Multiscale variability of amphipod assemblages in *Posidonia oceanica* meadows: a comparison between different protection levels

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Context

Very few studies have examined the potential effects of protection on small macrozoobenthos in the Mediterranean Sea. Assessing the responses of marine populations to the establishment of marine protected areas depends on the researcher's ability to separate the effects of management from other sources of variation. Thus, it is essential to quantify and understand the magnitude and range of the natural variability of populations at different scales of observation, especially in seagrass meadows, which are heterogeneous environments.

Posidonia oceanica meadows form a unique three-dimensional spatially complex habitat that provides a wide variety of microhabitats to benthic communities. Amphipod crustaceans account for more than 80 species in this ecosystem and are an important group within the vagile fauna from different perspectives (Fig. 1).

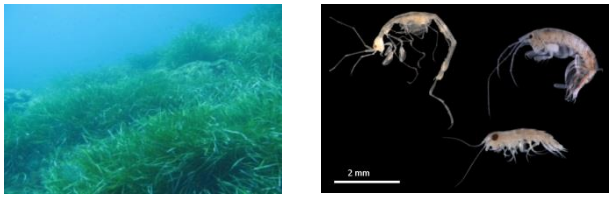

Fig 1. Amphipod species (right) associated to *Posidonia oceanica* meadows (left).
(Photos: Sturaro N)

They are one of the most useful groups of crustaceans used for monitoring environmental impact in *P. oceanica* meadows. From an ecological point of view, they are an important potential trophic resource for fish, which involves an essential role within the communities in terms of energy transfer from lower to higher trophic levels within the food web.

Objectives

The general purpose of this research was to assess and better understand the potential responses of amphipod assemblages in *P. oceanica* meadows between different protection levels both inside and outside a marine protected area (MPA).
Specific objectives include: (1) examining the variability patterns of amphipod assemblages over spatial scales spanning five orders of magnitude (1 metre to hundreds of kilometres) and the consistency of observations over two consecutive years; (2) identifying one or more relevant scales that contributed most to spatial variation, thus providing clues to the processes that are important for these assemblages; (3) exploring the relationships between amphipod faunal variables and habitat features as a factor likely to account for a significant part of the variability; and (4) evaluating the effect of fish predation on amphipod assemblages.

Study areas

All studies were conducted in two different areas of the Western Mediterranean Sea: the Tavolara-Punta Coda Cavallo Marine Protected Area (TMPA, Sardinia, Italy) and Revellata Bay (Corsica, France). The TMPA includes 3 protection zones: zone A (fully protected areas), zone B (partially protected areas) and zone C (also partially protected areas). The Revellata Bay is little polluted and is part of the European Natura 2000 network, which provides a comparative reference to the TMPA at the regional scale, and gives a valuable basis for the monitoring of *P. oceanica* amphipods.

General methods

Two general approaches were used. First, the multiscale variability patterns of amphipod assemblages were investigated at Revellata Bay and the TMPA. Particular attention was paid to the habitat-amphipod relationship. Second, the effect of fish predation on amphipod assemblages was evaluated using experimental manipulations of predation intensity.

In the sampling, we applied a spatially hierarchical design, both at the TMPA and Revellata Bay. All amphipod samples were collected at constant depth (10-15m) by scuba diving, using an air-lift and associated cylinder (Fig. 2), as well as light traps.

Fig 2. Set up of the cylinder enclosing *Posidonia oceanica* leaves (left), and airlift sampling (right). (Photos: Trainito E.)

Outcomes published in *Michel et al. 2010*

Multiscale variability of amphipod assemblages

Research on spatial patterns is fundamental for understanding the causes of the distribution-abundance of species. It provides also a valuable basis for management and conservation. Although amphipods are key organisms in seagrass ecosystems, little attention was given to the spatial scales at which amphipod assemblages may vary.

