A PROPOSAL FOR MEASURING EFFECTIVENESS IN MARINE PROTECTED AREAS

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Abstract

A large literature deals with Marine Protected Areas and their potential as conservation and management tools. However, field investigations of subtidal marine reserves are generally confounded by intrinsic ecological differences between sites investigated inside and outside reserves, by a lack of site and reserve replication, or by the absence of information about the natural variability of the biota before reserve establishment. In the Mediterranean Sea, the effectiveness of MPAs has been rarely demonstrated. Since an MPA can be considered as a zone subjected to human impact, presumably a positive one, the use of experimental procedures generally utilised for detecting environmental impacts is discussed.

Key words: Marine Parks, Rocky shores, Experimental design, Monitoring, Mediterranean Sea

To date, about 40 MPAs have been established in the Mediterranean, and there is a general interest in establishing networks of MPAs (1, 2). This spatially explicit approach to managing human impacts has ecological and socio-economic potential, but there is still little quantitative understanding of the benefits it may provide. The limited knowledge of the effects of protection is mainly linked to 1- haphazard siting and design of MPAs based on opportunity more than biological criteria and 2- conflicting objectives (*e.g.* ecosystem conservation, fisheries enhancement, ecotourism). The difficulties of measuring reserve effectiveness should be overcome by the use of appropriate sampling designs, distinguishing between the influences of management and the intrinsic natural variability of ecological systems. Comparing protected with unprotected systems should provide a better understanding of ecosystem-wide effects of human activities in coastal marine environments, above and beyond the natural variation that likely exists among different systems. In the last years, few papers have been published in the Mediterranean on the spatio-temporal variability of marine assemblages (3, 4, 5). The results show a consistent variability at all the spatial and temporal scales for all the rocky assemblages considered, either the intertidal and subtidal benthos, and the littoral fish assemblages.

Considering the protection as a positive impact (6), BACI (Before and After Control Impact) sampling designs (7) can be used, comparing one or more protected areas with multiple control sites, before and after the MPA institution. In most cases, no data are available before MPAs establishment, and the original BACI design can be modified and the protected and unprotected areas compared after the institution of the MPA (ACI, After Control Impact - 8). It is worth considering adopting:
- hierarchical sampling designs, measuring spatial variability at various scales;
- proper sampling frequencies to detect variability at different temporal scales (9). The best solution is to randomly choose several sampling times (the same for all locations) for each season. This stresses that the observed trends are not due to short-term fluctuations;
- replicate controls, chosen randomly from a set of similar locations unaffected by protection (10, 11);
- long enough study durations to allow separation between short-term variability and long-term trends;
- the choice of the most appropriate analytical tools. Some environmental impact studies have benefited from a combination of univariate and multivariate approaches (11, 12), although the most appropriate variables for the analyses are largely determined by the specific predictions about reserve effects, which in turn are determined by reserve objectives. The use of different analyses allows detecting effects on different components of the assemblage (13). These two approaches can complement each other, although there may be differences in the optimal allocation of sampling units required by the different designs.

Besides this source of natural variability, Mediterranean MPAs vary widely in their general features. The only common feature is the siting in shallow rocky areas. Thus, shallow subtidal benthic assemblages on hard substrate can be the ideal target for studying and monitoring MPAs. Shallow marine assemblages (between 5 and 10 metres depth) can be considered as good indicators of environmental changes because species living at shallow depths are particularly exposed to impacts from coastal activities and thus tend to exhibit stronger responses to human pressure than assemblages from deeper marine environments. Moreover, sessile organisms can be easily monitored and manipulated. Photographic methods are objective and can be analysed by many researchers (also by non-specialists).

At present, the lack of detailed and scientifically defensible knowledge regarding the effects of reserves makes the measure of their effectiveness very difficult, and predictions about the expected effects uncertain. Mediterranean MPAs greatly vary in their physical and biological characteristics as well as in the socio-economic context influencing their design and management, making it unlikely that a single study design will be applicable to all scenarios. However, it is possible to identify the logical structure that should guide the design and interpretation of monitoring studies:
- reserve goals have to be explicitly defined to develop specific predictions about the expected effects;
- sampling should quantify variation in populations and assemblages and tease apart natural variability from that caused by protection. To this end, studies should include multiple control locations, describe long-term trends, and include descriptions of the system before reserve establishment. Studying hard bottom benthic assemblages in MPAs and adjacent unprotected areas with similar characteristics may represent a rapid, cost-effective, and widely applicable mean of evaluating protection effects. This is a unique opportunity to investigate natural variability in marine ecosystems over broad spatial scales, potentially encompassing the whole Mediterranean basin if monitoring networks are established.

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