Marine assemblages on natural and coastal defence structures

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INTRODUCTION

Urbanization is a global trend [1, 2]. Natural habitat destruction and its replacement by artificial structures is increasing globally and will continue in the future due to rising and stormier seas predicted from global warming [3]. There is a growing interest in understanding the role of these artificial habitats in coastal ecosystems, essential information to predict the influence of habitat change on the distribution, abundance, dynamics and structure of intertidal communities [4, 5]. Artificial habitats provide different environment for many intertidal species. They are usually homogeneous and less diverse in types and number of microhabitats, supporting epibiotic assemblages that differ from those on natural reefs [6, 7, 8]. This work focuses on investigating:

(1) differences on patterns of distribution and abundance of intertidal organisms among natural basaltic shores and artificial substrates, either made of concrete or basalt (most common types of materials used on volcanic islands)

(2) the hypothesis that small-scale topographic variation affects benthic assemblages by comparing the abundances and distribution of key intertidal taxa in areas of high and low topographic complexity

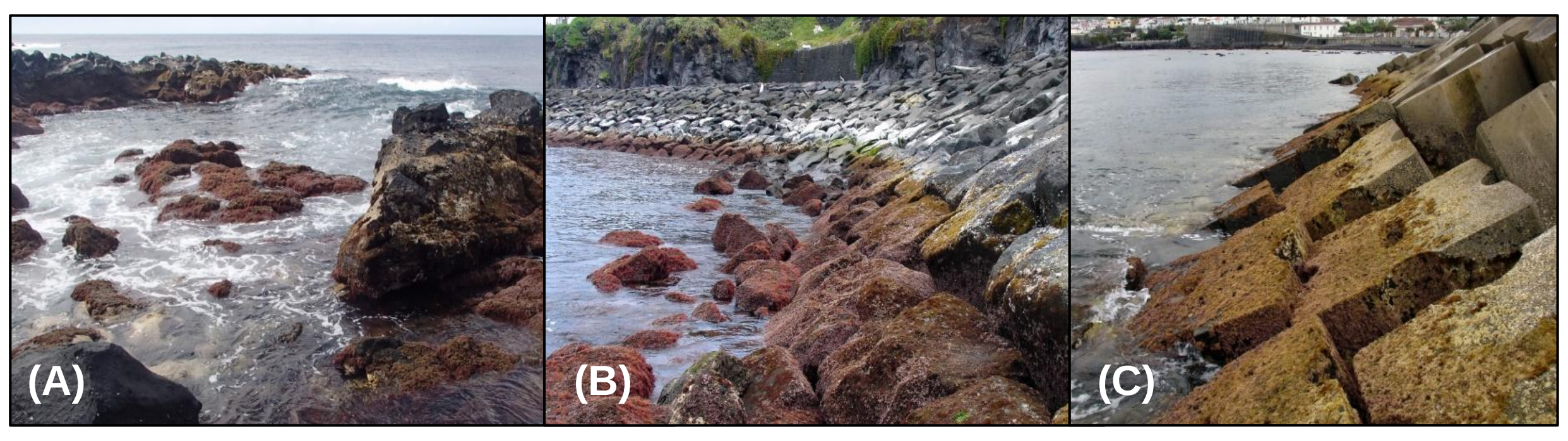

Fig. 1 Natural shores (A) and artificial basalt (B) and concrete (C) structures

RESULTS AND DISCUSSION

(1) Assemblage composition (Tab. 1) and the relative abundance of key organisms differed between natural and artificial shores. Although qualitatively similar assemblages of animals and plants were found on both the coastal defence structures and natural habitats, there were relevant effects of urbanization on the abundance of some intertidal organisms (Figs. 4, 5, 6).

