59	0.3200					

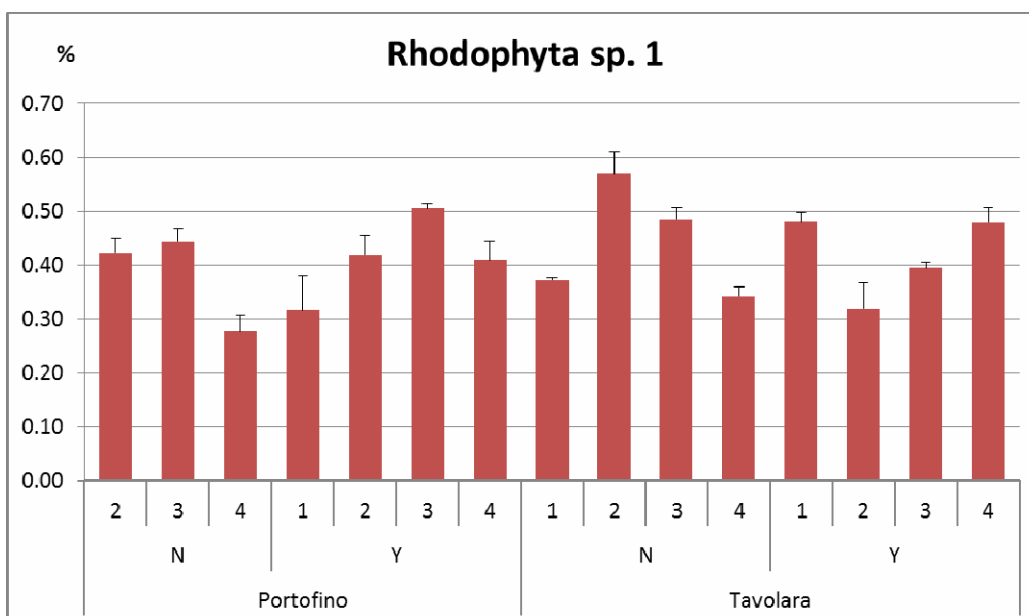


Fig. 3.1-6 Mean per cent cover of Rhodophyta sp.1 (\pm s.e.).

Table 3 Results from PERMANOVA on epibenthic per cent cover data of Rhodophyta sp.1.

Source	df	SS	MS	Pseudo-F	P(perm)	Unique perms	P(MC)
Fo	1	0.0002	0.0002	0.0182	0.8324	6	0.9117
Si	1	0.0165	0.0165	0.5299	0.4742	9822	0.4815
FoxSi	1	0.0111	0.0111	0.3582	0.5563	9834	0.5679
Pl(SixFo)	11	0.3417	0.0311	7.9620	0.0001	9933	0.0001
Res	45	0.1756	0.0039				
Total	59	0.5430					

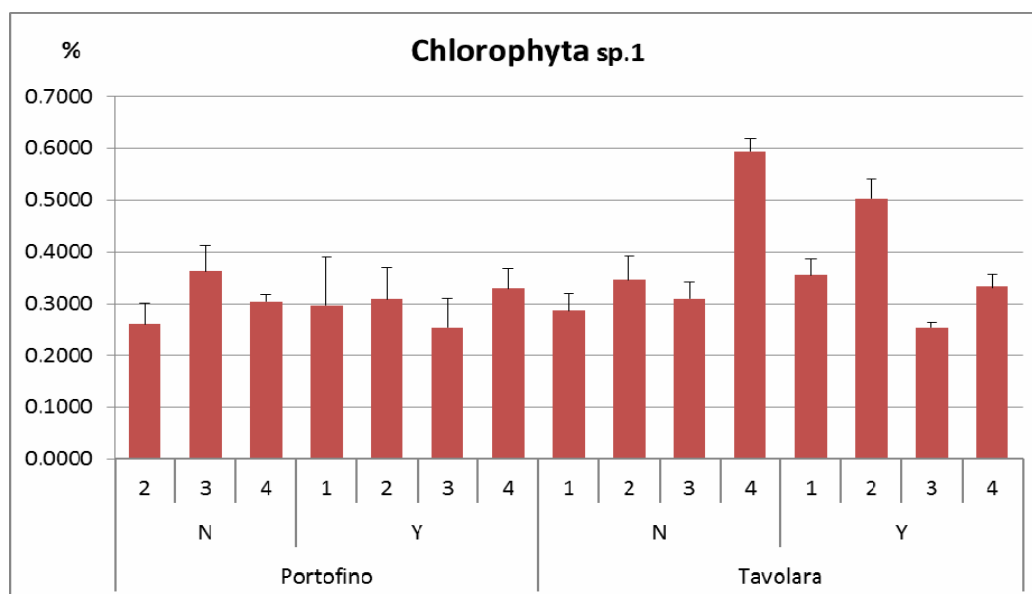


Fig. 3.1-7 Mean per cent cover of Chlorophyta sp.1 (± s.e.).

Table 4 Results from ANOVA on epibenthic per cent cover data of Chlorophyta sp.1.

Source	df	SS	MS	Pseudo-F	P(perm)	Unique perms	P(MC)
Fo	1	0.0045	0.0045	10.9910	0.4997	6	0.1816
Si	1	0.0707	0.0707	1.9111	0.2341	9813	0.1914
FoxSi	1	0.0004	0.0004	0.0112	0.9238	9872	0.9121
Pl(SixFo)	11	0.4070	0.0370	4.6722	0.0003	9934	0.0004
Res	45	0.3564	0.0079				
Total	59	0.8419					

Since the great difference in the assemblages found in the two sites, which can mask the possible gorgonian forest effects, as well as the loss of one experimental plot at Portofino site, which make the analyses unbalanced, reducing the power of the statistical tests, appeared reasonable to analyse separately the results of the experiments carried out at the two sites.

3.2. *Effects of gorgonian forest at Tavolara site*

At Tavolara, the multivariate analysis didn't show differences among epibenthic assemblages in the two treatments (Table 5). The PCO graph shows little differentiations among treatments but each plot seems to have a spatial grouping differentiation with little separation among treatments (Fig. 3.2-1).

Table 5 PERMANOVA analysis for differences of epibenthic assemblages found at Tavolara (in bold the significant results).

Source	df	SS	MS	Pseudo-F	P(perm)	Unique perms	P(MC)
Fo	1	2251.90	2251.90	1.5972	0.1454	35	0.1428
Pl(Fo)	6	8459.20	1409.90	4.4164	0.0001	9856	0.0001
Res	24	7661.60	319.23				
Total	31	18373.00					

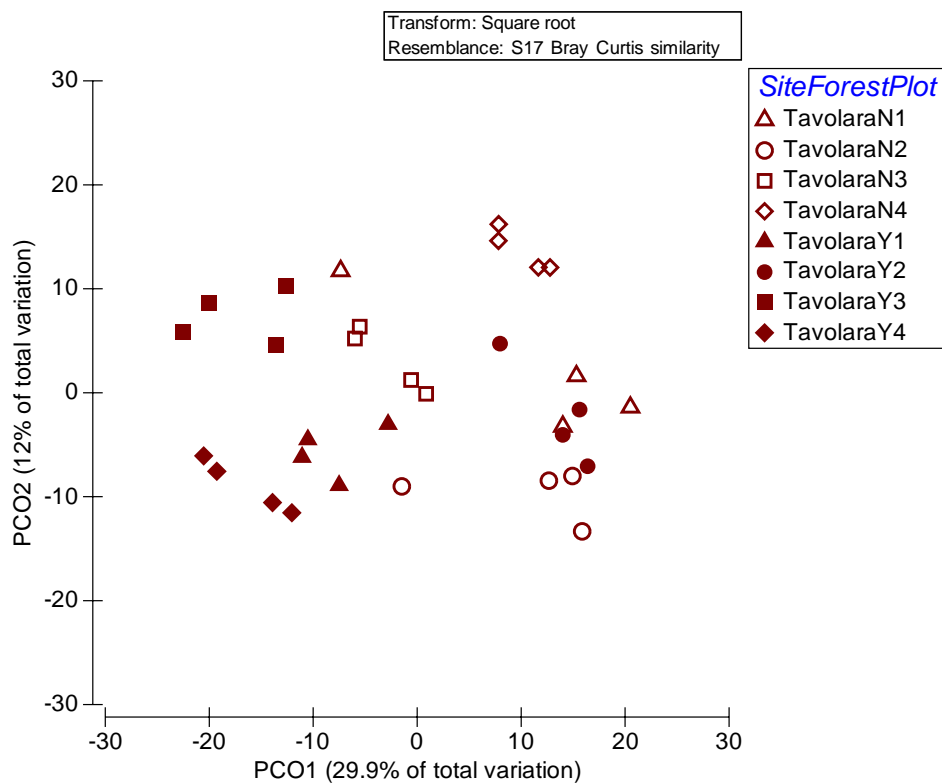


Fig. 3.2-1 PCO ordination plot showing similarities among assemblages found at Tavolara in each recruitment panel, grouped by plot (1..4) and presence of the gorgonian forest (Y/N).

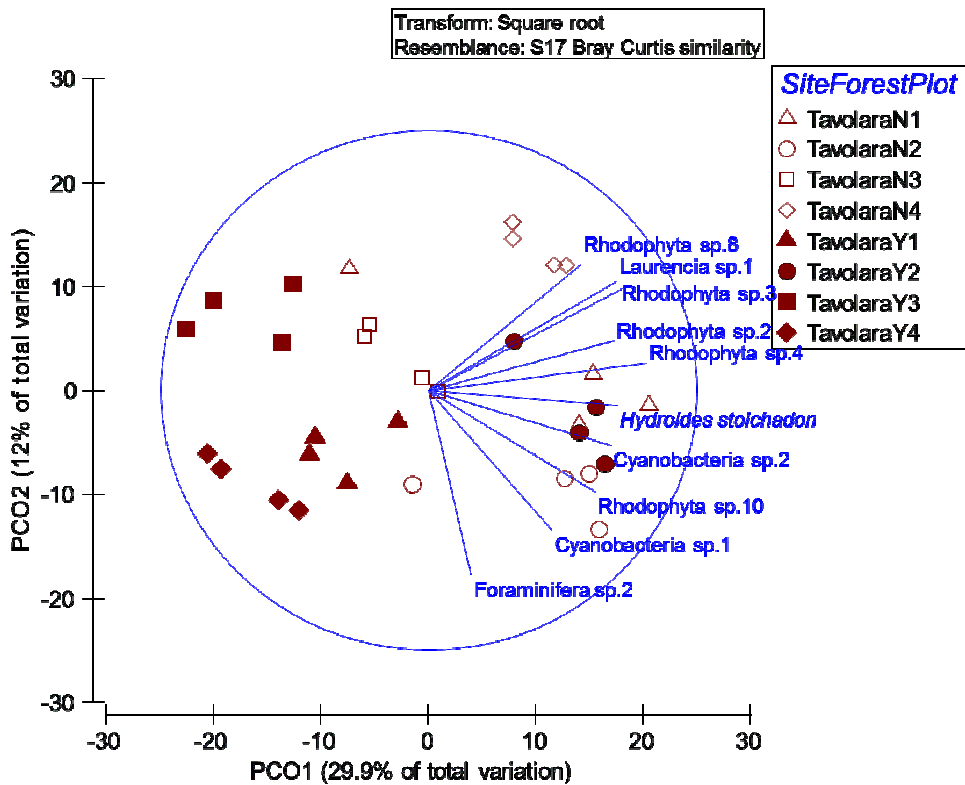


Fig. 3.2-2 Correlation vectors of the taxa that more contribute to the similarity patterns (Pearson correlation coefficient > 0.7), superimposed on the PCO ordination plot.

The analyses of single taxa were performed on relevant species from correlation vector of PCO graph and on most abundant species. The results of single taxa show that the *Corallinacea* sp. 1, the most abundant encrusting calcareous Rhodophyta, is differentiated between the two treatments, with prevalence in the plots with *E. cavolinii* (Fig. 3.1-5 and Table 6). The *Hydroides stoichadon* is more abundant in the plots without gorgonian forest (Fig. 3.2-3 and Table 7). The analyses of the other species didn't show any statistical difference between treatments (see examples in Table 8, Table 9 and Fig. 3.2-4, Fig. 3.2-5, and the summary results in Table 10).

Table 6 Results from PERMANOVA on epibenthic per cent cover data of *Corallinacea* sp.1.

