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Nowhere safe? Exploring the influence of urbanization across mainland and insular seashores in continental Portugal and the Azorean Archipelago

Iacopo Bertocci [a,b,*], Francisco Arenas [a], Eva Cacabelos [c], Gustavo M. Martins [c], Maria I. Seabra [d], Nuno V. Álvaro [c,e], Joana N. Fernandes [d], Raquel Gaião [a], Nuno Mamede [d], Martina Mulas [a], Ana I. Neto [c]

[a] CIIMAR/CIMAR,Centro Interdisciplinar de Investigação Marinha e Ambiental, Terminal de Cruzeiros do Porto de Leixões, Av. General Norton de Matos s/n, 4450-208, Matosinhos, Portugal
[b] Stazione Zoologica Anton Dohrn, Villa Comunale, 80121 Naples, Italy
[c] cE3c-Centre for Ecology, Evolution and Environmental Changes/Azorean Biodiversity Group - Universidade dos Açores, Rua da Mãe de Deus 13A, 9501-801 Ponta Delgada, Azores, Portugal
[d] MARE, Marine and Environmental Science Centre, Laboratório de Ciências do Mar, Universidade de Évora, Avenida Vasco da Gama, Apartado 190, 7521-903 Sines, Portugal
[e] CMMG-Centro do Clima, Meteorologia e Mudanças Globais da Universidade dos Açores, Pólo Universitário de Angra do Heroísmo, 9701-851 Angra do Heroísmo, Azores, Portugal

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ABSTRACT

Differences in the structure and functioning of intensively urbanized vs. less human-affected systems are reported, but such evidence is available for a much larger extent in terrestrial than in marine systems. We examined the hypotheses that (i) urbanization was associated to different patterns of variation of intertidal assemblages between urban and extra-urban environments; (ii) such patterns were consistent across mainland and insular systems, spatial scales from 10s cm to 100s km, and a three months period. Several trends emerged: (i) a more homogeneous distribution of most algal groups in the urban compared to the extra-urban condition and the opposite pattern of most invertebrates; (ii) smaller/larger variances of most organisms where these were, respectively, less/more abundant; (iii) largest variability of most response variables at small scale; (iv) no facilitation of invasive species by urbanization and larger cover of canopy-forming algae in the insular extra-urban condition. Present findings confirm the acknowledged notion that future management strategies will require to include representative assemblages and their relevant scales of variation associated to urbanization gradients on both the mainland and the islands.

1. Introduction

The evidence that patterns of distribution, abundance and diversity of species and assemblages vary across biogeographic scales has been gathered for decades by ecologists, although progressively developing from the qualitative appreciation to the design of descriptive and manipulative experiments (Maurer, 1999). Several abiotic and biological factors vary across large scales, such as along latitudinal gradients, and can modulate the strength and nature of biological interactions (Menge et al., 2003) and the biological responses to anthropogenic perturbations, including climate change (Parmesan and Yohe, 2003).

Despite an increasing interest in assessing the generality vs. context-dependency of ecological processes (Chamberlain et al., 2014) and the development of approaches to indirectly test for the effects of large-scale drivers and overcome the logistic difficulty of manipulating them in the field (Menge et al., 2002), experimental analyses allowing comparisons across broad spatial scales are still scarce (but see, for example, Pennings and Silliman, 2005).

Among anthropogenic disturbances, urban coastal sprawl is one of the strongest, most widespread and rising (Barragán and de Andrés, 2015). Urban development can be associated to habitat destruction (Dugan et al., 2011), introduction of alien species (Airoldi et al., 2015), pollution (Lotze et al., 2006) and contamination by marine debris (Leite et al., 2014). The separate and/or combined impacts of such stressors may be responsible for the decline, up to the extinction, of native species, landscape modifications, and biotic homogenization at local to regional, or even global, scales (McKinney and Lockwood, 1999; Knop, 2016) and across all levels of biological organization (Lotze et al., 2006; Halpern et al., 2008; Aronson et al., 2014). Recent progress of research in urban ecology has indicated differences in the structure and functioning of intensively urbanized vs. less human-affected systems, but such evidence was provided for a much larger extent in terrestrial than in marine systems (Bulleri, 2006).

Moreover, previous studies on the impacts of human pressure provided inconsistent evidence. An overall reduction of species diversity and evenness, through the replacement of numerous, relatively low abundant, sensitive species by a few, but very abundant, ones has

* CIIMAR/CIMAR,Centro Interdisciplinar de Investigação Marinha e Ambiental, Terminal de Cruzeiros do Porto de Leixões, Av. General Norton de Matos s/n, 4450-208, Matosinhos, Portugal.
E-mail address: ibertocci@ciimar.up.pt (I. Bertocci).

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