Source	df	Low-shore	Mid-shore	High-shore
Habitat	2	1.6	1.7	4.2**
N vs. B	1	0.9	2.9*	4.6**
N vs. C	1	1.6	1.9	7.2**
Location(Habitat)	12	21.4***	4.0***	4.6***
Residual	60			
Total	74			

Table 1. Comparisons of abundance (numbers of gastropods and percentage cover of macroalgal FGs and *C. stellatus*) on Natural shores (N), and Basalt (B) and Concrete (C) structures at different intertidal levels. Pseudo-*F* values are indicated. (****P*< 0.001, ***P*< 0.01, **P*< 0.05).

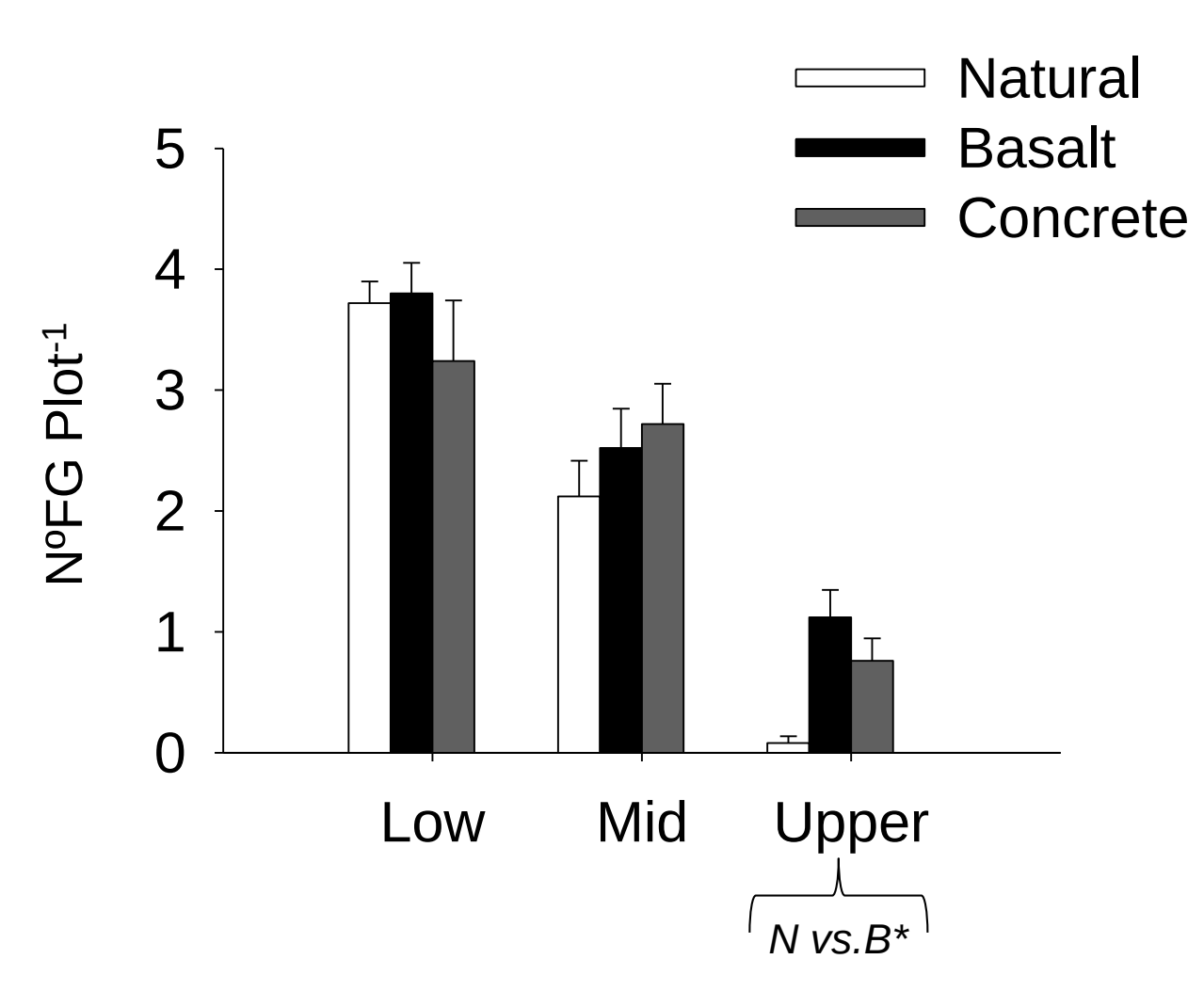

Fig.4. Number of macroalgal FGs (mean + SE, n=25) in different habitats and intertidal levels (**P*< 0.05).

