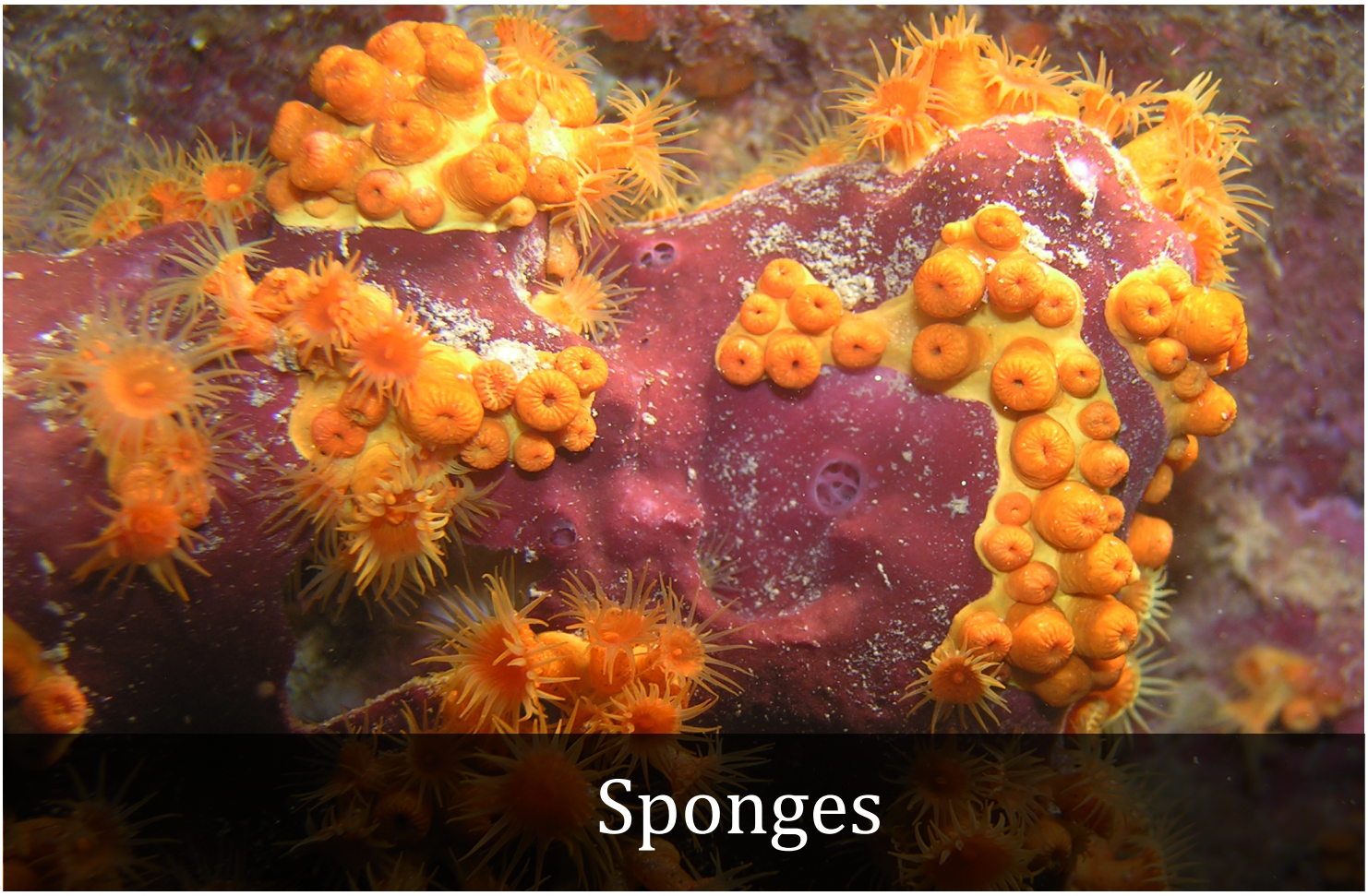

Sponges

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Abstract

A total of 121 individuals belonging to five common Mediterranean infralittoral sponge species (*Petrosia ficiformis, Raspaciona aculeata, Chondrosia reniformis, Aplysina aerophoba, Axinella damicornis*) were tagged in three different zones along the Costa Brava in years previous to the storm. The overall mortality of the tagged sponges was quite low (6.6%) after the storm. Moreover, it is suspected that part of the low mortality oberved, could be explained by the so-called red band disease. This was the case of *A. aerophoba* that presented a 20% mortality. Even in the case of *P. ficiformis*, with a rigid protruding body, the mortality was low. Collectively, the results suggest that most of the monitored sponges have evolved effective anchoring mechanisms and shapes to withstand the forces generated during heavy, periodic, and even extreme storms.