Source	df	SS	MS	Pseudo-F	P(perm)	Unique perms	P(MC)
Fo	1	0.1398	0.1398	21.7860	0.0315	30	0.0032 Y>N
PI(Fo)	6	0.0385	0.0064	2.3098	0.0694	9969	0.0657
Res	24	0.0667	0.0028				
Total	31	0.2450					

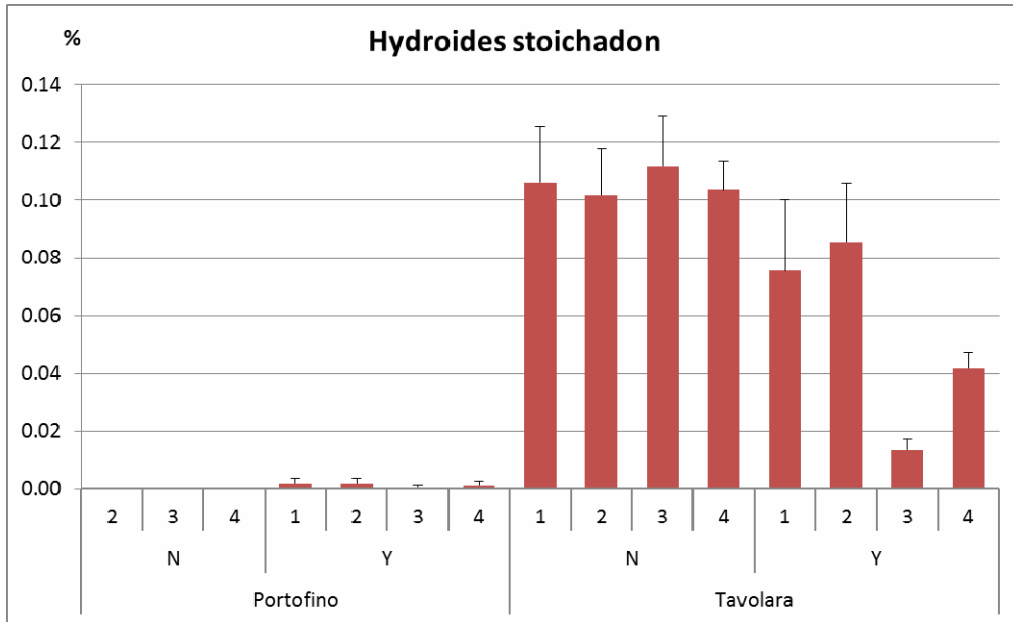


Fig. 3.2-3 Mean per cent cover of *Hydroides stoichadon* (\pm s.e.).

Table 7 Results from PERMANOVA on epibenthic per cent cover data of *Hydroides stoichadon*.

Source	df	SS	MS	Pseudo-F	P(perm)	Unique perms	P(MC)
Fo	1	0.0214	0.0214	9.7523	0.0259	29	0.0208 N>Y
Pl(Fo)	6	0.0132	0.0022	2.1124	0.0836	9951	0.0932
Res	24	0.0249	0.0010				
Total	31	0.0595					

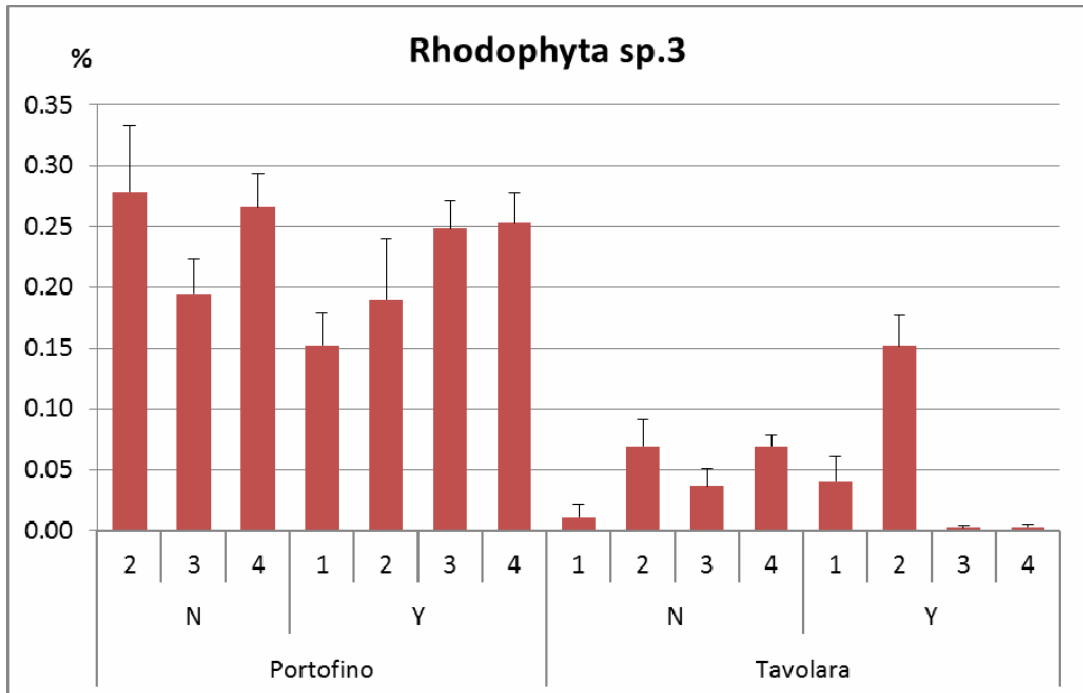


Fig. 3.2-4 Mean per cent cover of *Rhodophyta sp. 3* (\pm s.e.).

Table 8 Results from PERMANOVA on epibenthic per cent cover data of Rhodophyta sp.3.

Source	df	SS	MS	Pseudo-F	P(perm)	Unique perms	P(MC)
Fo	1	0.0001	0.0001	0.0082	0.9676	25	0.9267
Pl(Fo)	6	0.0692	0.0115	11.7600	0.0001	9953	0.0001
Res	24	0.0235	0.0010				
Total	31	0.0928					

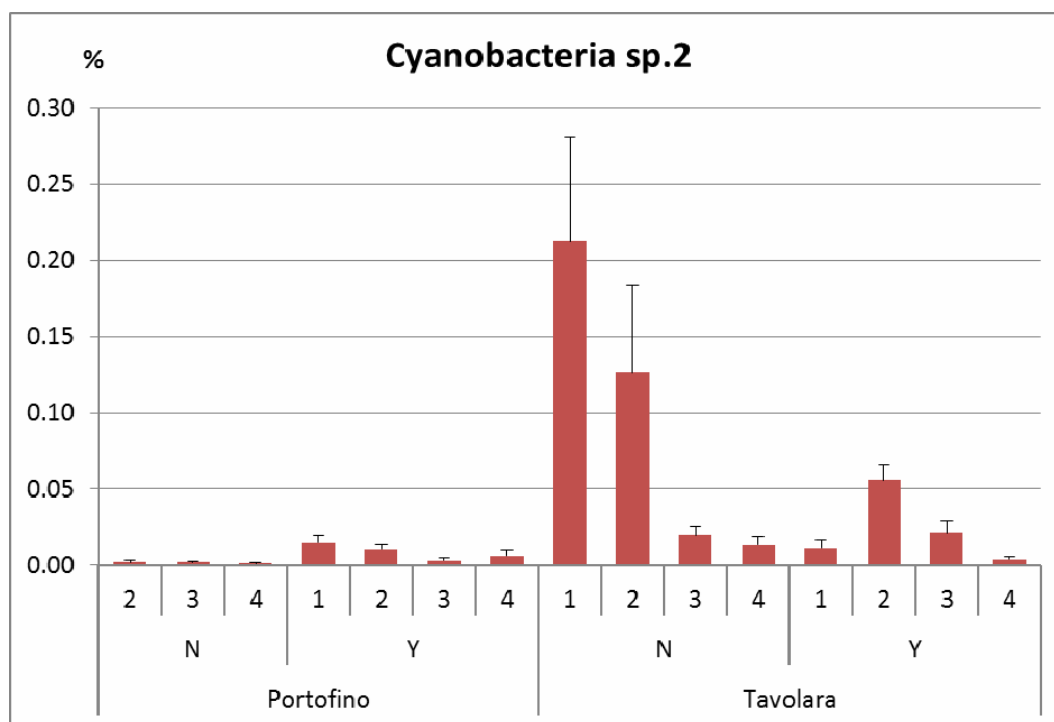


Fig. 3.2-5 Mean per cent cover of Cyanobacteria sp.2 (\pm s.e.).

Table 9 Results from PERMANOVA on epibenthic per cent cover data of Cyanobacteria sp.2.

Source	df	SS	MS	Pseudo-F	P(perm)	Unique perms	P(MC)
Fo	1	0.0394	0.0394	2.0672	0.2292	32	0.2016
Pl(Fo)	6	0.1143	0.0190	4.6305	0.0036	9955	0.0027
Res	24	0.0987	0.0041				
Total	31	0.2524					

Table 10 Mean abundance and number of occurrences on the 32 panels of the most abundant taxa at Tavolara. PERMANOVA results of selected taxa (based on their abundance and/or correlation with PCO axes) are reported (* P<0.05, ** P<0.01, * P<0.001, ns not significant).**

Taxa	Mean		PERMANOVA		
	abundance	Occurrence	Pl(Fo)	Fo	Result
Corallinacea sp. 1	0.5091	32	NS	*	Y>N
Rhodophyta sp. 1	0.4306	32	***	NS	
Chlorophyta sp.1	0.3727	32	***	NS	
Foraminifera sp.1	0.1609	32	NS	NS	
<i>Neosiphonia harveyi</i>	0.0955	30	NS	NS	
<i>Hydroides stoichadon</i>	0.0801	32	NS	*	N>Y
<i>Kirchenpaueria echinulata</i>	0.0591	16			
Cyanobacteria sp.2	0.0580	30	**	NS	
Cyanobacteria sp.1	0.0571	32	*	NS	
Rhodophyta sp.3	0.0478	26	***	NS	
<i>Halecium lanckesteri</i>	0.0471	28			
Rhodophyta sp.4	0.0393	32	*	NS	
<i>Dexiospira pagenstecheri</i>	0.0379	32			
Rhodophyta sp.3	0.0294	20	**	NS	
Rhodophyta sp.8	0.0288	18	***	NS	
Foraminifera sp.2	0.0267	32	*	NS	
Chlorophyta sp.2	0.0215	18	NS	NS	
Rhodophyta sp.13	0.0191	28	***	NS	
Cyclostomatida sp.1	0.0185	13			
<i>Sycon sp.1</i>	0.0177	32			
<i>Laurencia sp.1</i>	0.0169	20			
Corallinales sp. 1	0.0161	28	NS	NS	
Rhodophyta sp.5	0.0145	23			
Rhodophyta sp.4	0.0127	14	*	NS	
<i>Champia parvula</i>	0.0121	28			
Rhodophyta sp.12	0.0097	2			
Phaeophyta sp.1	0.0094	24	*	NS	
<i>Semivermilia cribrata</i>	0.0090	29			
Rhodophyta sp.9	0.0088	10			
Rhodophyta sp.2	0.0084	17	***	NS	
Rhodophyta sp.7	0.0056	18			
<i>Vinearia endoumensis</i>	0.0050	18			
Bryozoa sp.1	0.0045	23			
<i>Clytia linearis</i>	0.0041	6			
Hydrozoa sp.1	0.0033	5	NS	NS	
Entalophoroecia sp.1	0.0031	18			
<i>Aetea sp.1</i>	0.0031	9			
Rhodophyta sp.6	0.0022	12			
<i>Spirobranchus polytrema</i>	0.0008	3			
Rhodophyta sp.10	0.0007	7	**	NS	
Rhodophyta sp.14	0.0005	4			
<i>Dexiospira marinoi</i>	0.0002	3			
Phaeophyta sp.2	0.0001	1			
Chlorophyta sp.3	0.0001	1			
<i>Savignyella lafontii</i>	0.0000	0			
<i>Schizoporella magnifica</i>	0.0000	0			
Schizoporellidae sp.2	0.0000	0			
Schizoporellidae sp.1	0.0000	0			

3.3. *Effects of gorgonian forest at Portofino site*

Also for Portofino site, the multivariate analyses didn't show differences (the P value is slightly over 0.05) (Table 11), while very few taxa differ in the two treatments, as the Rhodophyta sp.2, an erected algae that is most abundant in the plots without gorgonian (Fig. 3.3-3 and Table 13) and the *Hydroides stoichadon* that present an inverse pattern than Tavolara (Fig. 3.2-3 and Table 12). The PCO show similar pattern to Tavolara, despite there is less variability among treatments (Fig. 3.3-1 and Fig. 3.3-2). Moreover this site present the lack of a plot without gorgonian as mentioned earlier.