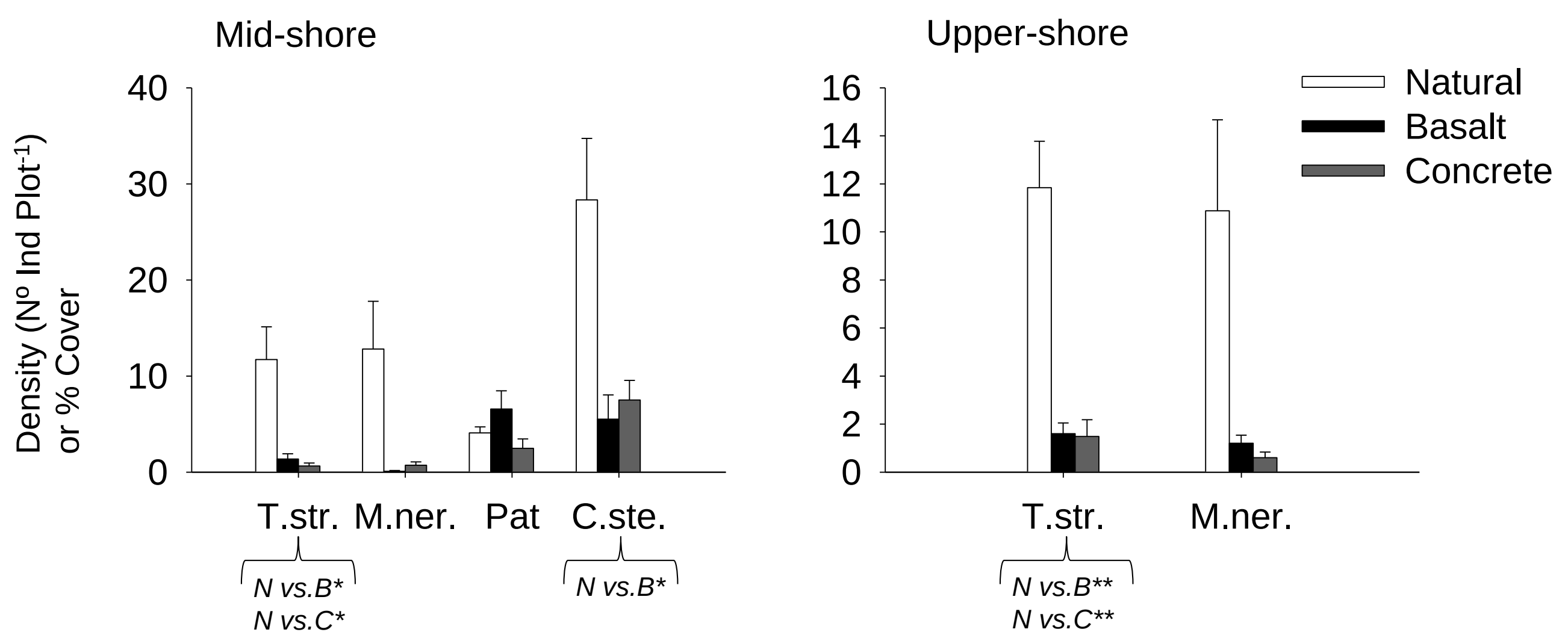

Fig. 5. Gastropod and barnacle (mean + SE, n=25) abundance associated with different habitats at mid– and upper–shore (molluscs: T.str, *T. striatus*; M.ner., *M. neritoides*; Pat, *Patella* spp.; barnacle *C. stellatus*, C.ste.) (***P*< 0.01, **P*< 0.05).

