CHAPTER 6

Interactions: algae, sponges, urchins

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A complex network of direct and indirect interactions shapes the dynamics of benthic communities. We investigated whether an exceptional storm in December 2008 disrupted the interactions between grazers (sea urchins), seaweeds and bioeroding sponges in a model sublittoral community that had been previously studied. This community was characterized by a negative correlation between grazers and canopy-forming seaweeds, as well as a positive indirect relationship between grazers and sponges. In 2009, the most obvious changes in this community were the extreme reduction in sea urchin and other macrofauna abundances, a massive deforestation of erect algae, substituted by low coralline turfs, and a loss of significant correlations between the three main components.

Image: Mediterranean photophilic community, Costa Brava, by Miguel A. Mateo

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Possible impact of Sant Esteve's storm on the interactions between sponges, sea urchins and erect algae in a subtidal community of the Costa Brava

By

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Resumen

Una compleja trama de interacciones directas e indirectas determina la dinámica de las comunidades bentónicas. En este trabajo investigamos la posible alteración por un temporal extremo de las interacciones entre herbívoros (erizos), algas erectas y esponjas bioerosionadoras en una comunidad modelo estudiada previamente. Dicha comunidad se caracterizaba por una correlación negativa entre herbívoros y algas erectas, así como una interacción indirecta positiva entre herbívoros y esponjas. En 2009 los cambios más conspicuos en esta comunidad fueron la reducción extrema de la abundancia de erizos y otra macrofauna, así como una deforestación masiva de algas erectas, sustituidas por coralináceas de escaso porte, y la pérdida de las correlaciones significativas entre los tres componentes principales de la comunidad.

Abstract

A complex network of direct and indirect interactions shapes the dynamics of benthic communities. We investigated whether an exceptional storm in December, 2008, disrupted the interactions between grazers (sea urchins), seaweeds and bioeroding sponges in a model sublittoral community that had been previously studied. This community was characterized by a negative correlation between grazers and canopy-forming seaweeds, as well as a positive indirect relationship between grazers and sponges. In 2009, the most obvious changes in this community were the extreme reduction in sea urchin and other macrofauna abundances, a massive deforestation of erect algae, substituted by low coralline turfs, and a loss of significant correlations between the three main components.

Introduction

It is widely known that direct and indirect interactions between grazers and seaweeds strongly influence the succession and dynamics of algal communities (e.g. Sala et al., 1998; Hughes et al., 2007; Mantyka & Bellwood, 2007). However, few studies address the cryptic, indirect interactions that are a by-product of direct interactions, and which can have unexpected, cascading impacts on benthic assemblages (Estes & Duggins, 1995). Most documented instances of cascading effects in the Mediterranean benthos refer to food web interactions (e.g. Sala et al., 1998), although other kinds of interactions concerning basic processes are also important.

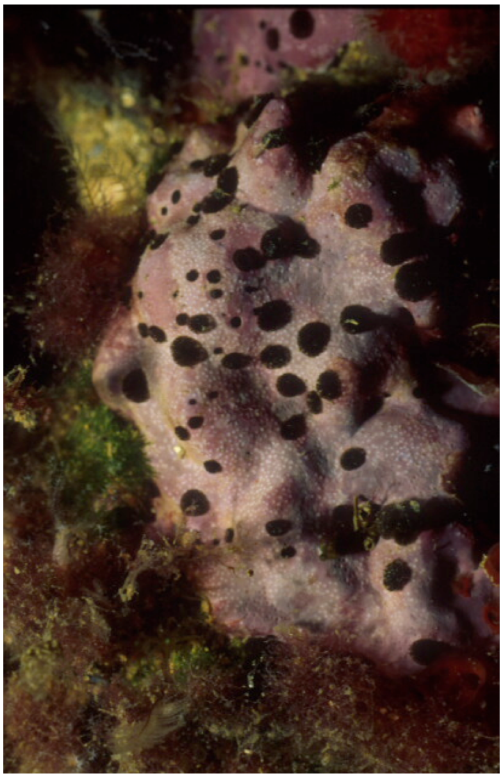


Figure 1. The sponge *Cliona viridis* excavating *Lithophylum incrustans* (image by Enrique Ballesteros).

In this line, we focused on the direct and indirect interactions among algal assemblages, grazers and bioeroding sponges (Cebrian and Uriz, 2006; Cebrian, 2010) in photophilic habitats. It has been found that grazing on macroalgal communities enhances the growth of bioeroding sponges (which have photosymbionts) because grazing on the seaweed canopy increases light availability at the substratum level. Therefore, grazing has a cryptic but consistent effect on substrate bioerosion.

