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# Changes in subtidal assemblages in a scenario of warming: Proliferations of ephemeral benthic algae in the Canary Islands (eastern Atlantic Ocean)

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ABSTRACT

The present work analysed the main changes in subtidal algal assemblages in the last decade in an oceanic archipelago (Canary Islands – eastern Atlantic Ocean). Changes result from increases in cover of ephemeral benthic algae, such as the non-native chlorophyte *Pseudotetraspora marina* and the native cyanophytes *Blennothrix lyngbyacea*, *Schizothrix calcicola* and *Schizothrix mexicana*. Ephemeral algae overgrow subtidal assemblages which are extensively dominated by *Lobophora variegata*, but competitively do not exclude other species. Increases in the abundance of species coincided with a warming of about 2 °C in surface seawater temperature (SST) linked to the weakening of the Cold Canary Current and the Northwestern African upwelling. Shifts in the distribution and cover of ephemeral species follow the SST gradient from warmer waters in the western islands to colder waters in the eastern ones. While in the warmest western islands, species have spread quickly colonizing all type of substrates in just a few years (2005–2008), the occurrence of ephemerals towards the coldest eastern islands is yet inconspicuous.



## 1. Introduction

Present global ocean warming is inducing changes in marine assemblages and in ecosystem functionality (Harley et al., 2006; Helmuth et al., 2006; Kordas et al., 2011). Marine macroalgae are engineering species in a variety of shallow ecosystems and are extremely sensitive to changes in oceanographic conditions (Crooks, 2002; Díaz-Pulido et al., 2007; Eriksson et al., 2002). Among these changes, rises in temperature stimulate photosynthesis and growth, promoting shifts in the distribution and abundance of some algal species (Wernberg et al., 2011). Increases in SST, allow the proliferation and extend the growing season of native organisms and facilitate local dominance of introduced species from warmer regions, having an adverse effect on species with colder affinities (Carstensen et al., 2010; Dijkstra et al., 2011; Lima et al., 2007). New environmental conditions, which induce the rupture of biogeographic boundaries and changes in oceanic currents, emerge as 'invasion windows' for expanding non-native species (Ashton et al., 2007; Occhipinti-Ambrogi, 2007). Introduced species can find more suitable conditions to grow in the new areas, becoming sometimes invasive. The potential for ocean warming to facilitate invasions and precipitate shifts in assemblage composition has been recently well documented (Sorte et al., 2010).

In the Canary Islands, the interaction between the Cold Canary Current and the Northwestern African upwelling determines a complex mosaic of physical and chemical seawater conditions. The cold current flows with a NNE-SSW direction and the upwelling has a greater influence on the eastern islands. SST varies from 17 to 19 °C in March–April to 23–25 °C in September–October (Fig. 1), with a difference of about 2 °C between the eastern and western islands (Barton et al., 1998). Result of this mosaic of environmental conditions is a marine biota characterized by tropical, subtropical, warm-temperate and cold-temperate species, which co-occur in