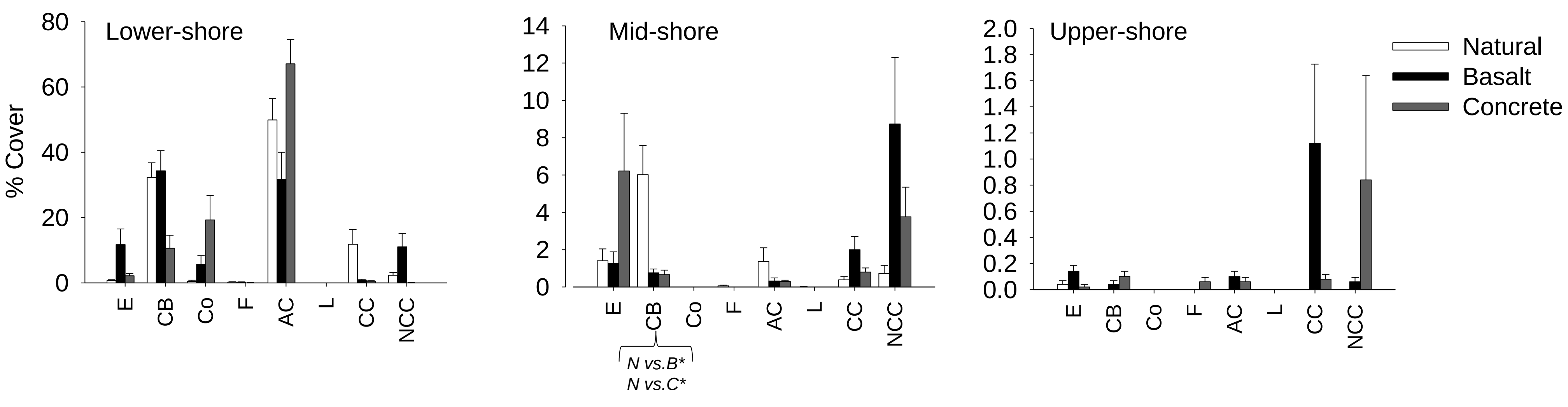

Fig. 6. Percent cover (mean + SE) of macroalgal FGs (E, Ephemeral Algae; CB, Coarsely branched; Co, Coenocytic; F, Foliose; AC, Articulated calcareous; L, Leathery; CC, Calcified crustose, NCC, Non–calcified crustose) associated with Natural, and Basalt and Concrete artificial structures at low, mid- and high levels.

(2) Intertidal species of macrofauna were highly influenced by small–scale variation in microtopography (Fig. 7).