In the present study we explored how an unusual event can alter generalised processes that take place in rocky photophilic habitats (Cebrian and Uriz, 2006; Cebrian, 2010). In particular, we focused on the relationships documented between sea urchins, erect algae, and excavating sponges in a NW Mediterranean shallow water assemblage (Cebrian and Uriz, 2006), which seemed altered after the storm event that occurred on 26 December 2008. Therefore, we re-analysed the same system in which the described interactions were assessed to explore the impact of the storm event on this assemblage.

Our hypothesis was that the known direct and indirect relationships established between grazers, erect algae and zooxanthellae-bearing excavating sponges would have broken down and no more significant abundance trends would occur, as at least two of the components of the system (sea urchins and canopy-forming algae) would have been drastically reduced by the storm. In order to test this hypothesis, a study similar to that performed in 2002 (Cebrian and Uriz, 2006) was conducted in 2009 in the same site and season.

Materials and Methods

Study site and community description

The study was conducted in October, 2009 in a shallow rocky bottom of the sublittoral community of Cala Sant Francesc, Blanes (NE Spain) (41°40.4'N, 2°48.2'E).

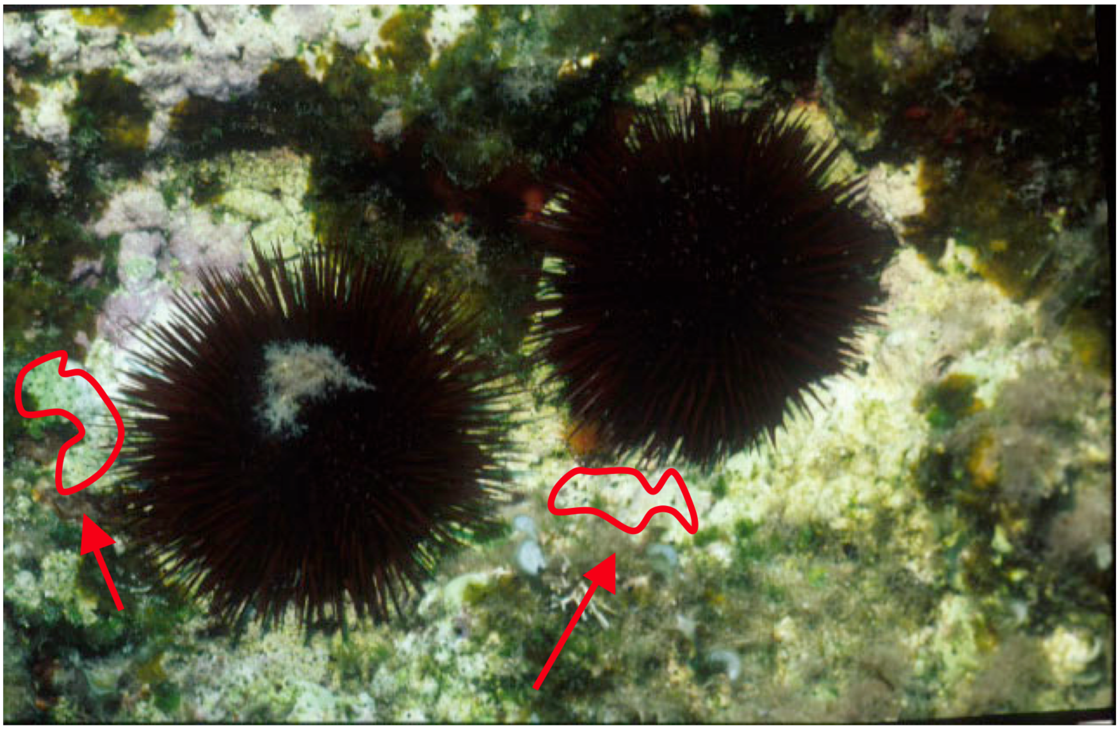


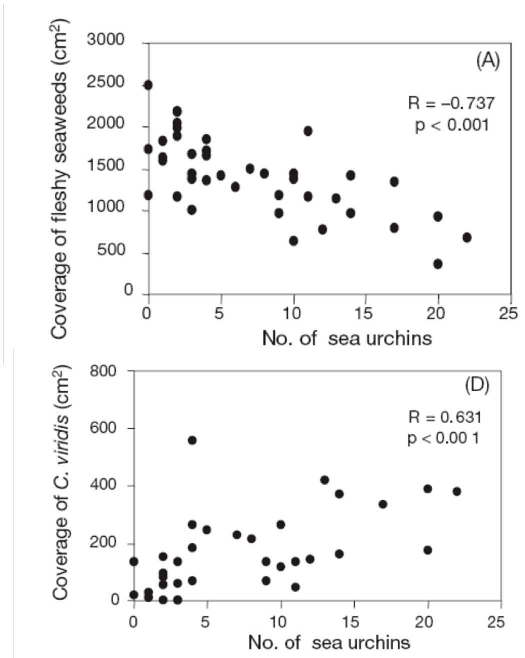
Figure 2. The sea urchin *Paracentrotus lividus* grazing on a photophilic community and uncovering *Cliona viridis* papillae (image by Enrique Ballesteros).