In this study, the variability patterns of amphipod assemblages inhabiting *P. oceanica* meadows were examined over spatial scales spanning four orders of magnitude (1 to 1000 metres) for two consecutive years. This research reports the scales that contributed most to the spatial variation of amphipod assemblages and explores the processes that may drive the observed patterns, with a particular emphasis on habitat features.

Amphipod assemblages were typified by high density and number of species. A total of 3337 amphipod specimens belonging to 36 taxa and 22 families were identified. Our research revealed that the natural variability in amphipods was great at both large and small scales. At a large scale (>100 km), the structure of amphipod assemblages varied between meadows and may be related to hydrodynamic forces. At small scales (from ~1 m to ~10 m), this pattern was related to total amphipod density and/or the density of several species. The patchiness that occurred at small scales may have been related to habitat features, but only weakly. Instead, we postulate that amphipod behavioural processes are likely good explanatory factors. Variability in spatial patterns at scales smaller than those investigated (i.e. cm) has not yet been quantified in *P. oceanica* ecosystem and deserves further investigation.

Outcomes published in *Sturaro et al. 2014b*

The effect of protection on amphipod assemblages

MPA are a key tool for conservation, but few studies have assessed the responses of small macrozoobenthic assemblages to different protection levels in the Mediterranean Sea. In this study, we investigate whether the establishment of an MPA has an effect on amphipod assemblages associated with *P. oceanica* meadows.

We report the spatial and temporal variability patterns of amphipod assemblages in four different protection levels and discuss potential confounding effects, such as habitat features.

A total of 4512 amphipod specimens belonging to 51 species and 25 families were identified. The structure of amphipod assemblages was patchy at all spatial scales investigated, but differed markedly among protection levels (Fig; 3).

Multiscale analyses showed that several taxa exhibited lower densities and/or biomasses within fully protected and external areas, in comparison with partially protected areas (Fig. 4). Furthermore, the features of *P. oceanica* meadows (shoot density, leaf and epiphyte biomasses and litter biomass) accounted for a low proportion of the total variability. Consequently, we can infer that the observed patchiness is likely to occur for multiple and interconnected reasons, ranging from the ecological and behavioural traits of amphipod species to protection-dependent processes (e.g. fish predation).

Long-term multiscale spatial and temporal monitoring and experimental manipulations are needed to fully understand the effects of protection on macrozoobenthic assemblages.

Outcomes published in *Sturaro et al. 2014b*

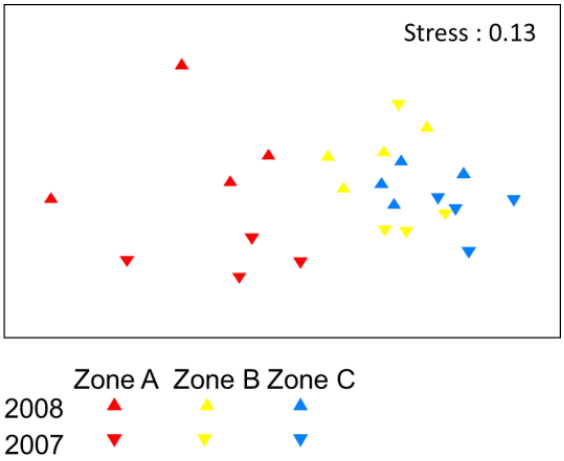

Fig. 3. Non-metric multidimensional scaling (NMDS) ordination of amphipod assemblages in the TMPA. Plot triangles indicate sector centroids, coded by zone and year.