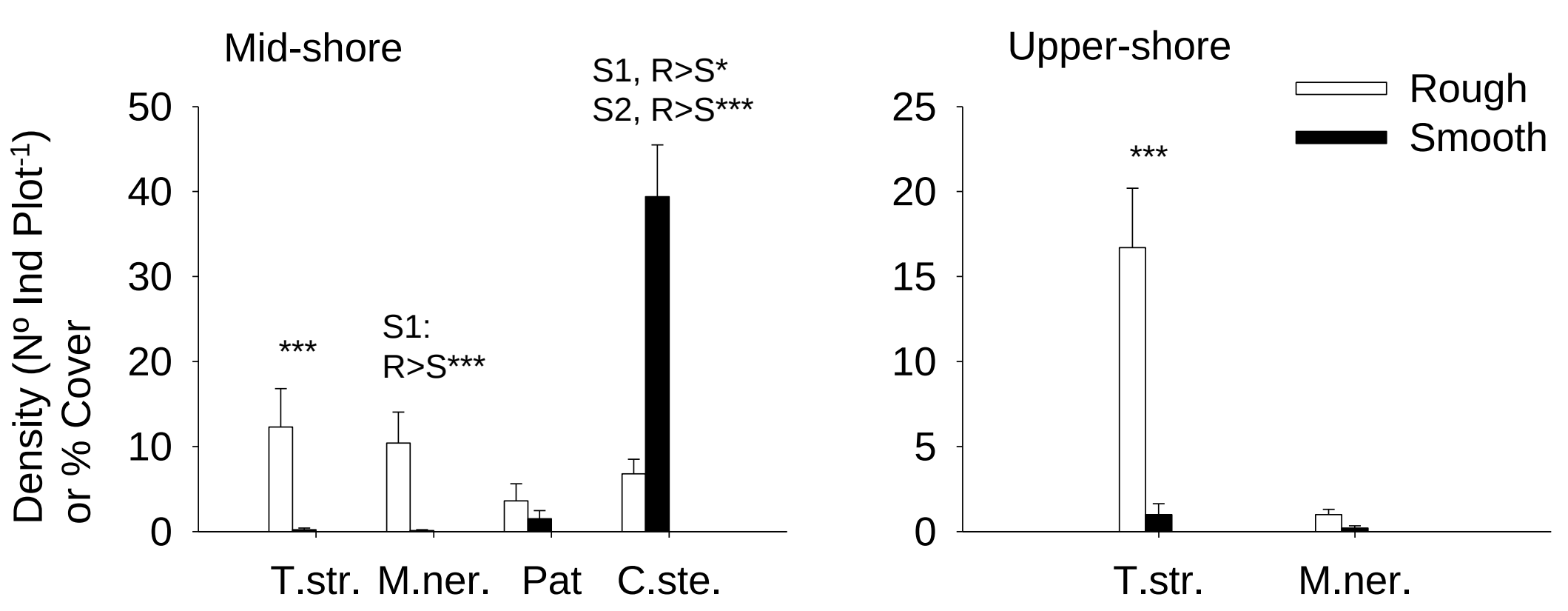

Fig. 7. Gastropod density and barnacle percent cover (mean density + SE, n = 10) associated with rough (R) and smooth (S) surfaces at mid– and upper–shore (molluscs: T.str, *T. striatus*; M.ner., *M. neritoides*; Pat, *Patella* spp.; barnacle *C. stellatus*, C.ste.; S = Site).

MATERIAL AND METHODS

(1) Species distribution and abundance on natural and artificial substrates:

Sampling was carried out on the different habitats (Ha): natural rocky shores of basaltic nature (Natural), and artificial coastal defence structures built of either Basalt or Concrete (Fig. 1) located along the coastline of São Miguel, Azores Archipelago (37º44'N, 25º 38'W) (Fig. 2).

