COMMUNITY COMPOSITION OF MACROINVERTEBRATES IN THE MEDITERRANEAN SEA

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Abstract
Artificial sampling units (ASUs) allow for standardized sampling in the marine environment. We deployed ASUs at three sites in the Bay of Marseille for 14 months to measure the diversity and community composition of macroinvertebrates within and among sites. Invertebrates were identified morphologically to the class level. At this resolution, variability within sites was high enough to obscure differences among sites in both taxonomic diversity and community composition. Future work will use metabarcoding techniques to study diversity at the species level, both in the Bay of Marseille and other sites in the Mediterranean and more regional European seas.

Keywords: Biodiversity, Mediterranean Sea, Monitoring

The subtidal environment is an area that is particularly difficult to access for ecological studies. The use of Artificial Sampling Units (ASUs) allows for standardization of the sampling of marine communities. To study community composition and diversity in the Mediterranean Sea, we deployed ASUs in the Bay of Marseille in coralligenous reef habitats. These reefs are important centers of biodiversity in the Mediterranean, but are usually located at greater than 5 m depth and are therefore difficult to sample [1]. Three replicate ASUs were deployed at each of 3 sites. The ASUs were made of four nylon pot scrubbers that were cable-tied together and fixed to the substrate [2]. They were left on the reefs for 14 months. After the ASUs were retrieved by divers, we removed all mobile macroinvertebrates and identified them morphologically to the class level. We then calculated Simpson's diversity index for each replicate, and compared taxonomic diversity among sites using an analysis of variance with Simpson's index as a response variable. We used an analysis of similarity (ANOSIM) and a nonmetric multidimensional scaling (NMDS) analysis to compare community composition across sites. At this level of taxonomic identification, Simpson's index was not different among sites ($F_{2,6} = 2.271$, $p = 0.184$; Figure 1).

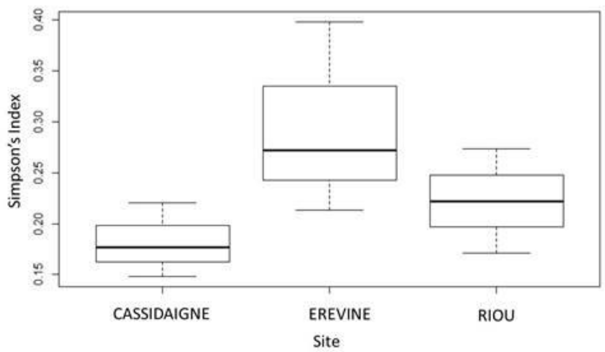

Fig. 1. Boxplots of Simpson's Index of diversity, calculated from three replicate ASUs at each of three sites. There were no significant differences among the sites.

Likewise, the ANOSIM revealed no differences in community composition among sites ($R = 0.1276$, $p = 0.266$). Figure 2 shows the NMDS plot of the data.

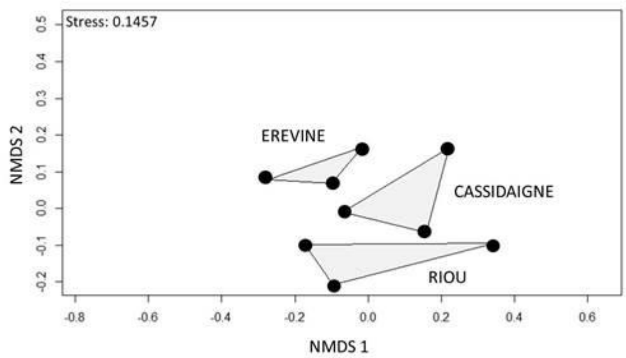

Fig. 2. Nonmetric multidimensional scaling plot of the community composition at three sites. An analysis of similarity showed no differences among the sites.

Although replicates within sites are generally clustered on the plot, the differences among sites are not significant. Future work is underway to use molecular metabarcoding techniques [3,4] to investigate community composition at the species level. We expect that there will be stronger differences among sites when data are collected at the species level. Given the large number of cryptic species found in marine environments [5], we may also uncover previously unknown cryptic diversity by using molecular methods rather than morphological ones. We will also expand this study to other sites in the Mediterranean and across different regional seas of Europe, to study diversity and composition on a larger spatial scale.