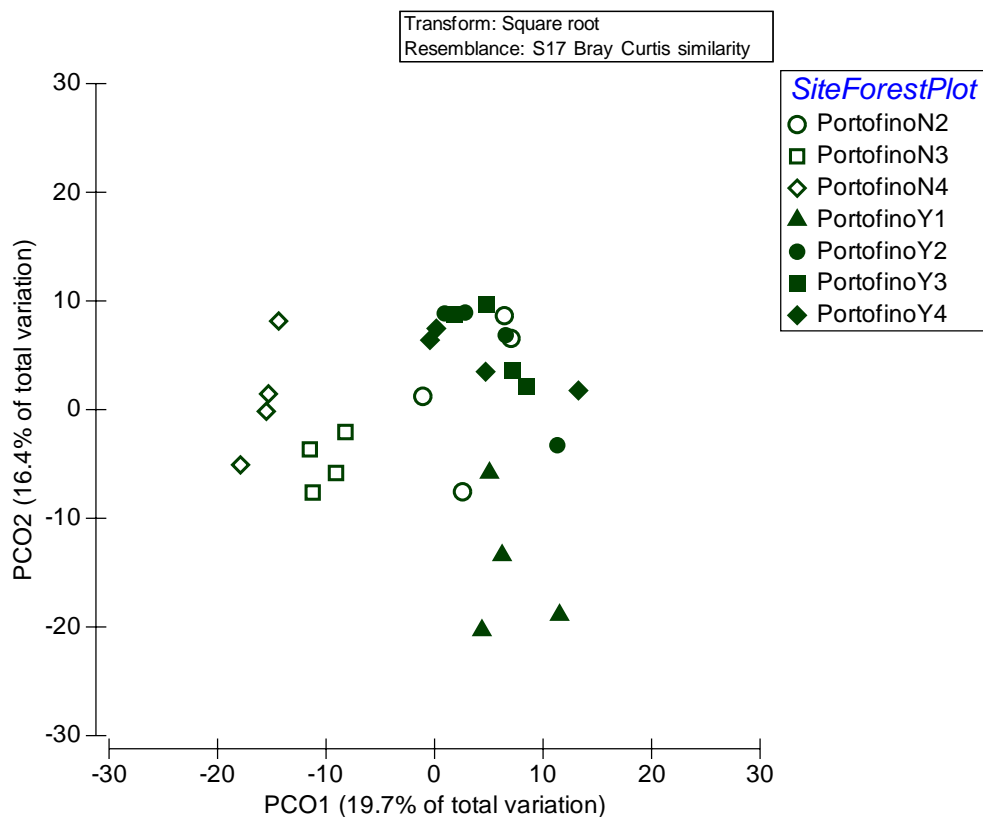


Fig. 3.3-1 PCO ordination plot showing similarities among assemblages found at Portofino in each recruitment panel, grouped by plot (1..4) and presence of the gorgonian forest (Y/N).

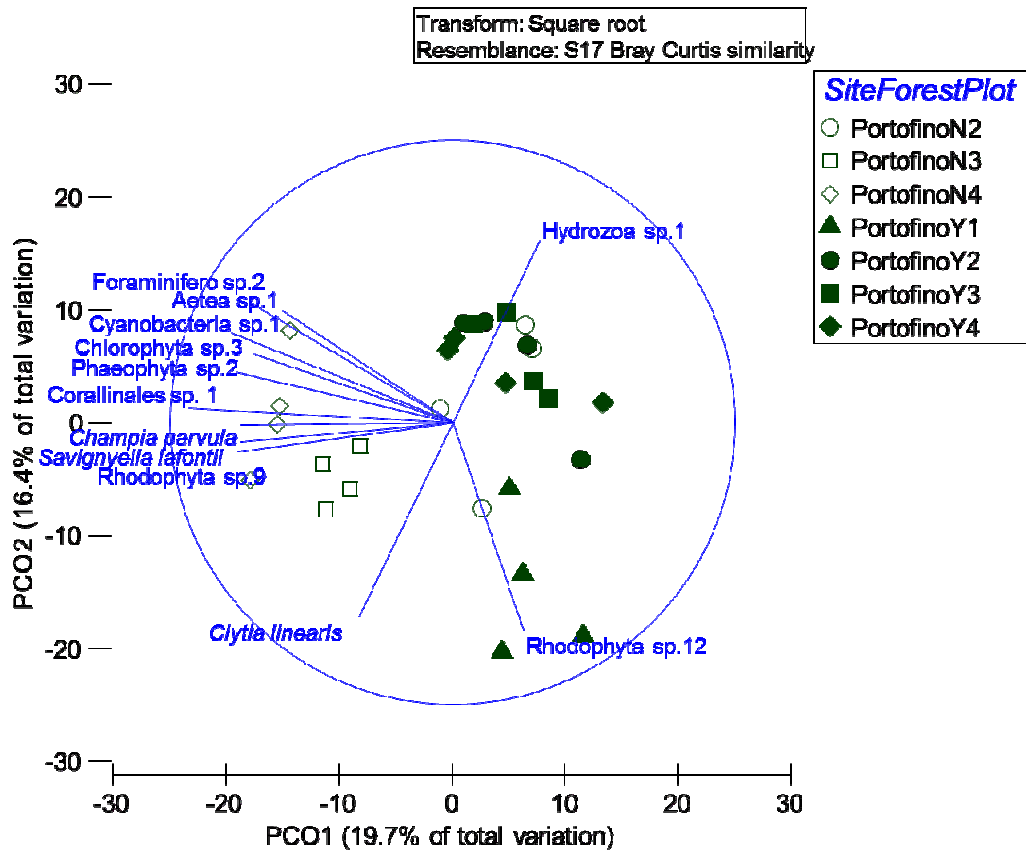


Fig. 3.3-2 Correlation vectors of the taxa that more contribute to the similarity patterns (Pearson correlation coefficient > 0.7), superimposed on the PCO ordination plot.

Table 11 PERMANOVA analysis for differences of epibenthic assemblages found at Portofino (in bold the significant results).

Source	df	SS	MS	Pseudo-F	P(perm)	Unique perms	P(MC)
Fo	1	1459.9	1459.90	1.8445	0.0570	35	0.0755
PI(Fo)	5	3957.6	791.52	2.7616	0.0001	9825	0.0001
Res	21	6019.0	286.62				
Total	27	11437.0					

Table 12 Results from PERMANOVA on epibenthic per cent cover data of *Hydroides stoichadon*.

Source	df	SS	MS	Pseudo-F	P(perm)	perms	P(MC)
Fo	1	0.000014	0.000014	15.7790	0.0580	9	0.0099 Y>N
PI(Fo)	5	0.000004	0.000001	0.1674	0.9863	4401	0.9732
Res	21	0.000108	0.000005				
Total	27	0.000126					

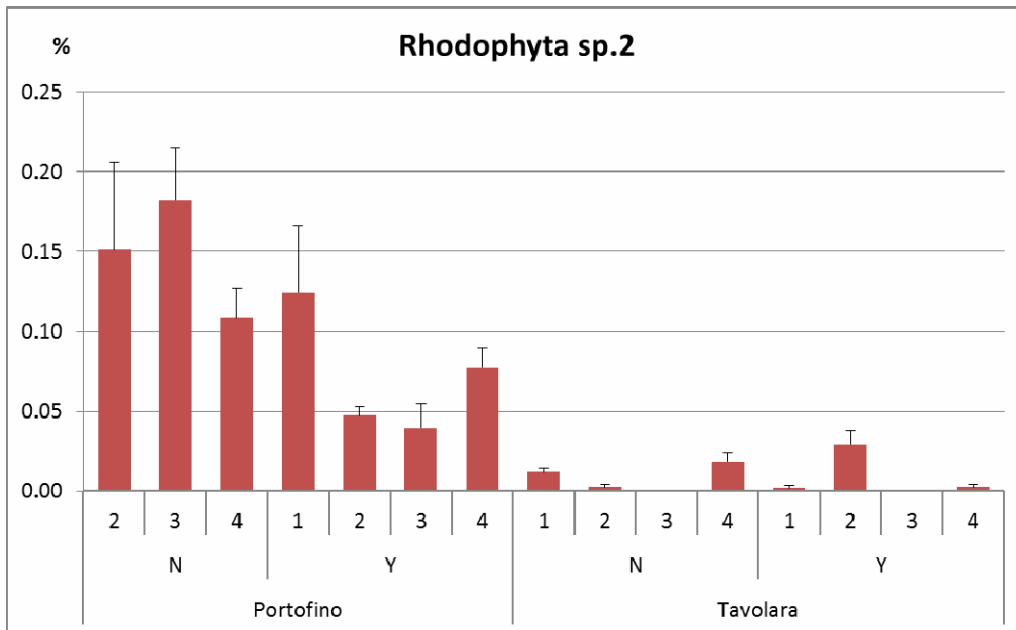


Fig. 3.3-3 Mean per cent cover of Rhodophyta sp. 2 (\pm s.e.).

Table 13 Results from PERMANOVA on epibenthic per cent cover data of Rhodophyta sp. 2.

Source	df	SS	MS	Pseudo-F	P(perm)	perms	P(MC)
Fo	1	0.0389	0.0389	6.7726	0.0857	32	0.0440 N>Y
Pl(Fo)	5	0.0287	0.0057	1.5527	0.2114	9947	0.2170
Res	21	0.0777	0.0037				
Total	27	0.1453					

The results of the other species analysed didn't show differences among the two forest treatments (Fig. 3.3-4 and Fig. 3.3-5; Table 14 and Table 15).

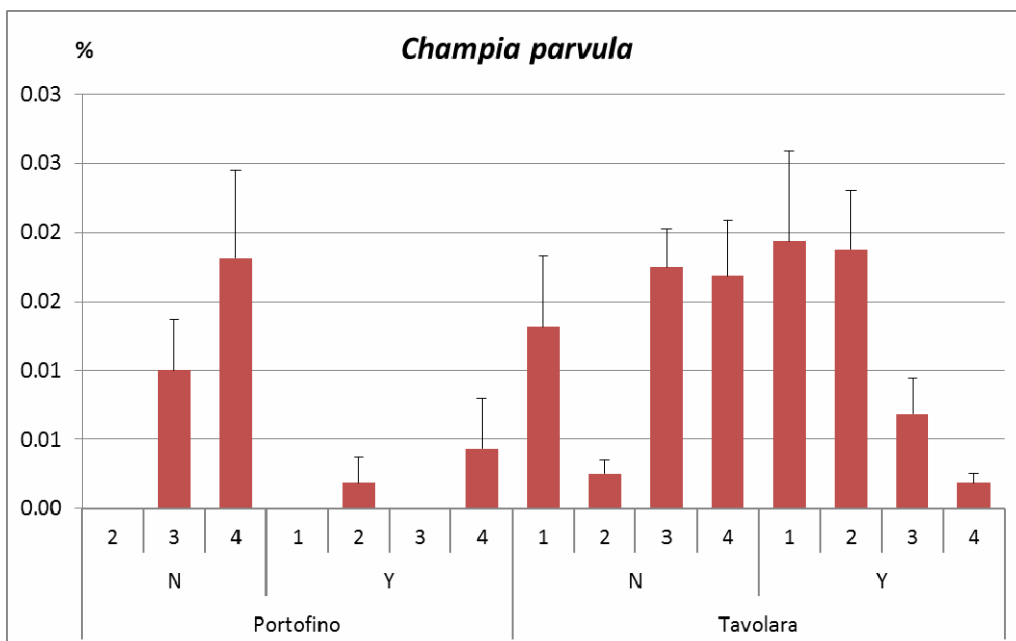


Fig. 3.3-4 Mean per cent cover of Champia parvula (\pm s.e.).

Table 14 Results from PERMANOVA on epibenthic per cent cover data of *Champia parvula*.