The assemblage studied was established in a photophilic seaweed biocoenosis (between 4 and 6 m depth) with algae distributed in two strata: an encrusting stratum dominated by the encrusting calcareous algae *Lithophyllum incrustans* (1); and an upper stratum consisting of erect algae such as Phaeophyceae *(Halopteris scoparia, Padina pavonica* and *Dictyota dichotoma)* and Corallinaceae (*Corallina granifera)*. In the present study, we regarded all non-encrusting seaweed species as a single entity because they all appeared to exert a similar shading effect on the basal stratum, and they have all been reported to be consumed with a similar preference by sea urchins (Verlaque 1987). Filter feeders such as the excavating sponges *Cliona viridis* and *Pione vastifica* were also present and even abundant in the study zone. *Cliona viridis* is the most common excavating sponge in the western Mediterranean (Rosell and Uriz, 1992). It is the only sponge in the study area that harbours symbiotic zooxanthellae, and the sponge-dinoflagellate symbiosis has been reported to be functional (Rosell and Uriz, 1992). *Pione vastifica* is a reddish-to-orange excavating sponge without symbiotic zooxanthellae (Rosell and Uriz, 2002). Other sessile macroinvertebrates were much less abundant. *Paracentrotus lividus* (Lamarck, 1816) was the most abundant echinoderm (Fig. 2), but scattered individuals of *Arbacia lixula* (Linnaeus, 1758) were also observed.

Methods

The sampling method used in 2009 was the same as that used in the previous study of 2002. A set of 30 quadrats of 50 x 50cm subdivided into 10 x10 cm were placed haphazardly on the photophilic biocoenosis where the studies on abundance correlations among algae, sponges and sea urchins were conducted in 2002. Algal and sponge coverage, and the number of sea urchins (mainly *Paracentrotus lividus* plus some individuals of *Arbacia lixula*) were measured in each quadrat.

The coverage of erect algae was measured by means of the 25 subquadrats of 10 x 10 cm (Cebrian et al., 2000). We recorded the number of subquadrats in which algae were present and the per cent of the quadrat occupied by the algae. We then removed the erect algae to reveal the excavating sponges. We quantified the area covered by the sponges by tracing the outline of their shape onto a plastic sheet. The sheets were later digitized and the areas measured. All results (sea urchin abundance and algal and sponge cover) are presented per square metre.



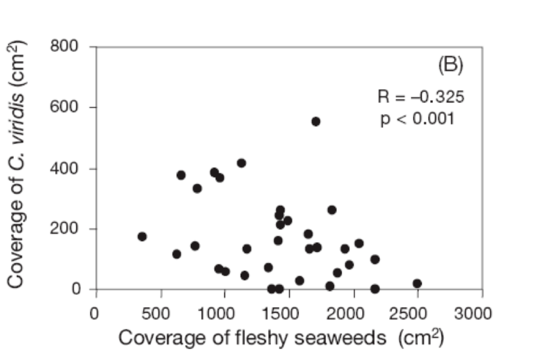


Figure 3. Correlations between pairs of variables analysed.

Data treatment

Relationships between the coverage of algae, *Cliona viridis* and *Pione vastifica*, and the number of sea urchins were assessed with correlation analyses. Multiple regression analysis was not used because of the clear multi-colinearity of some independent variables such as the number of sea urchins and coverage of erect algae (Berry & Feldman, 1985).

Results and discussion

In the study of 2002, several significant correlations among species (or groups of species) were found (Cebrian & Uriz, 2006). The erect algal coverage was negatively correlated with sea urchin abundance (Figure 3A), while abundance of the sponge *Cliona viridis* was positively correlated with the number of sea urchins and negatively correlated with algal cover (Figures 3B, 3C). These correlations indicate that sea urchins have a clear destructive effect on the canopy-forming algal stratum (as corroborated by an experimental study; Cebrian & Uriz, 2006) but also facilitate the growth of perforating sponges that depend on the photosymbiotic dinoflagellates. Therefore, in 2002 there was clear evidence of a 'cascading effect', with both positive (facilitation) and negative interactions.