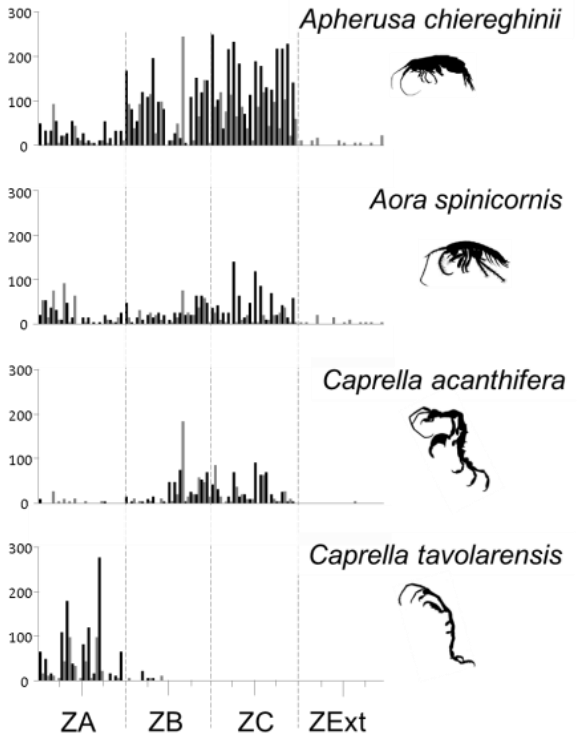

Fig. 4. Density values (individuals m^{-2}) of the amphipod species that contributed most to the dissimilarity among the different protection levels of the 4 zones at the TMPA in 2007 (black) and 2008 (grey). Bars show the values for each replicate sample.

A new species of *Caprella* from the Mediterranean Sea

During the course of this research, a new amphipod, *Caprella tavolarensis* was discovered and described. Specimens were collected from a *P. oceanica* seagrass meadow at the TMPA.

The species is close to *Caprella liparotensis*, but can be clearly distinguished by smaller size, body elongate and dorsally smooth, presence of a short rostrum, absence of fine setae on peduncle of antenna 1 and absence of swimming setae on antenna 2, mouthparts scarcely setose, absence of serrate carina on the basis of gnathopod 2 and pereopods (Fig. 5).

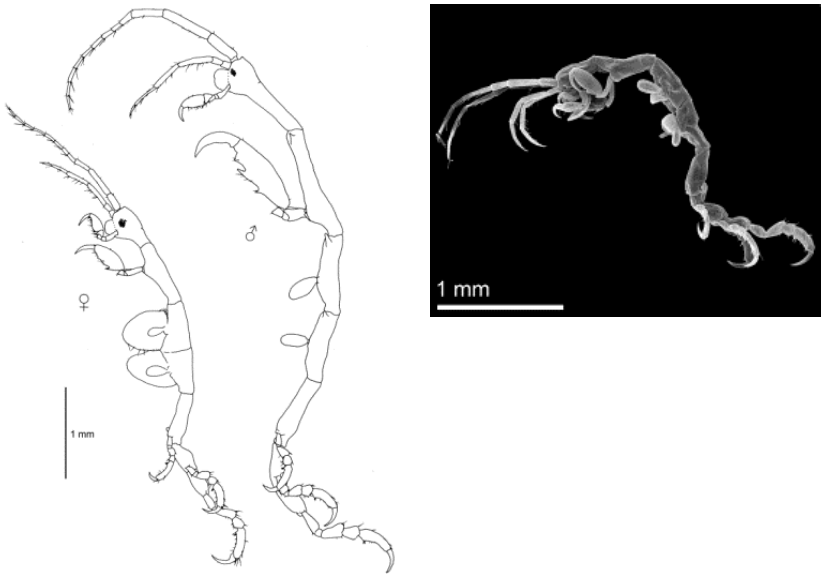

Fig. 5. SEM picture and lateral view of holotype male and paratype female of *Caprella tavolarensis* In the Mediterranean Sea, the number of caprellid species reported has increased from 23 (1993) to 41 (2010), consequently, further taxonomical studies should be addressed to properly estimate the total amphipod diversity in the Mediterranean Sea.