Source	df	SS	MS	Pseudo-F	P(perm)	Unique perms	P(MC)
Fo	1	0.0004	0.0004	2.9435	0.1708	15	0.1451
Pl(Fo)	5	0.0007	0.0001	3.5064	0.0187	9851	0.0194
Res	21	0.0009	0.0000				
Total	27	0.0020					

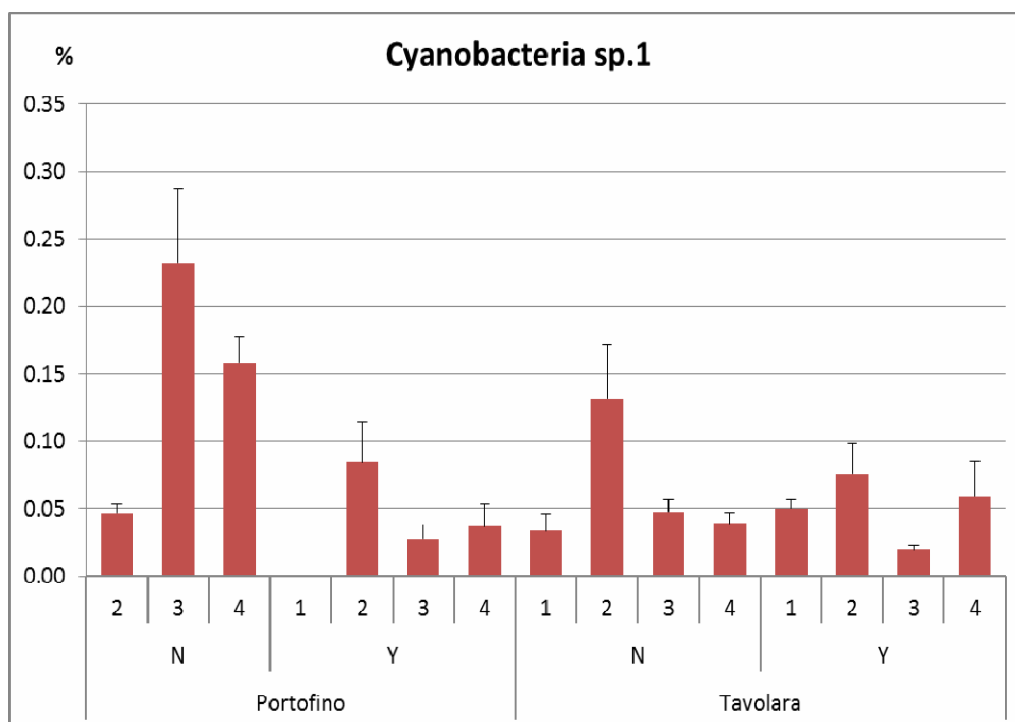


Fig. 3.3-5 Mean per cent cover of *Cyanobacteria* sp.1 (\pm s.e.).

Table 15 Results from PERMANOVA on epibenthic per cent cover data of *Cyanobacteria* sp.1.

Source	df	SS	MS	Pseudo-F	P(perm)	Unique perms	P(MC)
Fo	1	0.0807	0.0807	4.7548	0.0843	35	0.082
Pl(Fo)	5	0.0849	0.0170	6.4081	0.0004	9953	0.001
Res	21	0.0556	0.0026				
Total	27	0.2212					

Summary table of results of the most abundant taxa, as well the species detected by the correlations vector, are also showed (Table 16).

Table 16 Mean abundance and number of occurrences on the 28 panels of the most abundant taxa at Portofino. PERMANOVA results of selected taxa (based on their abundance and/or correlation with PCO axes) are reported (* P<0.05, ** P<0.01, * P<0.001, NS not significant).**

Taxa	Mean		PERMANOVA		
	abundance	Occurrence	Pl(Fo)	Fo	Result
Corallinacea sp. 1	0.6051	28	***	NS	
Rhodophyta sp. 1	0.3995	28	**	NS	
Chlorophyta sp.1	0.3026	28	NS	NS	
Foraminifera sp.2	0.2425	28	***	NS	
Rhodophyta sp.3	0.2262	28	NS	NS	
Foraminifera sp.1	0.1680	28	**	NS	
Chlorophyta sp.2	0.1388	28	NS	NS	
Rhodophyta sp.4	0.1238	28	*	NS	
Rhodophyta sp.2	0.1045	28	NS	*	N>Y
Phaeophyta sp.1	0.1038	28	**	NS	
Hydrozoa sp.1	0.0921	17	NS	NS	
Cyanobacteria sp.1	0.0838	23	***	NS	
Chlorophyta sp.3	0.0713	28	NS	NS	
<i>Clytia linearis</i>	0.0651	12	NS	NS	
<i>Neosiphonia harveyi</i>	0.0629	27	NS	NS	
Corallinales sp. 1	0.0603	28	***	NS	
Bryozoa sp.1	0.0479	28			
Rhodophyta sp.14	0.0306	24			
Rhodophyta sp.3	0.0268	26	NS	NS	
<i>Dexiospira marinoi</i>	0.0251	28			
<i>Aetea sp.1</i>	0.0218	17	**	NS	
Schizoporellidae sp.1	0.0196	28			
Phaeophyta sp.2	0.0152	15	*	NS	
<i>Semivermilia cribrata</i>	0.0131	26			
Rhodophyta sp.6	0.0129	22			
<i>Halecium lanckesteri</i>	0.0127	9			
Schizoporellidae sp.2	0.0125	22			
<i>Vinaria endoumensis</i>	0.0088	25			
Rhodophyta sp.4	0.0083	17			
Cyclostomatida sp.1	0.0081	10			
<i>Kirchenpaueria echinulata</i>	0.0081	4			
<i>Dexiospira pagenstecheri</i>	0.0080	22			
<i>Entalophoroecia sp.1</i>	0.0071	26			
<i>Schizoporella magnifica</i>	0.0069	21			
Cyanobacteria sp.2	0.0057	21			
<i>Champia parvula</i>	0.0049	9	*	NS	
Rhodophyta sp.10	0.0044	13			
<i>Spirobranchus polytrema</i>	0.0034	10			
<i>Savignyella lafontii</i>	0.0028	5	***	NS	
Rhodophyta sp.9	0.0017	6	*	NS	
<i>Laurencia sp.1</i>	0.0015	6			
<i>Sycon sp.1</i>	0.0012	9			
Rhodophyta sp.7	0.0008	6			
<i>Hydroides stoichadon</i>	0.0008	4	NS	**	Y>N

3.4. *Effects of gorgonian forest on the ecological groups*

During the analysis of data, 15 ecological groups were distinguished according to the ecological characteristics and the phylum membership of each taxon (Table 17 and Table 20).

At Tavolara the only two ecological groups significantly affected by the treatment were the encrusting calcareous algae (Table 17 and Table 18) and the Spirorbidae (Table 17 and Table 19). The former is more abundant in plots with gorgonians (Fig. 3.4-1), and the second in the plot without gorgonians (Fig. 3.4-2). The encrusting calcareous group is represented mainly by the *Corallinacea* sp.1 and by other algal species (like *Peyssonellia* sp.) in irrelevant abundance: this result is comparable with percent cover results for *Corallinacea* sp.1. The result of Spirorbidae seems to be due to higher density of *Hydroides stoichadon*, despite there is several other Spirorbidae species, but less abundant.

Table 17 Mean abundance and number of occurrences on the 32 panels of the ecological group at Tavolara. PERMANOVA results are reported (* P<0.05, ** P<0.01, * P<0.001, NS not significant).**

Ecological group	Mean abundances	Occurrence	PERMANOVA		
			PI(Fo)	Fo	Result
Encrusting algae	27.5775	32	NS	**	Y>N
Erected algae	16.8675	32	NS	NS	
Encrusting calcareous	16.2925	32	NS	NS	
Foraminifera	6.0150	32	NS	NS	
Spirorbidae	4.3175	32	NS	*	N>Y
Hydroid	3.7000	30	NS	NS	
Bryozoan stolonifera	1.0825	23	NS	NS	
Erect Porifera	0.5650	32	NS	NS	
Bryozoan encrusting	0.3650	30	NS	NS	
Bryozoan erect	0.1475	19	NS	NS	
Encrusting porifera	0.0225	5	NS	NS	
Clam	0.0100	4	NS	NS	
Not encrusting polychaetes	0.0075	1	NS	NS	
Social ascidian	0.0025	1	NS	NS	
Solitary polyp	0.0000	0	NS	NS	

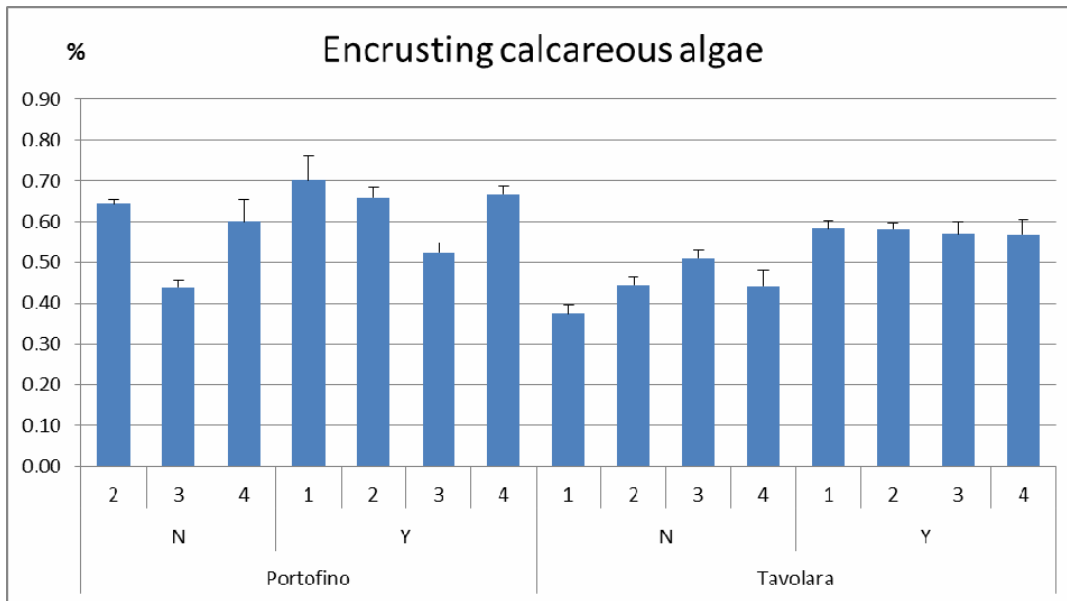


Fig. 3.4-1 Mean per cent cover of encrusting calcareous algae (\pm s.e.).

Table 18 Results from PERMANOVA on epibenthic per cent cover data of encrusting calcareous at Tavolara.

Source	df	SS	MS	Pseudo-F	P(perm)	Unique perms	P(MC)
Fo	1	0.1395	0.1395	21.7300	0.0258	28	0.0033 Y>N
Pl(Fo)	6	0.0385	0.0064	2.3087	0.0682	9951	0.0631
Res	24	0.0667	0.0028				
Total	31	0.2447					

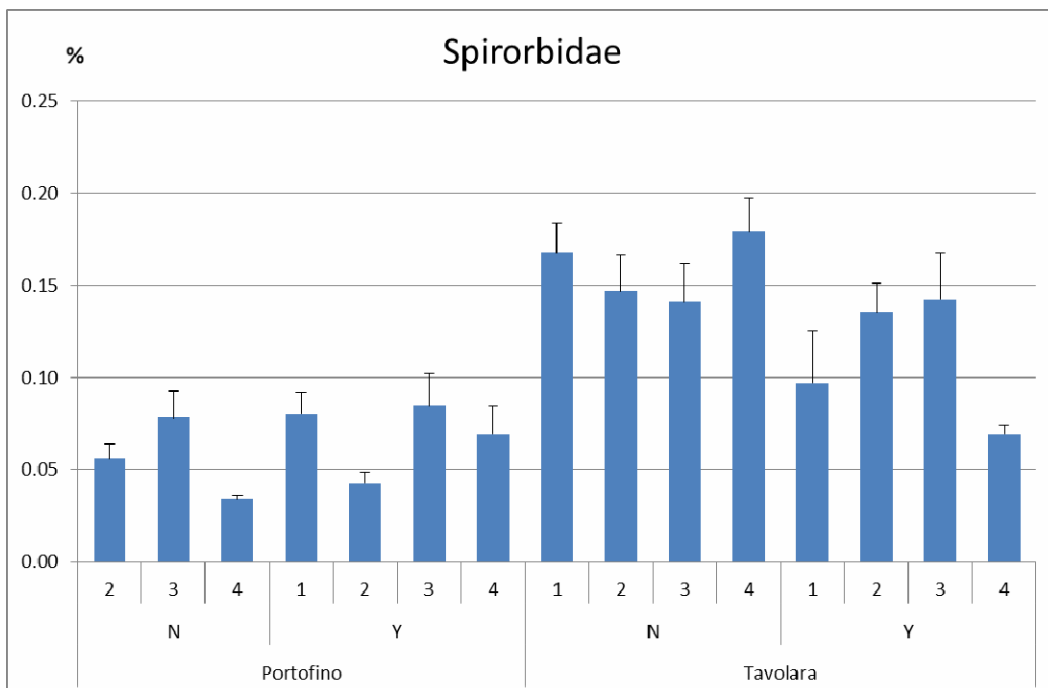


Fig. 3.4-2 Mean per cent cover of Spirorbidae (\pm s.e.).