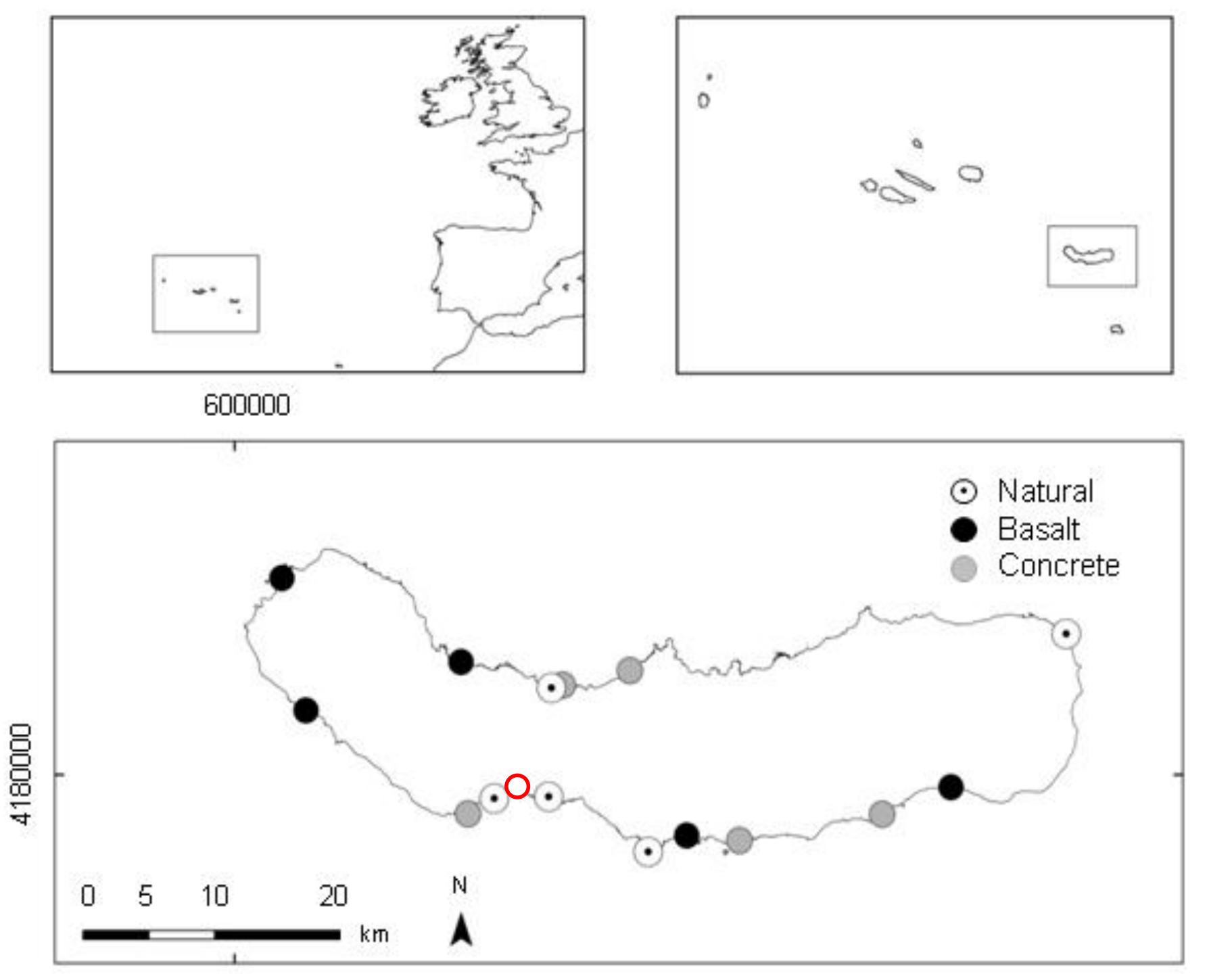

Fig. 2 Sampling locations on natural shores and artificial structures around São Miguel (Azores). Basalt seawall selected for small–scale analyses is indicated with a red circle.