Outcomes published in *Sturaro et al. 2011*, and *Sturaro & Guerra-García 2012*

The role of fish predation on amphipod assemblages

Our previous study conducted at the TMPA revealed that several amphipod taxa associated with *P. oceanica* meadows showed lower densities and/or biomasses within the fully protected area compared to the partially protected areas. By means of experimental manipulations of predation intensity (exclusion and inclusion cages), we tested the hypothesis that the structure of amphipod assemblages may change in relation to predatory fish abundance at the TMPA.
In the absence of predatory fishes (exclusion cages), the total amphipod density increased (Fig. 6). At the species level, differences in density between treatments appeared for *Caprella acanthifera* and *Iphimedia minuta*, suggesting a response to predation.

One enclosed labrid fish predator (inclusion cages) reduced the density of *Aora spinicornis* and *Phtisica marina*, though the total amphipod density was unaltered. The more substantial decrease of larger individuals suggests that amphipods with larger bodies were preferentially consumed. In both caging experiments, the total biomass, diversity and amphipod assemblage structures were unaffected when compared to the control group.

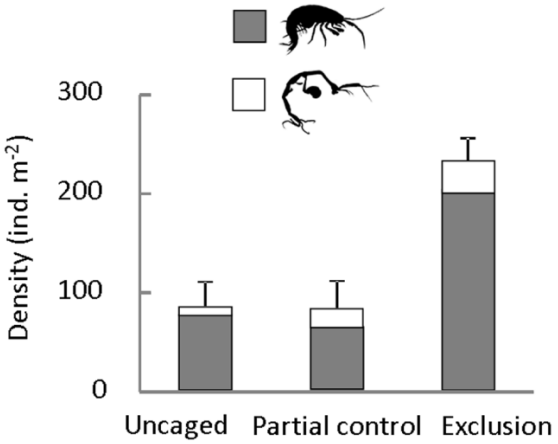

Fig. 6. Mean (± SE) density of total amphipods (Gammaridea in open bars + Caprellidea in solid bars) between uncaged areas, partial control cages and exclusion cages

The present study provides evidence that fish predation can be an important factor in the structuring of *P. oceanica* amphipod populations. Patterns observed at the species level suggest that complex interactions are likely related to the behaviour of amphipod and fish species.
Outcomes in revision in *Marine Biology*

General conclusions

Overall, this work suggests that full protection at the TMPA is likely to contribute partially (primarily via fish predation) to the observed variability patterns among zones. However, superimposed factors, including the behavioural traits of amphipod species and surrounding habitats, are likely also significant. Whether these changes are representative of all fully protected areas, and whether those effects are positive or negative to the meadows, is still unknown.

References

Michel L., G. Lepoint, P. Dauby, and N. Sturaro. 2010. Sampling methods for amphipods of *Posidonia oceanica* meadows: a comparative study. Crustaceana 83:39–47.

Sturaro N., S. Gobert, G. Lepoint, A. Pérez-Perera, and J.P. Guerra-García. 2011. Distribution patterns of *Caprella tavolarensis* (Crustacea: Amphipoda) in the Tavolara-Punta Coda Cavallo Marine Protected Area. Biologia Marina Mediterranea 18:290–291.

Sturaro N. and J.M. Guerra-García. 2012. A new species of *Caprella* (Crustacea: Amphipoda) from the Mediterranean Sea. Helgoland Marine Research 66:33–42.

Sturaro N., G. Lepoint, A. Pérez-Perera, S. Vermeulen, P. Panzalis, A. Navone, and S. Gobert. 2014a. Seagrass amphipod assemblages in a Mediterranean marine protected area: a multiscale approach. Marine Ecology Progress Series 506:175–192.

Sturaro N., G. Lepoint, S. Vermeulen, and S. Gobert. 2014b. Multiscale variability of amphipod assemblages in *P. oceanica* meadows. Journal of Sea Research DOI: 10.1016/j.seares.2014.04.011.

Sturaro N., S. Gobert, A. Pérez-Perera, S. Caut, P. Panzalis, A. Navone, and G. Lepoint. The role of fish predation on *Posidonia oceanica* amphipod assemblages. Marine Biology (in revision).