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AN IMPROVEMENT OF THE SEMI-EMPIRICAL METHOD OF ANALYSIS AND PROJECTION OF SEA LEVEL

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Abstract
A new variant of the semi-empirical method used to analyze and project sea level is developed. The variant allows for two response times, one of them being arbitrary and the other extending to infinity. Three parameters underlying the variant are determined from global temperature and sea level data extending over the 1880-2009 interval. The results show that the data provide useful information on fast processes but do not adequately document slow processes. Projections based on the semi-empirical method that allows for fast processes reveal the future behavior not only of sea levels but also of related trends.

Keywords: Sea level, Temperature, Mediterranean Sea

Global warming brings about expansion of the sea and melting of the land-based ice and therefore results in a rise of sea level [1]. With about 10% of the global population living in the coastal area at an altitude not surpassing 10 m, the rise is already very worrisome and is expected to be even more so in the future. In the analysis and projection of sea level, two dynamic methods are commonly used: the process-based one and the semi-empirical one. It is increasingly recognized that a combination of the two methods represents the best approach to the study of sea level [2], because it strengthens confidence in the results obtained with both methods.

In a previous study [3] we have compared three variants of the semi-empirical method, all of them characterized by a single response time but assuming that the response of sea level to temperature forcing is purely equilibrium, purely inertial, or some combination of the two. It turned out that a realistic response time is obtained only if both the equilibrium and inertial dynamics are taken into account. In the same paper another variant of the semi-empirical method, allowing for two response times and assuming that one of them equals zero whereas the other extends to infinity, has also been commented upon. It was found that application of this variant results in at least one parameter having numerical value that is not physically acceptable.

Here we introduce a new variant of the semi-empirical method, allowing for two response times with the fast-process one being arbitrary and the slow-process one extending to infinity. The variant is calibrated using global temperature data [4, with updates] and global sea level data [5] that extend over the 1880-2009 interval. The three parameters underlying the variant are obtained by a two-step procedure. First, the equilibrium and inertia coefficients controlling the fast response are determined by performing a two-to-one orthogonal regression analysis of the data. Second, the inertia coefficient constraining the slow response is calculated by assuming that the two coefficients characterizing the fast response are known and therefore applying a one-to-one orthogonal regression analysis on the data.

It turns out that the two coefficients related to fast processes are realistic: the equilibrium coefficient equals 3.3 °C/m whereas the inertia coefficient amounts to 143 °Cyr/m, which implies the response time of 43 yr. On the other hand, the inertia coefficient related to slow processes is found to equal –605 °Cyr/m, thus suggesting that these processes are not well documented by the available data sets. It is not clear whether the problem stems from the method used to extend coastal measurements to the open ocean, from the way the glacial isostatic adjustment is taken into account, or from the influence of terrestrial water storage on sea level. Whatever the reason, it is concluded that the semi-empirical method and the available data allow fast processes to be projected into the future, but leave us silent on slow processes.

Finally, we present in Fig. 1 observations and projections of temperatures and related trends as well as of sea levels and related trends. Temperature projections under the RCP4.5 scenario are taken from literature [1], whereas sea level projections are obtained by the semi-empirical method allowing for fast processes only. The results are interesting. In particular, they show that the global warming hiatus has manifested itself in the recent slowdown of temperature increase, and that it will result in a steady, non-accelerating sea level rise over the next decade or two if the RCP4.5 scenario is realized.

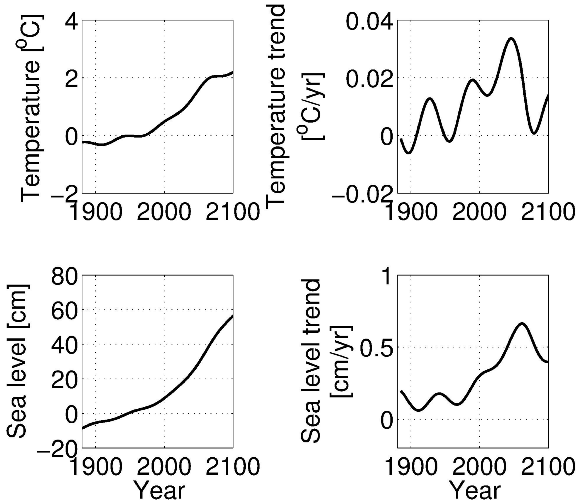

Fig. 1. Temperatures (up, left) and related trends (up, right), sea levels (down, left) and related trends (down, right). Time series represent observations prior to the year 2009 and projections under the RCP4.5 scenario after that year. Methodology used to construct the time series is explained in the text.

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