In 2009, after the storm, the study area changed dramatically. Even the landscape was totally different due to a change in the distribution of sand bodies. At the community level the most obvious features were: an extreme reduction in the abundance of sea urchins (*Paracentrotus lividus*) and a massive deforestation of erect algae (mostly *Halopteris scoparia*, whose thalli were beginning to sprout), with a proliferation of low erect algae (*Corallina granifera*), whose coverage values approached 100% in some quadrats. The erosion produced by

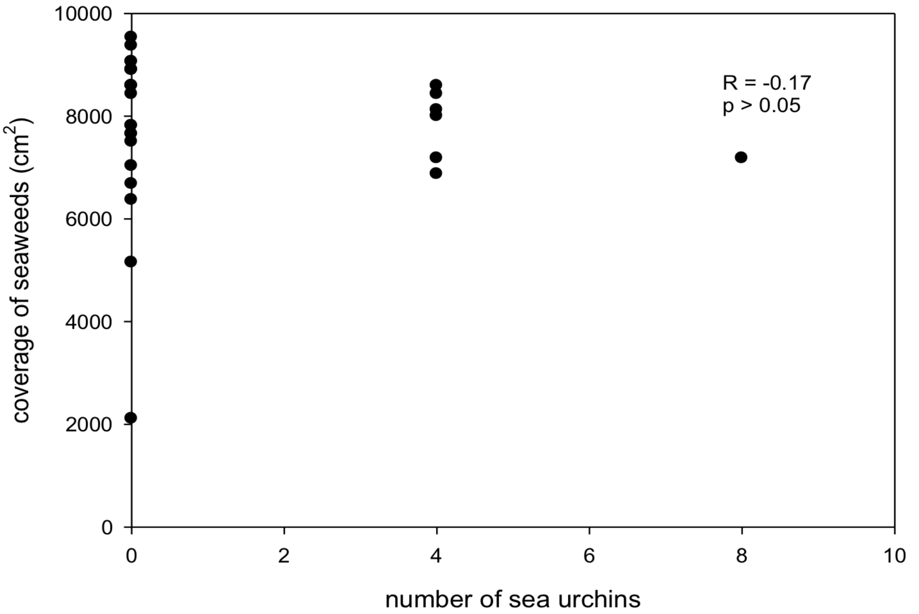


Figure 4. Graphic representation of the relationship between erect algal cover and number of sea urchins in 2009 resulting from the correlation analysis.

sand due to wave action seemed to have eliminated most of the macrofauna. None of the previous correlations was found to be significant after the storm (Figure 4-6).

Conclusions

The effects of the storm of 26 December on the photophilic community of Cala St. Francesc (Blanes) have purportedly altered the interactions that shaped this assemblage. The effects found are not limited to mere changes in the relative abundances of some species, the landscape has also changed and the correlations previously observed between important components of the community (grazers, seaweeds, sponges) no longer hold. Assessing the time necessary for these species to recover their abundances and interactions would provide useful information about the vulnerability and dynamics of this representative sublittoral community.

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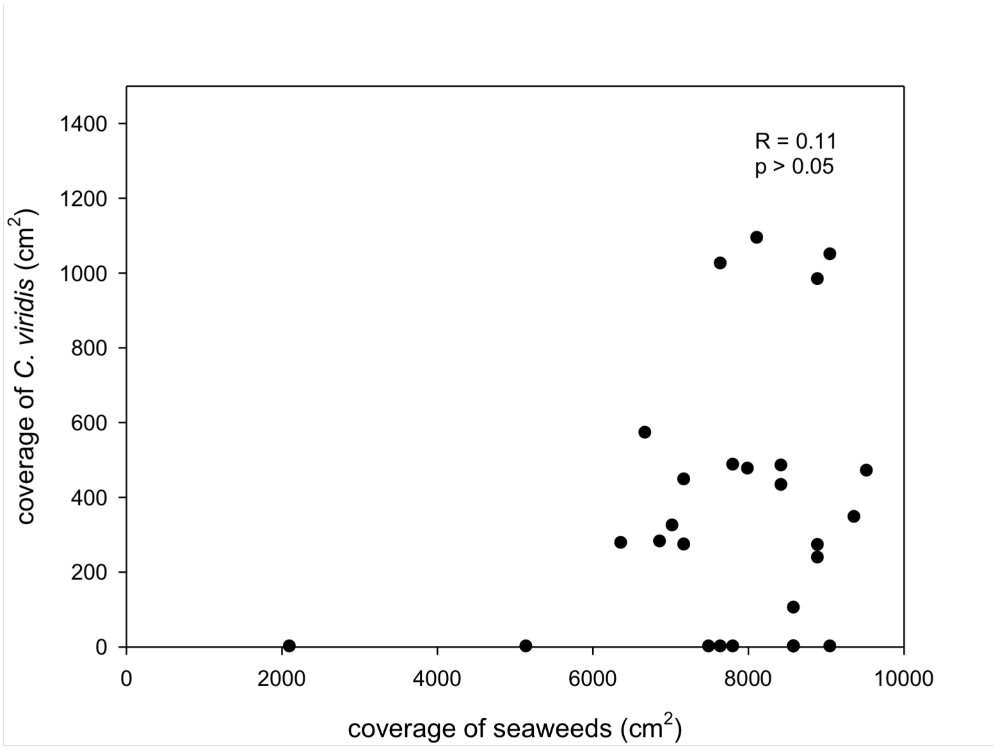