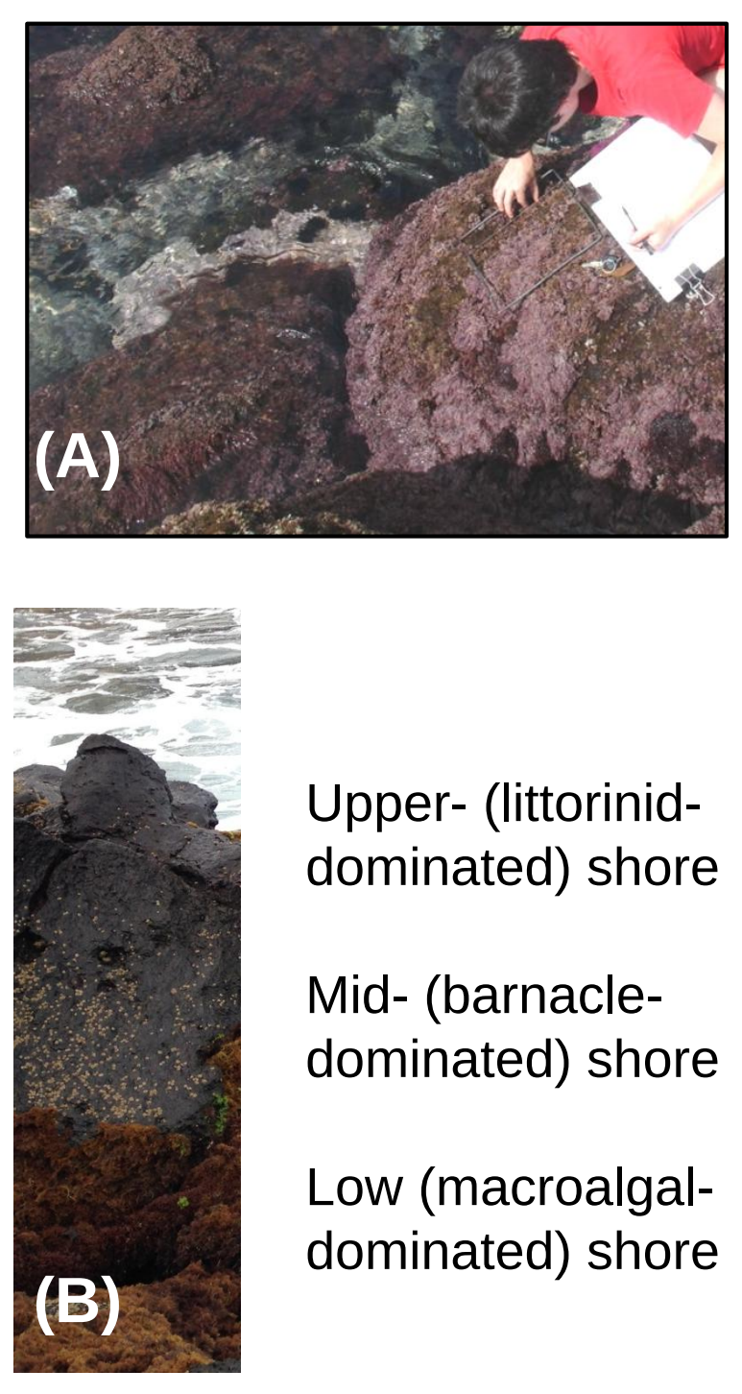

Fig.3. Sampling (A) in the (B) low, mid- and upper shores

- 5 locations (Lo) per habitat type were randomly selected.
- 5 replicate quadrats (25x25 cm) were haphazardly placed on the seaward side of emergent substrata at low-, mid- and upper-shores (Fig. 3).
- Motile invertebrates were counted.
- Percentage cover of sessile organisms (macroalgae and barnacles) and bare rock were sampled following [9]. Macroalgae were grouped into distinct morpho–functional groups (FGs).
- Surveys between 24th June - 4th August 2013.

Data analysis: Differences in the abundance of biota were analysed thought two–way ANOVAs, with factors:

- Habitat (Ha, fixed, 3 levels)
- Location (Lo, random nested in habitat, 5 levels)

and contrasts to specifically compare the effects of artificial structures and natural controls.

Similar designs to analyse the differences in structure of assemblages, but using PERMANOVA (based on Bray Curtis similarity).

(2) Small–scale patterns of species distribution

- Abundance of organisms in blocks with smooth and rough surfaces were sampled on *a priori* selected blocks on a basalt seawall (see Fig. 2).
- 5 replicate quadrats (25x25 cm) were sampled per rugosity level on 2 sites at mid- and upper-shore .
- Substrate microtopography was measured adapting a pin–microrelief method [10].
- Surveys between August 12th - September 12th 2014.

Data analysis: Differences in the abundance of biota analysed thought two–way ANOVAs with factors:

- Roughness (Ro, fixed, 2 levels (Smooth and Rough))
- Site (S, random, nested in Roughness, 2 levels (S1 and S2))

TAKE-HOME MESSAGE

Small–scale substratum topographic complexity, rather than substratum type, influence intertidal community structure in coastal defence structures.

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