Image: *Petrosia ficiformis* with the epibiont *Parazoanthus axinellae*, by M. Maldonado

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Sponge mortality caused by the Sant Esteve's 2008 sea storm

By

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Resumen

Se marcaron un total de 121 individuos pertenecientes a 5 especies de esponjas comunes en el infralitoral mediterráneo (*Petrosia ficiformis, Raspaciona aculeata, Chondrosia reniformis, Aplysina aerophoba, Axinella damicornis*) en 3 zonas diferentes a lo largo de la Costa Brava. La mortalidad global tras la tormenta fue baja (6.6%). Por añadidura, se sospecha que parte de la mortalidad pueda atribuirse a la enfermedad de la banda roja (*red band disease*). Este es el caso de *A. aerophoba* que presentó un 20% de mortalidad. Incluso en el caso de *P. ficiformis*, de cuerpo rígido y protuberante, la mortalidad fue baja. En su conjunto, los resultados sugieren que la mayoría de esponjas estudiadas han desarrollado mecanismos de anclaje y formas efectivas para afrontar con éxito las fuerzas generadas durante tormentas intensas, periódicas e incluso extremas.

Abstract

A total of 121 individuals belonging to five common Mediterranean infralittoral sponge species (*Petrosia ficiformis, Raspaciona aculeata, Chondrosia reniformis, Aplysina aerophoba, Axinella damicornis*) were tagged in three different zones along the Costa Brava in years previous to the storm. The overall mortality of the tagged sponges was quite low (6.6%) after the storm. Moreover, it is suspected that part of the low mortality oberved, could be explained by the so-called red band disease. This was the case of *A. aerophoba* that presented a 20% mortality. Even in the case of *P. ficiformis*, with a rigid protruding body, the mortality was low. Collectively, the results suggest that most of the monitored sponges have evolved effective anchoring mechanisms and shapes to withstand the forces generated during heavy, periodic, and even extreme storms.

Introduction

Sponges play an important ecological role in sublittoral Mediterranean ecosystems, particularly in rocky-bottom communities. These organisms are key space occupiers. They are highly competitive and add complexity to marine habitats (Vacelet et al., 1979; Pansini & Pronzato, 1990; Uriz et al., 1991; Becerro et al., 1994). They are also significant consumers of bacterioplankton and mediate part of the benthic-pelagic coupling of crucial dissolved nutrients and organic matter (Vacelet et al., 1979; De Goeij et al., 2006; Jiménez & Ribes, 2007;

Maldonado et al., 2010a). In most cases, sponges are slow-growing, long-lived organisms, with estimated life spans ranging from decades to centuries (McMurray et al., 2008; Fallon et al., 2010). For all these reasons, the general view is that any serious natural or anthropogenic disruption of sponge communities could initiate a cascade of ecological changes in the sublittoral systems.

Epidemic diseases are dramatically damaging sublittoral sponge populations of different species all around the world, including in the Mediterranean (Perez et al., 2000; Webster, 2007; Maldonado et al., 2010b). Nevertheless, very little is known about the impact of other factors of natural mortality, such as sea storms. The Sant Esteve storm in 2008 provided a unique opportunity for assessing the impact of this potential mortality factor on some of the most common Mediterranean sublittoral species.

Materials and Methods

Studied sponge species

With the aim of studying reproductive processes in sponges, up to 121 individuals belonging to five common Mediterranean infralittoral sponge species (*Petrosia ficiformis, Raspaciona aculeata, Chondrosia reniformis, Aplysina aerophoba, Axinella damicornis*) had been tagged in three different zones along the Costa Brava in previous years. The tagged specimens, which had been monitored previously for either months or years (in some cases) without recording any mortality, were revisited in January 2009 right after the storm.