Table 19 Results from PERMANOVA on epibenthic per cent cover data of Spirorbidae at Tavolara.

Source	df	SS	MS	Pseudo-F	P(perm)	Unique perms	P(MC)
Fo	1	0.0182	0.0182	6.0834	0.0552	34	0.0474 N>Y
PI(Fo)	6	0.0179	0.0030	1.9569	0.1120	9940	0.1156
Res	24	0.0366	0.0015				
Total	31	0.0727					

At Portofino, the ecological group didn't show any significant difference between treatments, except only for the erected algae that show higher abundances in plots without *E. cavolinii* (Fig. 3.4-3). The result of PERMANOVA shows that there is a high difference in the structure of this assemblages ($P < 0.01$) (Table 20 and Table 21).

Table 20 Mean abundance and number of occurrences on the 28 panels of the ecological group at Portofino. PERMANOVA results are reported (* $P < 0.05$, ** $P < 0.01$, * $P < 0.001$, NS not significant).**

Ecological group	Mean abundances	Occurrence	PERMANOVA		
			PI(Fo)	Fo	Result
Erected algae	28.8825	28	NS	**	N>Y
Encrusting algae	26.7750	28	NS	NS	
Encrusting calcareous algae	16.9425	28	NS	NS	
Foraminifera	11.5025	28	NS	NS	
Hydroid	5.4875	27	NS	NS	
Bryozoan encrusting	2.5625	28	NS	NS	
Spirorbidae	1.7825	28	NS	NS	
Bryozoan stolonifera	1.0275	22	NS	NS	
Bryozoan erect	0.2750	27	NS	NS	
Clam	0.0625	13	NS	NS	
Erect Porifera	0.0325	9	NS	NS	
Solitary polyp	0.0075	2	NS	NS	
Not encrusting polychaetes	0.0050	1	NS	NS	
Encrusting porifera	0.0000	0	NS	NS	
Social ascidian	0.0000	0	NS	NS	

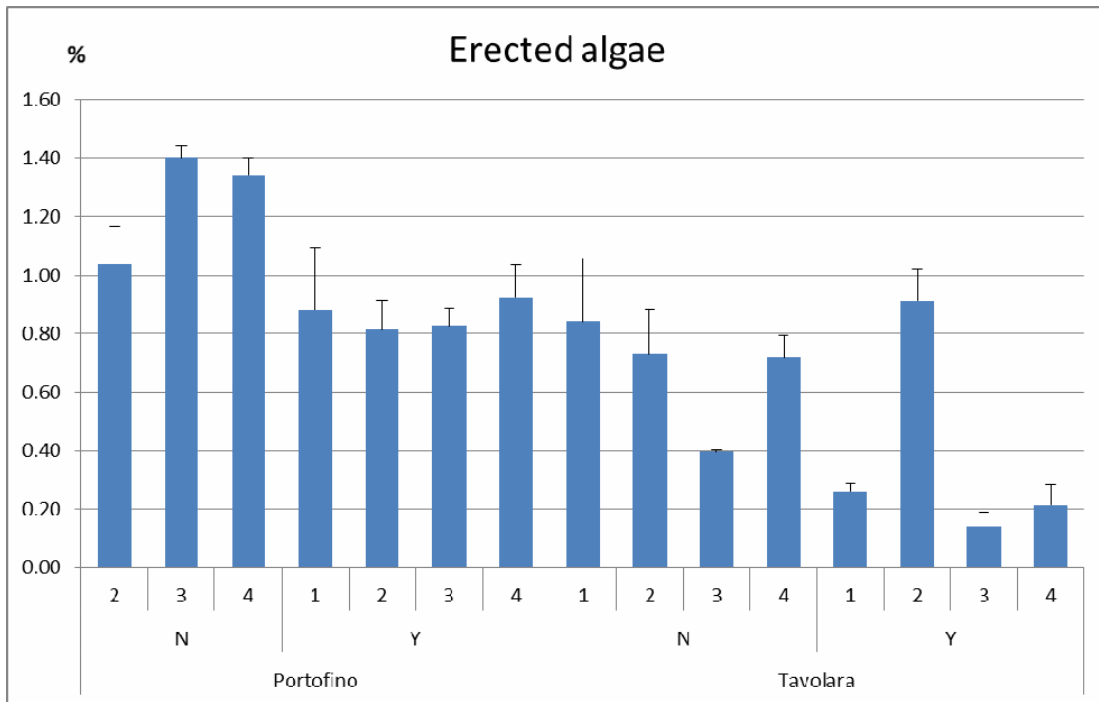


Fig. 3.4-3 Mean per cent cover of Erected algae (\pm s.e.).

Table 21 Results from PERMANOVA on epibenthic per cent cover data of erected algae at Portofino.

Source	df	SS	MS	Pseudo-F	P(perm)	Unique perms	P(MC)
Fo	1	1.0863	1.0863	16.2060	0.0263	35	0.0099 N>Y
Pl(Fo)	5	0.3352	0.0670	1.2452	0.3222	9943	0.3184
Res	21	1.1304	0.0538				
Total	27	2.5519					

3.5. Effects of gorgonian forest on the species diversity

The possible effects of gorgonian forest on the species diversity were analysed separately between the two sites. At Tavolara, the presence of the gorgonian forest didn't affect species richness (S) and overall species heterogeneity (N1), while benthic assemblages developed in absence of the gorgonian showed a significant higher evenness (N10) (Table 22 and Fig. 3.5-1).

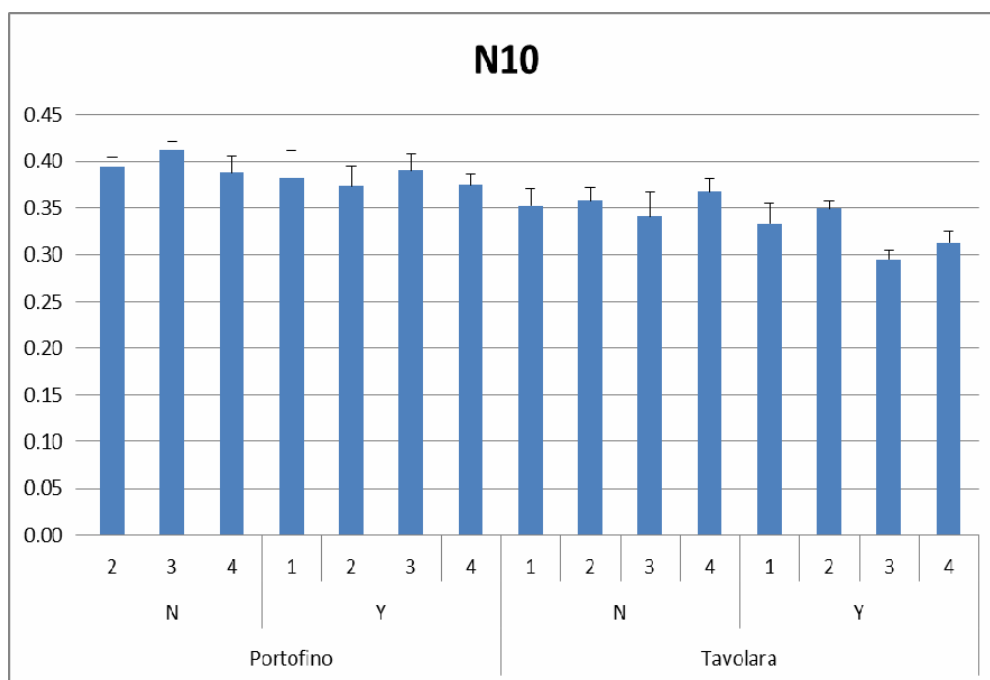


Fig. 3.5-1 Mean Hill's diversity index N10 (± s.e.)

Table 22 Results from PERMANOVA of N10 index at Tavolara

Source	df	SS	MS	Pseudo-F	P(perm)	Unique perms	P(MC)
Fo	1	0.0082	0.0082	5.9749	0.0604	35	0.0443 N>Y
PI(Fo)	6	0.0083	0.0014	1.2682	0.3050	9944	0.3101
Res	24	0.0260	0.0011				
Total	31	0.0425					

At Portofino, species richness (S), overall heterogeneity (Hill's N1 index) and Simpson's diversity index ($1-\lambda'$) were significantly affected by the presence of the gorgonian forest (Table 23). At this site, gorgonian forest reduced species richness and overall heterogeneity, while increase the Simpson's diversity index (Table 24, Table 25 and Table 26).

Table 23 Summary table results of PERMANOVA analysis of diversity indices (* P<0.05, ** P<0.01, *** P<0.001, NS not significant, X not performed).

Index	Tavolara			Portofino	
	PI(Fo)	Fo		PI(Fo)	Fo
S	NS	NS		pooled	* N>Y
1-λ'	NS	NS		NS	** Y>N
N1	NS	NS		NS	* N>Y
N10	NS	* N>Y		pooled	NS

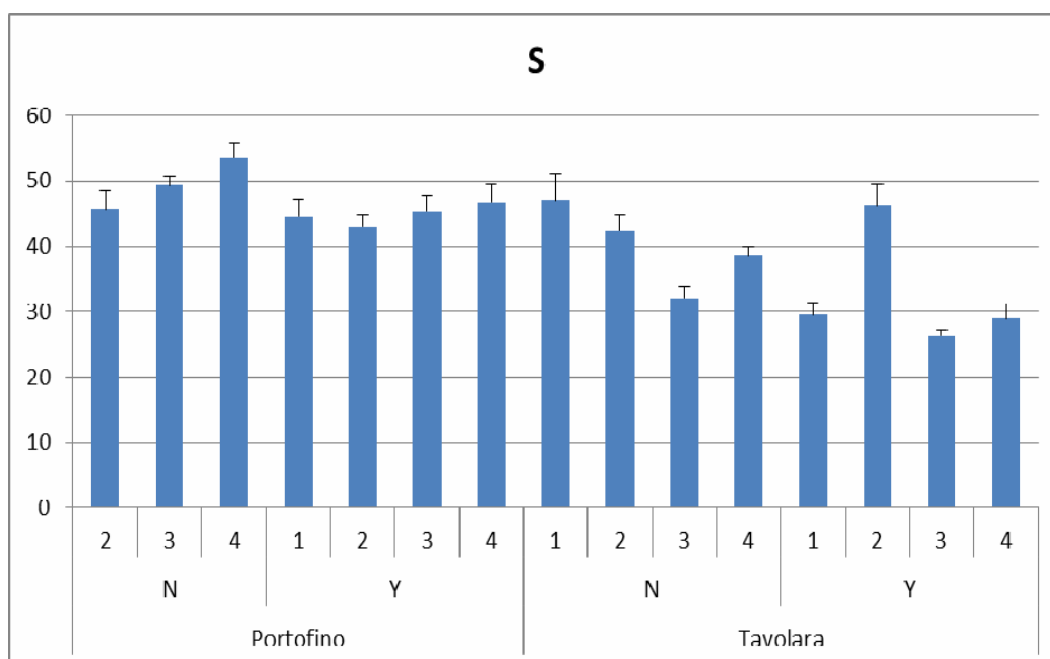


Fig. 3.5-2 Mean species richness S (± s.e.)