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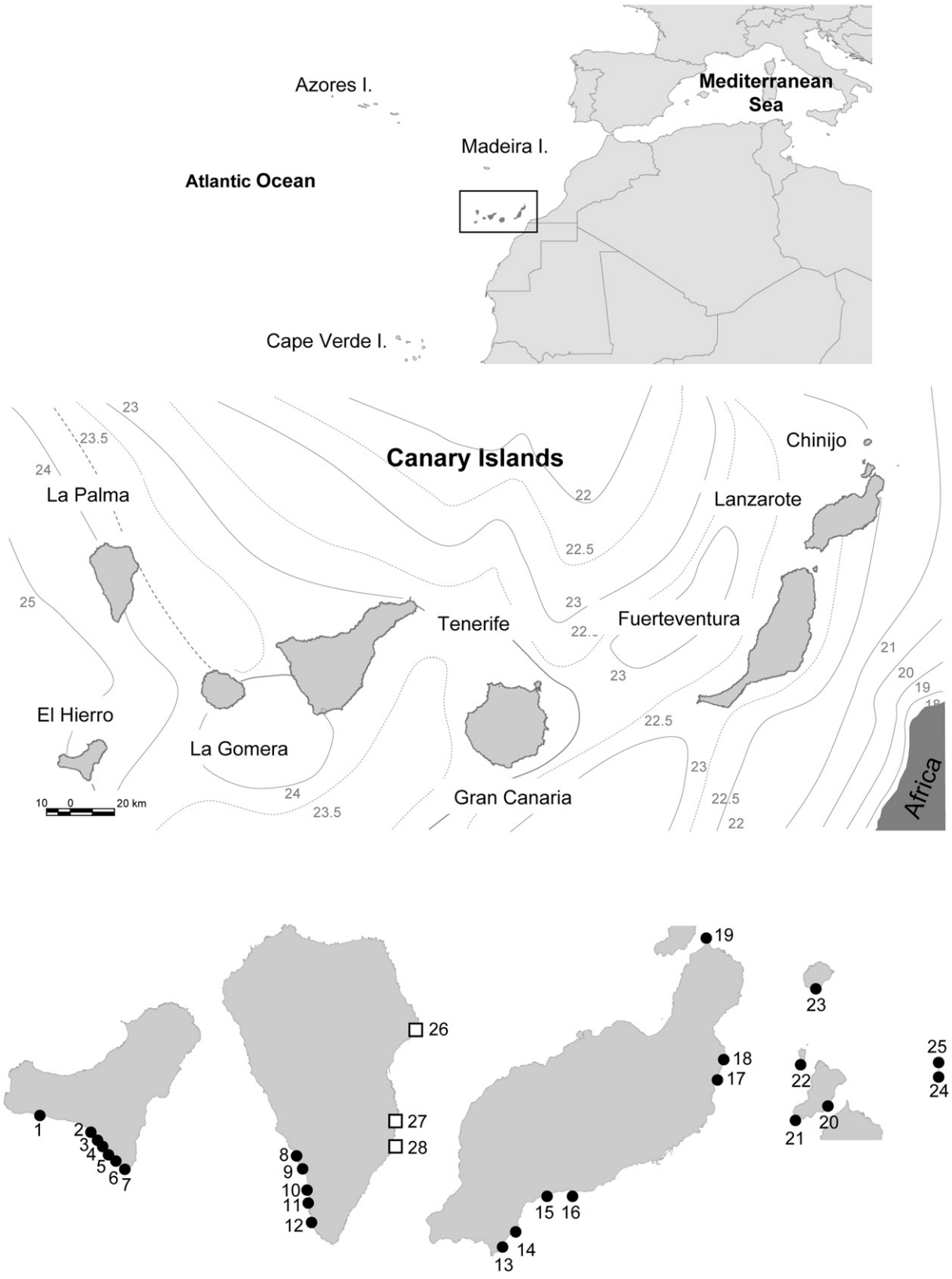


**Fig. 1.** Location of the Canary Islands in the northeastern Atlantic (top), surface seawater isotherms in September–October around the Canary Islands (middle), and sampling sites (bottom). Sites studied for comparative results in 2005 and 2008: El Hierro [1 Laja de Orchilla, 2 Tacorón, 3 Las Lapillas, 4 Las Cañas, 5 La Gabarra, 6 Cueva de Los Frailes, 7 La Herradura], La Palma [8 Punta Bogullos, 9 El Remo, 10 Punta Banco, 11 Siete Islas, 12 La Resbaladera], Lanzarote [13 Caleta Larga, 14 Punta Gorda, 15 Risco Prieto, 16 Playa Blanca, 17 Los Cocoteros, 18 Charco del Palo, 19 Punta Fariones] and Chinijo [20 Caleta de Sebo, 21 Montaña Amarilla, 22 Cuevas Coloradas, 23 La Mareta, 24 Roque del Este, 25 Roque del Este]; and sites studied bimonthly for annual variation in *Pseudotetraspora marina* cover: La Palma [26 Puerto Trigo, 27 La Bajita; 28 Playa del Pozo].