Study sites

The sampling points were located at:

1) Santa Ana Point (Blanes): site at 10 to 15 m depth, with sponges growing on vertical and overhanging rocky walls that underwent heavy abrasion during the storm, mostly due to the impact of sand and gravel suspended in the waves. Two of the three small canyons studied at this site lost a lot of sand, so that the the bottom line at the base of the rocky walls was lowered by 0.5m to 1m.
2) Moro rock (Tossa): site at 15 to 20m depth, with sponges growing on the rocky walls of a 3 to 5 m wide canyon that also underwent severe abrasion from sand and gravel suspended in the waves during the storm. The bottom level of the canyon walls was lowered by 20 to 40cm as a result of the storm.
3) Portlligat Bay (Cadaqués): site at 4 to 7m depth, with sponges growing on the horizontal surfaces of large boulders surrounded by a sandy bottom with a dense *Posidonia oceanica* meadow. There were no appreciable changes in the soft bottom surrounding the boulders, probably because the

Posidonia meadow contributed to making the wave action smoother and because the bay is relatively sheltered from the storm surge (east sea and wind).

Results and discussion

The overall mortality of the tagged sponges was quite low (6.6%) after the storm (Table 1). In Punta Santa Ana, where there were 71 tagged specimens belonging to three different species (*Petrosia ficiformis*, *Raspaciona aculeata* and *Chondrosia reniformis*), only one individual had disappeared after the storm. In Tossa de Mar no more than two specimens (8%) out of 25 *Axinella damicornis* had vanished due to storm action, and in Portlligat Bay, just 5 specimens (20%) of *Aplysina aerophoba* were killed out of the 25 that had been tagged before the storm. The losses of individuals between the pre-storm and post-storm monitoring dates are assumed to be a direct consequence of the storm, as these individuals had been monitored for months or even years prior to the storm and there had been virtually no mortality.

The recorded mortality data suggest that this severe storm, despite being the largest storm in the last 75 years, had a low impact on the studied sponge populations. It is worth noting the low mortality rate detected among the large specimens of *Petrosia ficiformis,* whose rigid (i.e., breakable) massive and expansive body markedly protrudes from the rock walls, and is attached to the substrate by only one or a few points, but rarely by the entire basal surface. At first sight, it would be expected that this characteristic would favour detachment and/or breakage and we expected a large number of individuals of this species to be wiped out, especially in the narrow canyons of Punta Santa Ana (Blanes), where many rocks fell from the walls and enormous amounts of gravel and coarse sand were dislodged from the bottom, evidencing that the wave action was particularly severe at this site. It is also worth noting that the

Table 1. Number of tagged individuals of each species monitored at different dates before and after the storm, which served to estimate the impact of mortality (%) by the storm in the various sponge populations.

Species	Pre-storm monitoring date	Post-storm monitoring date	No. of tagged sponges	No. of dead sponges	Mortality (%)
Petrosia ficiformis	Sep-07	Jan-08	28	1	3.6
Raspaciona aculeata	Nov-07	Jan-08	18	0	0.0
Chondrosia reniformis	Apr-07	Jan-08	25	0	0.0
Axinella damicornis	Mar-07	Feb-08	25	2	8.0
Aplysina aerophoba	Jun-07	Apr-08	25	5	20.0
TOTAL			121	8	6.6

only specimen of *P. ficiformis* missing after the storm was observed at the time of tagging to be affected by an infectious process, which probably facilitated it becoming detached. The other two species that were tagged at Punta Santa Ana (*Raspaciona aculeata* and *Chondrilla nucula*) are thickly encrusting and more leathery in consistency, and thus less likely to be torn off the rock than massive, expansive, rigid sponges. Nevertheless, it was surprising that no *R. aculeata* individuals were lost or even partially damaged, as this sponge grows mainly on horizontal substrates that are highly susceptible to both burial by sediment loads and abrasion by re-suspended sand and gravel. Individuals of *Axinella damicornis* suffered 8% mortality; however, we expected higher mortality because it is an erect, branching species that attaches to rock walls with only one or a few narrow stems.