Table 24 Results from PERMANOVA of species richness S at Portofino

Source	df	SS	MS	Pseudo-F	P(perm)	Unique perms	P(MC)
Fo	1	141.44	141.44	5.8126	0.0234	92	0.0232 N>Y
PI(Fo)	5	pooled					
Res	26	632.67	24.333				
Total	27	774.11					

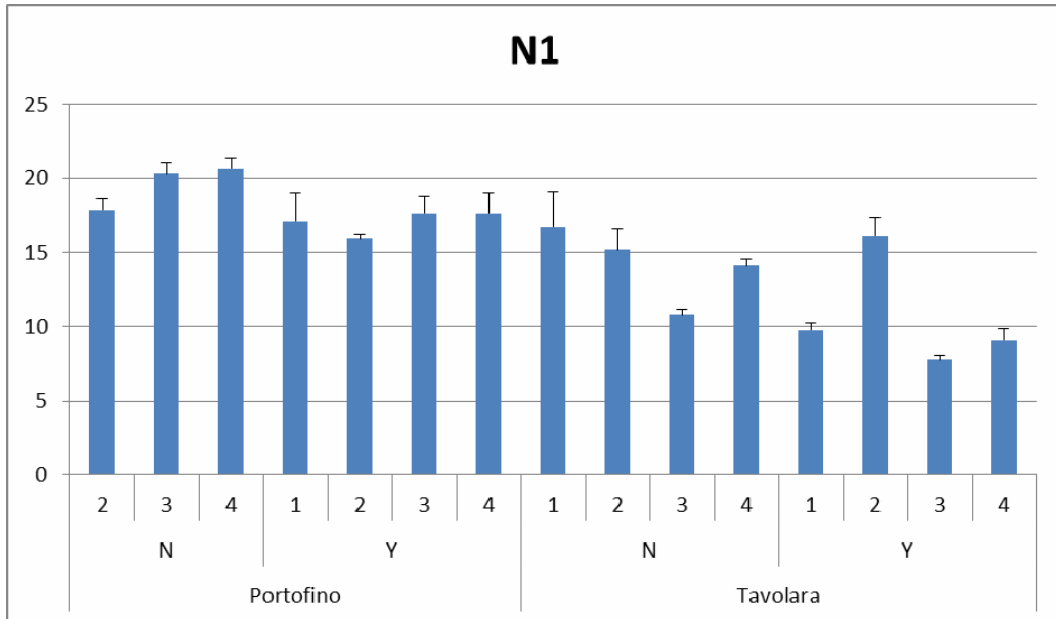


Fig. 3.5-3 Mean Hill's diversity index N1 (± s.e.).

Table 25 Results from PERMANOVA of N1 index at Portofino.

Source	df	SS	MS	Pseudo-F	P(perm)	Unique perms	P(MC)
Fo	1	43.7420	43.7420	8.4342	0.0269	35	0.0322 N>Y
Pl(Fo)	5	25.9320	5.1863	1.0440	0.4184	9956	0.4185
Res	21	104.3200	4.9678				
Total	27	174.0000					

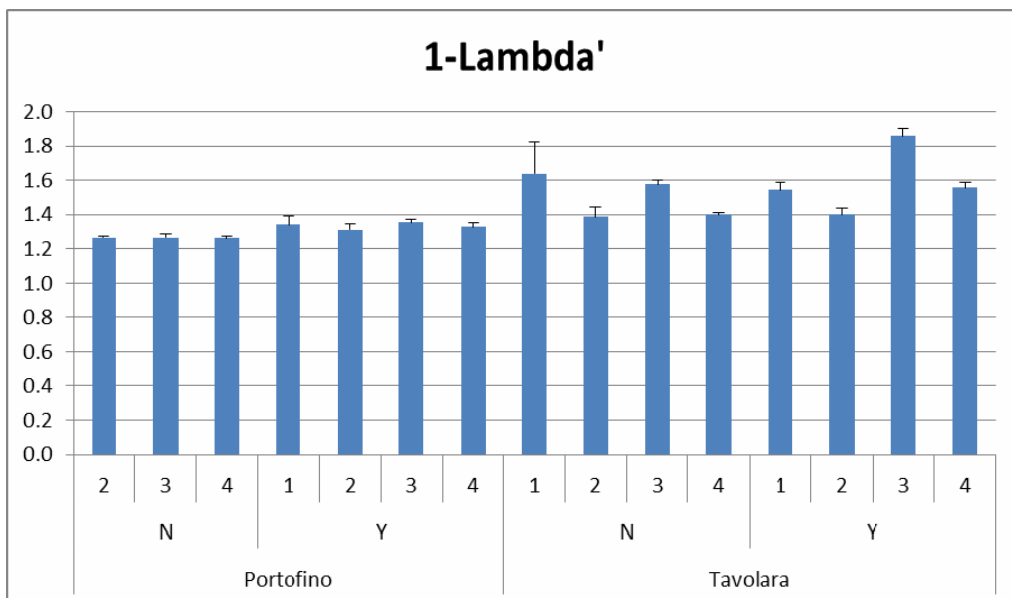


Fig. 3.5-4 Mean Simpson diversity index 1-λ' (± s.e.).

Table 26 Results from PERMANOVA of Simpson index $1-\lambda'$ at Portofino.

Source	df	SS	MS	Pseudo-F	P(perm)	Unique perms	P(MC)
Fo	1	0.0303	0.0303	44.5590	0.0246	35	0.0013 Y>N
Pl(Fo)	5	0.0034	0.0007	0.2288	0.9461	9956	0.9441
Res	21	0.0625	0.0030				
Total	27	0.0962					

Table 27 Results from PERMANOVA of N10 Hill's index at Portofino.

Source	df	SS	MS	Pseudo-F	P(perm)	Unique perms	P(MC)
Fo	1	0.0022	0.0022	1.9176	0.1845	9830	0.1747
Pl(Fo)	5	pooled					
Res	21	0.0293	0.0011				
Total	27	0.0315					

4. Discussion

The separation of the analyses among the two sites was necessary to better understand the effects of the gorgonian forests, which seems to be very different site by site. Indeed, these effects could be masked by the different degree of colonization occurring at different sites. The observed differences between sites and among plots seem to be related to local environmental conditions. As suggested by Bulleri (2005), hydrodynamic conditions, in terms of flow and turbulence, can be important in determining recruitment success and/or the scales at which settlers can interact with the substratum. Other studies have also showed that the Mediterranean coralligenous reefs may encompass a number of markedly different biogenic formations (Virgilio, Airoidi, & Abbiati 2006). Furthermore, high small spatial scale variability is a well-known characteristic of the coralligenous epibenthic assemblages (Ferdegini et al. 2000; Piazzi et al. 2004). Similar inclination and orientation of plots were applied in order to prevent different colonisation pattern due to this factors (Glasby & Connell 2001; Piazzi et al. 2004; Virgilio, Airoidi, & Abbiati 2006).

Differences among sites have been recognised in environmental features including river inputs, sea currents and sedimentation, which probably affected the average growth of the populations. Furthermore, at Tavolara we have registered a period of mucilage bloom during august at depth over 20 m (personal observations).

Despite this, the random choice of the study areas in MPAs has presented several advantages. First, the exclusion of some human impacts, like pollution, which could alters the diversity and growth of assemblages (Ballesteros 2006; Coma et al. 2004). Several studies show the role of the MPAs in protecting the marine environment in terms of biodiversity conservation, compared with neighbouring areas (Mangialajo et al. 2007; Zeichen et al. 2008). However, some studies show that the presence of diving activities (especially in the summer season) influence gorgonian populations (Ballesteros 2006; Coma et al. 2004).

4.1. *Forest effect on community and single species*

Results show that there isn't a clear forest effect of *E. cavolinii* on settlement and recruitment of epibenthic species. Despite this general pattern, the analyses allow us to make some important considerations. First, the PCO ordination plots showed that, despite the high differentiation among sites, there was a slight separation between treatments, especially for Tavolara. The PCO ordination plots also showed a spatial grouping of the plots, which could explain the high variability observed. Considering the small spatial scale investigated (order of few meters), the results seem to be in accordance with previous results of other studies on the variability of coralligenous assemblages (Abbiati, Virgilio, & Querci 1996; Balata, Acunto, & Cinelli 2006; Ferdeghini et al. 2000; Virgilio, Airoidi, & Abbiati 2006).

The analyses on single sites showed that some species were influenced by the presence of the forest. For instance the Corallinacea sp.1, the most abundant species found, was affected by the presence of the gorgonians at Tavolara. This is probably due to the shading effect, which reduces the light irradiance, and favours the developing of Corallinaceae (Ballesteros 2006). Differently, at Portofino this species followed a different pattern and the variability between plots is greater than between treatments. Perhaps other factors have influenced this result, and differences among environmental conditions on small scale probably have influenced the colonisation pattern at Portofino, masking a possible forest effect.

The Rhodophyta sp. 2, an erected alga, is significantly inhibited by the presence of gorgonian forest at Portofino, and this result seems to be in accordance with the shading effect, that reduces the growth of some erected algal species (Glasby 1999; Williams 1994). At Tavolara this species was present in low abundances on few panels, making it difficult to compare.

The *Hydroides stoichadon* showed a characteristic pattern that seems to be related with two factors: the competition with algae and the presence of gorgonian forest. As well recognised in other works the Spirorbidae are early-stage colonisers of new substrata, well known as "pioneer species" (Boaventura et al. 2006; Relini, Zamboni, & Tixi 1994). However, the Spirorbidae may have suffered the competition with erected algae (Baynes 1999). Another negative effect could be made by sediment deposition. The rates of sediment deposition were not measured

during this study; however, the visual analysis of panels showed that a thin coat of sediment commonly covered the Portofino's panels where erected algae are present. This seems to be in agreement with our results, where the abundance of the *Hydroides stoichadon* was inversely related to the presence of erected algae (see also Balata et al. 2005; Glasby & Connell 2001). Similar, but less strong effect probably is attributable by the presence of gorgonian forest, which partially inhibits the recruitment of this Spirorbidae. The possible interactions between these three factors give a complex pattern, where gorgonians may act as inhibitors or facilitator, depending on the power of interaction with erected algae. At Tavolara, where the erected algae were less abundant, the gorgonians played a negative role on recruitment of *H. stoichadon*, inhibiting its growth. Conversely, at Portofino the forest effect preserve the survival of this species, by affecting the erected algae growth. In this case the gorgonians forest can be considered as habitat modifiers.

4.2. *Forest effect on ecological group*

The analyses of ecological group have showed some interesting results about differences in colonization pattern between treatments. The study of coralligenous assemblages through ecological groups gives a better understanding of the ecological processes that occur in these habitats (Piazzi et al. 2004). For our purpose the use of ecological groups allow us to distinguish the differences due to species interactions and analyse the response of a class of organisms with the same characteristic to the forest effect.

Overall, the calcareous tube worms, which include *Hydroides stoichadon*, were affected by gorgonian populations. Gorgonians seem to play an inhibiting role on the recruitment of these polychates in the early-stage succession, and this could be due to anti-proliferative compound that inhibit the recruitment (Faulkner 1998). This result is also confirmed by our analysis on species heterogeneity at Tavolara, and by species richness and heterogeneity at Portofino, where the total colonisation is higher.

At Portofino the development of erected algae seem to be influenced by the gorgonians forest. Despite the erected algae were normally presented in habitats with *E. cavolinii* (Cocito, Bedulli, & Sgorbini 2002; True 1970), no specific

studies have demonstrated this phenomenon. We argue that probably it is due to the reduction of light irradiance, but other factors, as sedimentation or grazing, can explain this pattern (Airoldi 2003). Moreover, no distinctions are made for turf-forming species and other erected algae: studies show that the turf-forming species are most abundant in late august-september period (Balata, Acunto, & Cinelli 2006) and can have different response when are subject to other disturbances (Piazzi et al. 2004). More focused studies are needed to clarify this aspect.

4.3. *Forest effect on species diversity*

Gorgonians forest seems to affect the species diversity at the small spatial scale investigated in the two sites. At Tavolara the overall heterogeneity was different between the two treatments and showed that the species were more equally distributed in plots without gorgonians.

The evenness could be affected by gorgonians, which altering species recruitment both directly with anti-proliferative compound and indirectly by altering micro-physical conditions. Despite this hypothesis, other factors can be responsible of this pattern, as larval supply or the mucilage event that have affected the health of some species.

The results of Portofino, where the colonisation is clearly higher, showed that the gorgonians affect species richness. The forest effect seems to act in synergism with other factors, both internal (physiological response) and external such as competition between individual species on a small-scale or grazing. Baynes (1999) has shown that pressure of grazers is high in sheltered areas, because they find refuges from predators.

From this point of view the gorgonian reducing the total diversity, but don't affect the evenness, despite this last results need further validation from other experiments. As expected, the final result was an unbalanced distribution of the species among the two treatments, with a prevalence of more diversified habitats in gorgonian absence. Cerrano et al. (2009) in a similar work on the gold coral *Savalia savaglia* point out that in the mesophotic zone the presence of engineering species as sea fans can increase surrounding biodiversity and faunal biomass. He also specifies that ecosystems characterised by the presence of gold corals can

enhance benthic biodiversity in the long term. This result refer to a soft bottom and are in opposite with our results on hard substrata. Although it may seem negative on a small-scale, gorgonians contribute to the formation of diversified patches within the coralligenous habitat that increase the total diversity on a more large scale (β -diversity).