Figure 5. Graphic representation of the relationship between cover of the drilling sponge *C. viridis* and erect algal cover in 2009.

"Assessment of the ecological impact of the extreme storm of Sant Esteve (26 December 2008) on the littoral ecosystems of the north Mediterranean Spanish coasts" (PIEC 200430E599).

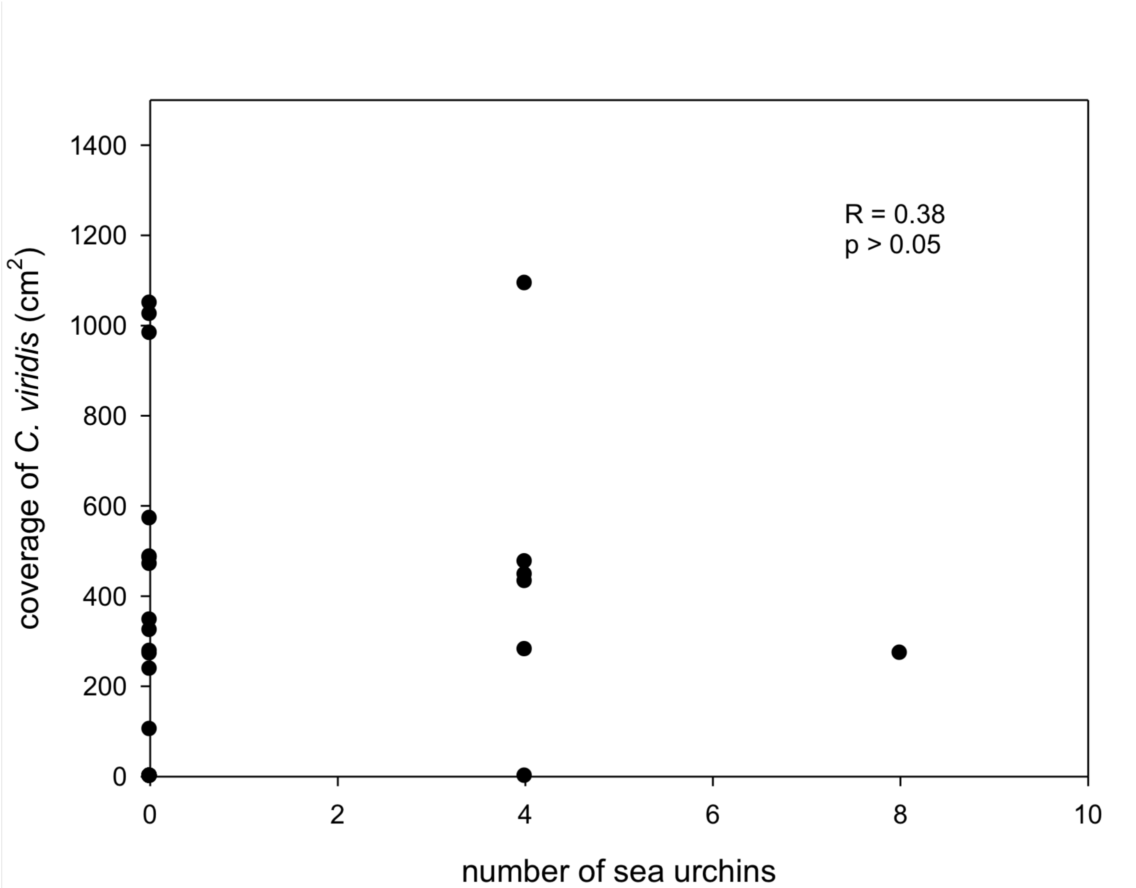

Figure 6. Graphic representation of the relationship between cover of the drilling sponge *C. viridis* and the number of sea urchins in 2009.

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