MARINE PROTECTED AREAS EFFECTIVELY MAINTAIN ENDEMIC *PINNA NOBILIS* POPULATIONS

Salud Deudero [1]* and Maite Vázquez-Luis [1]
[1] Instituto Español de Oceanografía (IEO) Centro Oceanográfico de Baleares - salud.deudero@ba.ieo.es

Abstract
Coastal habitat degradation compromise sessile marine species. Populations of the endemic species, fan shell bivalve *Pinna nobilis* are declining in spite of species protection. Models analyzed environmental versus human-derived stressors as explanatory variables depicting populations at mesoscale level. Human stressors explained most variability in density spatial distribution significantly disturbing benthic communities, while habitat protection affected *P. nobilis* structure and physical aggression by anchoring highly impact on densities. Environmental variables played a secondary role, indicating that global change processes are not so relevant in coastal benthic communities as human-derived impacts.

Keywords: Mediterranean Sea, Conservation, Endemism, Stressors, Marine reserves

Coastal degradation, habitat fragmentation and habitat losses are undermining marine biodiversity and especially sessile marine species. The largest bivalve in the Mediterranean basin – the fan shell *Pinna nobilis* - is an endemic, vulnerable species and in spite of species legal protection, populations are declining. Climate change, invasive species, contaminants, food web alterations, habitat loss and anchoring and have been claimed to the main treats affecting *Pinna nobilis* populations [1].

In this study we analysed the contribution of several explanatory variables that depict *Pinna nobilis* populations at mesoscale level. We have applied multivariate models (DistLM distance-based linear model routine marginal test) to assess the relationships between environmental variables (mean depth, Hs mean, Hs maximum, mean Tp and mean direction) and human-derived stressors (anchoring, protection status, sewage effluents, fishing activity and diving) in the Balearic Islands, W Med. Human stressors that disturb the benthic communities mainly determine the density spatial distribution of fan shell (Table 1). Habitat protection affected *P. nobilis* structure and physical aggression by anchoring reveals a high impact on its densities. Environmental variables contributed less to the variability in densities, but did influence the size structure. Human derived impacts in the coastal zones must be properly addressed to guarantee protection of coastal benthic communities. Altogether, indicating that global change processes are not as relevant as human-derived impacts.

Tab. 1. DistLM (distance-based linear model routine) marginal test for relationships among environmental (mean depth, Hs mean, Hs maximum, mean Tp and mean direction) and human variables (anchoring, protection status, sewage effluents, fishing activity and diving) for: *P. nobilis* densities, sizes and *P. nobilis* densities, major variables.

	***Pinna nobilis* density**			***Pinna nobilis* size**		
Explanatory variable	**% var.**	**Pseudo-*F***	***p***	**% var.**	**Pseudo-*F***	***p***
Mean depth	<0.01	0.0079	0.9658	**7.1**	130.6	**0.01**
Hs mean	0.81	43.023	**0.0204**	0.18	3.12	0.072
Hs maximum	0.16	0.8431	0.3182	<0.01	1.063	0.304
Mean Tp	0.18	0.9655	0.2789	1.62	28.117	**0.001**
Mean direction	2.55	13.579	**0.0001**	**4.007**	71.3	**0.001**
Anchoring	**19.93**	106.16	**0.0001**	**3.918**	69.656	**0.001**
Protection status	**11.72**	62.412	**0.0001**	**3.296**	58.214	**0.001**
Sewage effluents	<0.01	0.1216	0.7044	0.922	15.904	**0.001**
Fishing activity	4.38	23.343	**0.0001**	**3.877**	68.897	**0.001**
Diving	6.05	32.255	**0.0001**	1.33	22.985	**0.001**

***Pinna nobilis* density Major Variable**	**% var.**	**Pseudo-*F***	***p***
Environmental	6.602	92.603	**0.001**
Human	**21.575**	36.039	**0.001**

This large-scale study performed with a high spatial resolution demonstrates that the spatial distribution of *Pinna nobilis* is distressed by human stressors more than environmental variables. Anchoring is the main factor affecting density of the fan mussel in the studied sites as already stated in previous studies [2, 3]. Legal protection of habitats is crucial in maintaining population structure of large, long-lived and sessile benthic organisms such as the fan mussels. This study shows that protection is widely affecting densities of *P. nobilis* at the studied geographical extent. Contrasted densities are two-fold in the MPA (Cabrera) where no-take reserves have been effectively set for more than 20 years [4]. Those results indicate that MPAs guarantee conservation demonstrating that a combination of protection size and age of the MPAs [5] seems to set the optimal conditions for growth and development of the species.

References
1 - Basso L, Vázquez-Luis M, García-March JR, Deudero S, Alvarez E, Vicente N, Duarte CM, Hendriks I. The pen shell, *Pinna nobilis*: A review of population status and recommended research priorities in the Mediterranean Sea. Advances in Marine Biology, 71: 109-160.
2 - Hendriks, I.E., Tenan, S., Tavecchia, G., Marbà, N., Jordà, G., Deudero, S., Álvarez, E., Duarte, C.M., 2013. Boat anchoring impacts coastal populations of the pen shell, the largest bivalve in the Mediterranean. Biol. Conserv. 160, 105–113.
3 - Vázquez-Luis, M., Borg, J.A., Morell, C., Banach-Esteve, G., Deudero, S., 2015. Influence of boat anchoring on *Pinna nobilis*: a field experiment using mimic units. Mar. Freshw. Res.
4 - Deudero S, Vázquez-Luis M, Alvarez E, 2015. Human stressors are driving coastal benthic long-lived sessile fan mussel *Pinna nobilis* population structure more than environmental stressors. Plos One 10(7):1-14.
5 - Claudet J, Osenberg CW, Benedetti-Cecchi L, Domenici P, García-Charton J-A, Pérez-Ruzafa Á, Planes S. Marine reserves: Size and age do matter. Ecology Letters. 2008; 11(5): 481–489.