Mass mortality events that affect gorgonians species play a negative role on the diversity of the habitat, and our results confirm this hypothesis. From a conservationist point of view, more effort are needed to clarify the role *E. cavolinii* in benthic communities. This work should serve as a cue to attract the attention of environmental managers.

In conclusion, despite the large differences among sites, gorgonian forests exercised an influence on coralligenous communities. Probably, a more prolonged experiment could provide better results. Moreover, our work show only the effect of gorgonians in the summer season, while a full year study takes into account the seasonal changes of physical conditions and the changes in composition of the assemblages (Balata, Acunto, & Cinelli 2006).

Improvements for further experiments must to take into account measurement of sedimentation rates that are also important for structuring coralligenous communities (Airoldi 2003; Balata et al. 2005; Virgilio, Airoldi, & Abbiati 2006). Its interaction with gorgonians forest is also important, because the response of many species depends on the interaction with sedimentation and other factors as the shading effect. Connell (2003) have showed that some encrusting coralline algae were equally influenced by sedimentation and shading effect of gorgonian. Should be interesting distinguish the physical effects of the presence of gorgonians (the three dimensional structure), from their biological anti-proliferative effects of active compounds. This could be tested by comparing true gorgonians with simulated gorgonians by plastic branches that reproduce their presence.

Given the high diversity of coralligenous habitat on small scales (Bourget, DeGuise, & Daigle 1994; Ferdeghini et al. 2000; RAC/SPA 2009), another important improvement would be the increase of the spatial replication of the experiment.

5. Acknowledgements

Special thank to Massimo Ponti for the trust and the opportunity to participate in the realization of this experiment; I learned a lot from him...thank not only as a teacher, but as a friend. Other thanks to Carlo Cerrano and his staff, particularly Monica Previati, Carla, Daniele and Marco the “videoreporter”. Thanks to the staff of MPA of Tavolara-P.ta Coda Cavallo, the director Augusto Navone, Pièrre Panzeris and the “boatman unnamed” for their valuable help, the great passion for their work and the logistic supports. Thank to Egidio Trainito for its wonderful photos and the pleasant company. Thanks to the Mario and the ESA staff of “Ahioò Diving” of Porto Santo Stefano for technical support and the European Dive’in Center of Santa Margherita Ligure. Thanks to Prof. Marco Abbiati for the thesis, to Prof. Marina Antonia Colangelo my precious counterreport and all other Professors for what they have taught me.

Thanks to my father Mario and my mother Caterina for the moral support and much more..., to my brother Fabio “the architect”, and the smiles of my little sister Elena. Thanks to Rossella for sharing with me the Sea and this experience and, especially, thanks to all my closest friends because they are the most valuable thing a man can have. Thank to my friends of the Diving Le Tonnare, because if the divers are crazy, you are the crazies of all...and to Franco, my first underwater master. Thanks to Andrea, a friend and a brother, for his advices and the adventures spent together...even though we took different ways, we can still trust each other!

What I am I owe to you all...

Dedicated to my grandmother, which now looks at me from above

*Even when the problems seem huge
and life gives you even a joy,
do not give up ever!
Addressed the difficulties with a smile,
planted a dream in your heart
and everything will seem less difficult!
Do not bend ever
always walk tall!
I do not give up!
Not until the hope's dream is burning inside me!*

A pirate

6. References

- Abbiati, M., Virgilio, M. & Querci, J. (1996) Spatial and temporal variability of species distribution on a sublittoral rocky cliff in the Ligurian Sea. *S. It. E. Atti*, **17**, 337–340.
- Airoldi, L. (2003) The effects of sedimentation on rocky coast assemblages. *Oceanography and Marine Biology, an Annual Review*, **41**, 161–236.
- Anderson, M.J. (2001) Permutation tests for univariate or multivariate analysis of variance and regression. *Canadian Journal of Fisheries and Aquatic Sciences*, **58**, 626–639.
- Anderson, M.J. & Robinson, J. (2001) Permutation test for linear models. *Australian & New Zealand Journal of Statistics*, **43**, 75–88.
- Balata, D., Acunto, S. & Cinelli, F. (2006) Spatio-temporal variability and vertical distribution of a low rocky subtidal assemblage in the north-west Mediterranean. *Estuarine, Coastal and Shelf Science*, **67**, 553–561.
- Balata, D., Piazzini, L., Cecchi, E. & Cinelli, F. (2005) Variability of Mediterranean coralligenous assemblages subject to local variation in sediment deposition. *Marine environmental research*, **60**, 403–21.
- Ballesteros, E. (2006) Mediterranean coralligenous assemblages: a synthesis of present knowledge. *Oceanography and Marine Biology*, **44**, 123–195.
- Barnes, R.D., Ruppert, E.E. & Litvaitis, M.K. (1974) *Invertebrate zoology*. Saunders Philadelphia.
- Bavestrello, G., Bianchi, C., Calcinai, B., Cattaneo-Vietti, R., Cerrano, C., Morri, C., Puce, S. & Sarà, M. (2000) Bio-mineralogy as a structuring factor for marine epibenthic communities. *Marine Ecology Progress Series*, **193**, 241–249.
- Baynes, T.W. (1999) Factors structuring a subtidal encrusting community in the southern Gulf of California. *Bulletin of Marine Science*, **64**, 419–450.
- Benedetti-Cecchi, L., Rindi, F., Bertocci, I., Bulleri, F. & Cinelli, F. (2001) Spatial variation in development of epibenthic assemblages in a coastal lagoon. *Estuarine, Coastal and Shelf Science*, **52**, 659–668.
- Bianchi, C.N., Morri, C. & Navone, A. (2010) I popolamenti delle scogliere rocciose sommerse dell'Area Marina Protetta di Tavolara Punta Coda Cavallo (Sardegna nord-orientale). *Scientific reports of Port-Cros national park*, **24**, 39–85.

- Bianchi, C., Pronzato, R., Cattaneo-Vietti, R., Benedetti-Cecchi, L., Morri, C., Pansini, M., Chemello, R., Milazzo, M., Frascchetti, S. & Terlizzi, A., others. (2003) I fondi duri. *Manuale di metodologie di campionamento e studio del benthos marino mediterraneo. Biol. Mar. Med*, **10**, 199–232.
- Boaventura, D., Moura, A., Leitão, F., Carvalho, S., Cúrdia, J., Pereira, P., Fonseca, L.C.D., Santos, M.N.D. & Monteiro, C.C. (2006) Macrobenthic Colonisation of Artificial Reefs on the Southern Coast of Portugal (Ancão, Algarve). *Hydrobiologia*, **555**, 335-343.
- Boer, W.D. (2007) Seagrass–sediment interactions, positive feedbacks and critical thresholds for occurrence: a review. *Hydrobiologia*.
- Boudouresque, C.F. (2004) Marine biodiversity in the mediterranean; status of spicks, populations and communities. *com.univ-mrs.fr*, **20**, 97-146.
- Bourget, E., DeGuise, J. & Daigle, G. (1994) Scales of substratum heterogeneity, structural complexity, and the early establishment of a marine epibenthic community• 1. *Journal of Experimental Marine Biology and Ecology*, **181**, 31–51.
- Bruno, J.F. & Bertness, M.D. (2001) Habitat modification and facilitation in benthic marine communities. *Marine community ecology*, 201–218.
- Bulleri, F. (2005) Role of recruitment in causing differences between intertidal assemblages on seawalls and rocky shores. *Marine Ecology Progress Series*, **287**, 53–65.
- Burlando, B., Cattaneo-Vietti, R., Parodi, R. & Scardi, M. (1991) Emerging fractal properties in gorgonian growth forms (Cnidaria: Octocorallia). *Growth, development, and aging: GDA*, **55**, 161.
- Casellato, S. & Stefanon, A. (2008) Coralligenous habitat in the northern Adriatic Sea: an overview. *Marine Ecology*, **29**, 321–341.
- Castilla, J., Lagos, N. & Cerda, M. (2004) Marine ecosystem engineering by the alien ascidian *Pyura praeputialis* on a mid-intertidal rocky shore. *Marine Ecology Progress Series*, **268**, 119-130.
- Cerrano, C., Arillo, A., Azzini, F., Calcinai, B., Castellano, L., Muti, C., Valisano, L., Zega, G. & Bavestrello, G. (2005) Gorgonian population recovery after a mass mortality event. *Aquatic Conservation: Marine and Freshwater Ecosystems*, **15**, 147-157.
- Cerrano, C., Bavestrello, G., Bianchi, C., Cattaneo-vietti, R., Bava, S., Morganti, C., Morri, C., Picco, P., Sara, G. & Schiaparelli, S., others. (2000) A catastrophic mass-mortality episode of gorgonians and other organisms in the Ligurian Sea (North-western Mediterranean), summer 1999. *Ecology letters*, **3**, 284–293.

- Cerrano, C., Calcinai, B., Bertolino, M., Valisano, L. & Bavestrello, G. (2006) Epibionts of the scallop *Adamussium colbecki* in the Ross Sea, Antarctica. *Chem Ecol*, **22**, 235–244.
- Cerrano, C., Danovaro, R., Gambi, C., Pusceddu, A., Riva, A. & Schiaparelli, S. (2009) Gold coral (*Savalia savaglia*) and gorgonian forests enhance benthic biodiversity and ecosystem functioning in the mesophotic zone. *Biodiversity and Conservation*, **19**, 153-167.
- Cerrano, C. & Bavestrello, G. (2008) Medium-term effects of die-off of rocky benthos in the Ligurian Sea. What can we learn from gorgonians? *Chemistry and Ecology*, **24**, 73–82.
- Cimino, G., De Rosa, S. & De Stefano, S. (1984) Antiviral agents from a gorgonian, *Eunicella cavolini*. *Cellular and Molecular Life Sciences*, **40**, 339–340.
- Cocito, S., Bedulli, D. & Sgorbini, S. (2002) Distribution patterns of the sublittoral epibenthic assemblages on a rocky shoal in the Ligurian Sea (NW Mediterranean). *Scientia Marina*, **66**, 175-181.
- Coma, R., Linares, C., Ribes, M., Diaz, D., Garrabou, J. & Ballesteros, E. (2007) Consequences of a mass mortality in populations of *Eunicella singularis* (Cnidaria: Octocorallia) in Menorca (NW Mediterranean). *Marine Ecology Progress Series*, **327**, 51–60.
- Coma, R., Pola, E., Ribes, M. & Zabala, M. (2004) Long-Term Assessment of Temperate Octocoral Mortality Patterns, Protected Vs. Unprotected Areas. *Ecological Applications*, **14**, 1466-1478.
- Connell, S.D. (2003) The monopolization of understory habitat by subtidal encrusting coralline algae: a test of the combined effects of canopy-mediated light and sedimentation. *Marine Biology*, **142**, 1065–1071.
- Dayton, P. & Hessler, R. (1972) Role of biological disturbance in maintaining diversity in the deep sea. *Deep Sea Research and Oceanographic Abstracts*. p. 199–204. Elsevier.
- Doglioli, A.M., Griffa, A. & Magaldi, M.G. (2004) Numerical study of a coastal current on a steep slope in presence of a cape: the case of the Promontorio di Portofino. *Journal of Geophysical Research*, **109**, C12033.
- Eckman, J.E., Nowell, A.R.M. & Jumars, P.A. (1981) Sediment destabilization by animal tubes. *Journal of Marine Research*, **39**, 361–374.
- Faulkner, D.J. (1998) Marine natural products. *Natural product reports*, **15**, 113–158.