Collectively, the results suggest that most of the monitored sponges have evolved effective anchoring mechanisms to withstand the forces generated during heavy, periodic storms. The attaching systems are probably the result of a long evolutionary process of adaptation, since these species have evolved in the Mediterranean sublittoral over several millions of years and have faced many diverse marine conditions involving multiscale geological cycles.

The highest mortality was paradoxically observed within a population of *Aplysina aerophoba* established in a very shallow (5-6m deep) but wave-protected bay. Nevertheless, unlike in the other monitored sponge species, there are two factors that suggest that caution should be taken before concluding that all losses recorded in the *A. aerophoba* population are due to the effects of the storm: 1) Some individuals of the population studied showed clear symptoms of being affected by the so-called red band disease, which usually ends up killing the infected sponge (Olson et al., 2006); 2) The *A. aerophoba* population was monitored long before the storm in August 2008 and it was only revisited several months after the storm, in April 2009. Consequently, it is possible that at least some specimens could have become infected by red band disease during the eight months between the two sampling dates.

Acknowledgements

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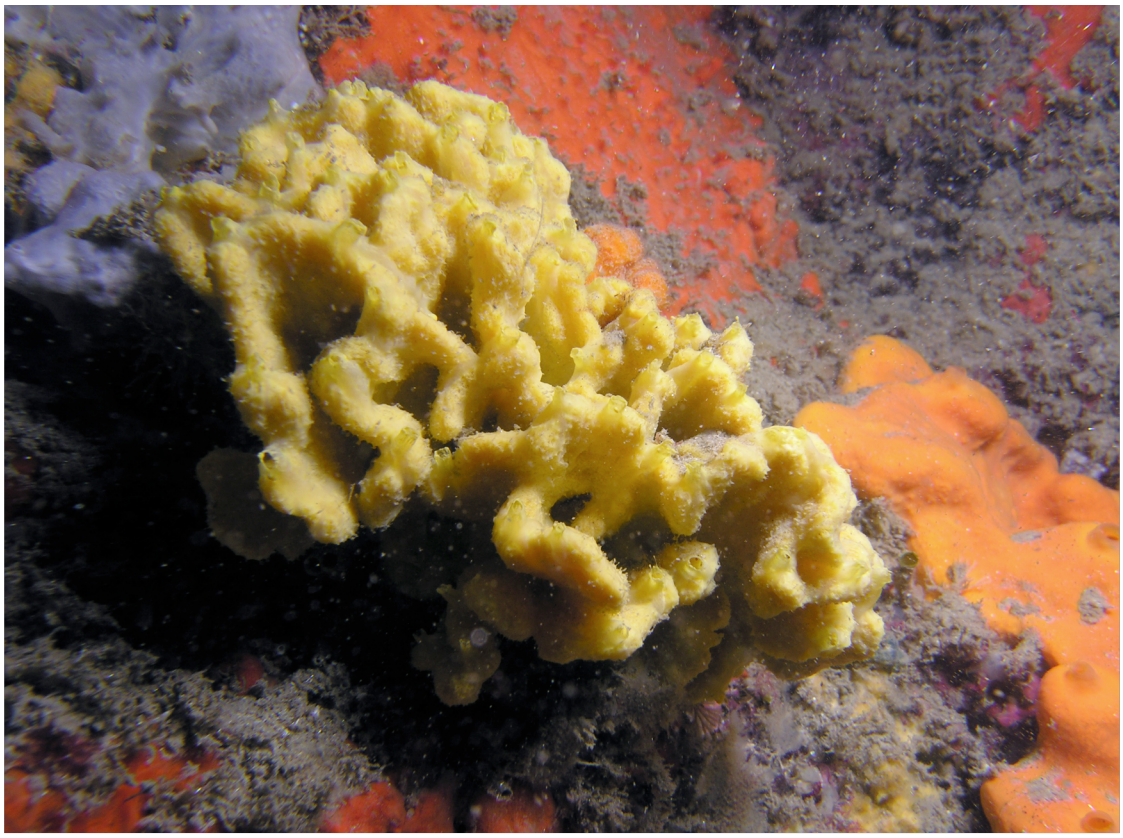

Axinella damicornis among a colourfull sponge community, by M. Maldonado