- Fava, F., Bavestrello, G., Valisano, L. & Cerrano, C. (2010) Survival, growth and regeneration in explants of four temperate gorgonian species in the Mediterranean Sea. *Italian Journal of Zoology*, **77**, 44–52.
- Fava, F., Ponti, M. & Abbiati, M. (2008) Spatial-temporal variability of epibenthic assemblages on rocky outcrops in the northern Adriatic continental shelf. *Science and management of estuaries and coasts: a tale of two hemispheres. Abstract of the ECSA 44 th International conference. Bahia Blanca, Argentina.*
- Fava, F. & Valisano, L. (2007) Climatic anomalies during summer 2003 in the Ligurian sea: a comparative study on four gorgonian species. *Biol. Mar. Mediterr.*, **14**, 80-81.
- Ferdeghini, F., Acunto, S., Cocito, S. & Cinelli, F. (2000) Variability at different spatial scales of a coralligenous assemblage at Giannutri Island (Tuscan Archipelago, northwest Mediterranean). *Hydrobiologia*, **440**, 27-36.
- Ferrier-Pagès, C., Tambutté, E., Zamoum, T., Segonds, N., Merle, P.-L., Bensoussan, N., Allemand, D., Garrabou, J. & Tambutté, S. (2009) Physiological response of the symbiotic gorgonian *Eunicella singularis* to a long-term temperature increase. *The Journal of experimental biology*, **212**, 3007-15.
- Gacia, E. & Duarte, C. (2001) Sediment retention by a Mediterranean *Posidonia oceanica* meadow: the balance between deposition and resuspension. *Estuarine, Coastal and Shelf Science*, **52**, 505–514.
- Gambi, M., Nowell, A. & Jumars, P. (1990) Flume observations on flow dynamics in *Zostera marina* (eelgrass) beds. *Marine ecology progress series.*, **61**, 159–169.
- Garrabou, J., Coma, R., Bensoussan, N., Bally, M., Chevaldonne, P., Cigliano, M., Diaz, D., Harmelin, J., Gambi, M. & Kersting, D., others. (2009) Mass mortality in Northwestern Mediterranean rocky benthic communities: effects of the 2003 heat wave. *Global Change Biology*, **15**, 1090–1103.
- Gaylord, B., Rosman, J., Reed, D. & Koseff, J. (2007) Spatial patterns of flow and their modification within and around a giant kelp forest. *Limnology and*.
- Glasby, T.M. (1999) Interactive effects of shading and proximity to the seafloor on the development of subtidal epibiotic assemblages. *Marine Ecology-Progress Series*, **190**, 113-124.
- Glasby, T.M. & Connell, S.D. (2001) Orientation and position of substrata have large effects on epibiotic assemblages. *Marine Ecology Progress Series*, **214**, 127-135.
- Glasby, T. (2001) Development of sessile marine assemblages on fixed versus moving substrata. *Marine Ecology Progress Series*, **215**, 37–47.

- Glasby, T. (2000) Surface composition and orientation interact to affect subtidal epibiota. *Journal of Experimental Marine Biology and Ecology*, **248**, 177–190.
- Gori, A., Linares, C., Rossi, S., Coma, R. & Gili, J.-M. (2007) Spatial variability in reproductive cycle of the gorgonians *Paramuricea clavata* and *Eunicella singularis* (Anthozoa, Octocorallia) in the Western Mediterranean Sea. *Marine Biology*, **151**, 1571-1584.
- Gori, A., Rossi, S., Berganzo, E., Pretus, J.L., Dale, M.R.T. & Gili, J.M. (2010) Spatial distribution patterns of the gorgonians *Eunicella singularis*, *Paramuricea clavata*, and *Leptogorgia sarmentosa* (Cape of Creus, Northwestern Mediterranean Sea). *Marine Biology*, 1–16.
- Harrison, P. & Wallace, C. (1990) Reproduction, dispersal and recruitment of scleractinian corals. *Ecosystems of the world*, **25**, 133–207.
- Huber, J. (1998) The importance of voucher specimens, with practical guidelines for preserving specimens of the major invertebrate phyla for identification. *Journal of Natural History*, **32**, 367–385.
- Ioannou, E., Abdel-Razik, A.F., Alexi, X., Vagias, C., Alexis, M.N. & Roussis, V. (2009) 9,11-Secosterols with antiproliferative activity from the gorgonian *Eunicella cavolini*. *Bioorganic & medicinal chemistry*, **17**, 4537-41.
- Ioannou, E., Abdel-Razik, A.F., Zervou, M., Christofidis, D., Alexi, X., Vagias, C., Alexis, M.N. & Roussis, V. (2009) 5alpha,8alpha-Epidioxysterols from the gorgonian *Eunicella cavolini* and the ascidian *Trididemnum inarmatum*: isolation and evaluation of their antiproliferative activity. *Steroids*, **74**, 73-80.
- Jackson, G.A. & Winant, C.D. (1983) Effect of a kelp forest on coastal currents. *Continental Shelf Research*, **2**, 75–80.
- Jones, C., Lawton, J. & Shachak, M. (1994) Organisms as ecosystem engineers. *Oikos*, **69**, 373-386.
- Jones, T.R. (1861) *General outline of the organization of the animal kingdom and manual of comparative anatomy*. J. Van Voorst.
- Kingsley, R.J., Tsuzaki, M., Watabe, N. & Mechanic, G.L. (1990) Collagen in the spicule organic matrix of the gorgonian *Leptogorgia virgulata*. *The Biological Bulletin*, **179**, 207.
- Lang, J. & Chornesky, E. (1990) Competition between scleractinian reef corals- a review of mechanisms and effects. *Ecosystems of the world*, **25**, 209–252.
- Linares, C., Coma, R., Diaz, D., Zabala, M., Hereu, B. & Dantart, L. (2005) Immediate and delayed effects of a mass mortality event on gorgonian population dynamics and benthic community structure in the NW Mediterranean Sea. *Marine Ecology Progress Series*, **305**, 127-137.

- Linares, C., Coma, R., Garrabou, J., Díaz, D. & Zabala, M. (2008) Size distribution, density and disturbance in two Mediterranean gorgonians: *Paramuricea clavata* and *Eunicella singularis*. *Journal of Applied Ecology*, **45**, 688-699.
- Manca Zeichen, M., Finioia, M., Locritani, M., Ruggeri, N., Tunesi, L., Gasparini, G., Bassetti, M., Grandi, V., Cattaneo-Vietti, R. & Povero, P. (2008) A preliminary analysis of in situ and remotely sensed environmental variables in the coastal region of the Portofino Marine Protected Area. *Chemistry and Ecology*, **24**, 57-66.
- Mangialajo, L., Ruggieri, N., Asnaghi, V., Chiantore, M., Povero, P. & Cattaneo-Vietti, R. (2007) Ecological status in the Ligurian Sea: The effect of coastline urbanisation and the importance of proper reference sites. *Marine Pollution Bulletin*, **55**, 30-41.
- Martin, Y. (2002) Gorgonians mass mortality during the 1999 late summer in French Mediterranean coastal waters: the bacterial hypothesis. *Water Research*, **36**, 779-782.
- Mistri, M. & Ceccherelli, V.U. (1994) Growth and secondary production of the Mediterranean gorgonian *Paramuricea clavata*. *Marine Ecology Progress Series*, **103**, 291-296.
- Piazzzi, L., Balata, D., Pertusati, M. & Cinelli, F. (2004) Spatial and temporal variability of Mediterranean macroalgal coralligenous assemblages in relation to habitat and substratum inclination. *Botanica Marina*, **47**, 105-115.
- PLAN, M.A. (2008) *Impact of climate change on biodiversity in the Mediterranean Sea* (R Edit., Ed.). UNEP-MAP-RAC/SPA, Tunis.
- Pusceddu, A., Frascchetti, S., Mirto, S., Holmer, M. & Danovaro, R. (2007) Effects of intensive mariculture on sediment biochemistry. *Ecological Applications*, **17**, 1366-1378.
- RAC/SPA, U.M. (2009) *Proceedings of the 1st Mediterranean symposium on the conservation of the coralligenous and other calcareous bio-concretions (Tabarka, 15-16 January 2009)* (CP-MMB Edits, Ed.). RAC/SPA publ., Tunis.
- Reichman, O. & Seabloom, E.W. (2002) Ecosystem engineering: a trivialized concept?: Response from Reichman and Seabloom. *Trends in ecology and evolution*, **17**, 308.
- Relini, G., Zamboni, N. & Tixi, F. (1994) Patterns of sessile macrobenthos community development on an artificial reef in the Gulf of Genoa (northwestern Mediterranean). *Bulletin of Marine Science*, **55**, 745-771.

- Rule, M.J. & Smith, S.D.A. (2005) Spatial variation in the recruitment of benthic assemblages to artificial substrata. *Marine Ecology Progress Series*, **290**, 67–78.
- Russo, A. (1985) Ecological observations on the gorgonian sea fan *Eunicella cavolinii* in the Bay of Naples. *Marine Ecology Progress Series*, **24**, 155–159.
- Shashar, N., Kinane, S., Jokiel, P. & Patterson, M. (1996) Hydromechanical boundary layers over a coral reef. *Journal of Experimental Marine Biology and Ecology*, **199**, 17–28.
- Skoufas, G. (2006) Comparative biometry of *Eunicella singularis* (Gorgonian) sclerites at East Mediterranean Sea (North Aegean Sea, Greece). *Marine Biology*, **149**, 1365–1370.
- Tidball, J.G. (1982) Fine structural aspects of anthozoan desmocyte development (Phylum Cnidaria). *Tissue and Cell*, **14**, 85–96.
- Trainito, E. (2005) Atlante di flora e fauna del Mediterraneo. *Edizioni il Castello, Trezzano sul Naviglio*.
- True, M.A. (1970) Etude quantitative de quatre peuplements sciaphiles sur substrat rocheux dans la region marseillaise. *Bull Inst Oceanogr Monaco*, **1410**, 1–48.
- Tunesi, L. (2009) Facies of the coralligenous biocenosis. *Priority habitats according to the SPA7BIO protocol (Barcelona convention) present in Italy - Identification Sheets*. (eds R. G. & G. G.), pp. 247–261.
- Turner, S.J. & Tood, C.D. (1993) The early development of epifaunal assemblages on artificial substrata at 2 intertidal sites on an exposed rocky shore in St Andrews Bay, NE Scotland. *Journal of Experimental Marine Biology and Ecology*, **166**, 251–272.
- Velimirov, B. (1975) Growth and age determination in the sea fan *Eunicella cavolinii*. *Oecologia*, **19**, 259–272.
- Velimirov, B. (1973) Orientation in the sea fan *Eunicella cavolinii* related to water movement. *Helgoländer Wissenschaftliche Meeresuntersuchungen*, **24**, 163–173.
- Velimirov, B. (1976) Variations in growth forms of *Eunicella cavolini* Koch 1887 (Octocorallia) related to intensity of water movement. *Journal of Experimental Marine Biology and Ecology*, **21**, 109–117.
- Vezzulli, L., Previati, M., Pruzzo, C., Marchese, A., Bourne, D.G. & Cerrano, C. (2010) *Vibrio* infections triggering mass mortality events in a warming Mediterranean Sea. *Environmental Microbiology*.

- Virgilio, M., Airoidi, L. & Abbiati, M. (2006) Spatial and temporal variations of assemblages in a Mediterranean coralligenous reef and relationships with surface orientation. *Coral Reefs*, **25**, 265-272.
- Weinbauer MG, V.B. (1996) Population Dynamics and Overgrowth of the Sea Fan *Eunicella cavolini* (Coelenterata: Octocorallia). *Estuarine, Coastal and Shelf Science*, **42**, 583-595.
- Weinbauer, M.G. & Velimirov, B. (1995a) Morphological variations in the Mediterranean sea fan *Eunicella cavolini* (Coelenterata: Gorgonacea) in relation to exposure, colony size and colony region. *Bulletin of Marine Science*, **56**, 283–295.
- Weinbauer, M.G. & Velimirov, B. (1996) Relative habitat suitability and stability of the Mediterranean gorgonian coral *Eunicella cavolini* (Coelenterata: Octocorallia). *Bulletin of Marine Science*, **58**, 786–791.
- Weinbauer, M. & Velimirov, B. (1995b) Biomass and secondary production of the temperate gorgonian coral *Eunicella cavolini* (Coelenterata: Octocorallia). *Marine Ecology Progress Series*, **121**, 211-216.
- Wilby, A. (2002) Ecosystem engineering: a trivialized concept? *Trends in Ecology and Evolution*, **17**, 307.
- Williams, G.A. (1994) The relationship between shade and molluscan grazing in structuring communities on a moderately-exposed tropical rocky shore. *Journal of Experimental Marine Biology and Ecology*, **178**, 79–95.
- Wright, J.P. & Jones, C.G. (2006) The concept of organisms as ecosystem engineers ten years on: progress, limitations, and challenges. *BioScience*, **56**, 203–209.
- Wright, J., Jones, C. & Flecker, A. (2002) An ecosystem engineer, the beaver, increases species richness at the landscape scale. *Oecologia*, **132**, 96-101.
- Zeevi Ben-Yosef, D. & Benayahu, Y. (1999) The gorgonian coral *Acabaria biserialis* : life history of a successful colonizer of artificial substrata. *Marine Biology*, **135**, 473-481.