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Reproduction strategies of *Macrocystis pyrifera* (Phaeophyta) in Southern Chile: The importance of population dynamics

Alejandro H. Buschmann[1,*], Cristina Moreno[1], Julio A. Vásquez[2,3] & María C. Hernández-González[1]

[1]*i∼mar, Universidad de Los Lagos, Camino Chinquihue km 6, Casilla 557, Puerto Montt, Chile;* [2]*Facultad de Ciencias del Mar, Universidad Católica del Norte, Coquimbo, Chile;* [3]*Centro de Estudios Avanzados de Zonas Áridas (CEAZA), Coquimbo, Chile*

*Author for correspondence: e-mail: abuschma@ulagos.cl

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Abstract

Macrocystis pyrifera is an ecologically dominant species along the temperate Northern and Southern Pacific Coast of America, showing some similarities and differences at population and community level. In general, this kelp is reported to be reproductive all year round. Annual populations present in wave-protected areas of southern Chile suggest that the reproductive strategies of this population can be different. In this study we explore the reproductive strategies of annual *M. pyrifera* present in wave-protected areas and perennial populations encountered in exposed areas of southern Chile (41°S). Our results show that *M. pyrifera* present in wave-exposed locations has a reproductive strategy that is similar to populations in the northern hemisphere. These populations reproduce all year round and their strategy is to produce high numbers of sporophylls and ensure that most of them (over 90%) become sporogenous. On the other hand, the protected populations with an annual life cycle, produce more spores per area of sorus. In a few months, they are able to produce sufficient propagules to recolonize areas before the adult plants disappear in autumn.

Introduction

Macrocystis pyrifera (L.) C. Ag. is abundant along the Chilean coastline from Cape Horn up to Valparaíso (33°S), but has also been reported on the Peruvian coast (Hoffmann & Santelices, 1997). Abundant populations are located south of Concepción (37°S) down to Patagonia in protected bays open to the Pacific Ocean, as well as in channels and fjords, forming conspicuous belts along the coastline. In this southern region, fluctuation of environmental parameters, especially temperature, salinity and nutrients, are greater in the inner waters than in bays open to the Pacific Ocean (Buschmann et al., 2004). Also, the morphology of plants from these populations differs significantly. Plants present in the inner sea (the most wave-protected populations) have broader blades, smaller pneumatocysts, and more ribbed blades, among other characteristics suggesting that the environmental conditions have considerable individual and population consequences for this brown alga (Buschmann, 1992; Vásquez & Buschmann, 1997).

Previous results indicate that wave-exposed sites produce fewer perennial populations than wave-protected sites (e. g. Seymour et al., 1989; Harrold & Reed, 1985). Studies of the reproduction ecology of *Macrocystis pyrifera* in the North Pacific show that this species is reproductive all year round (Reed et al., 1996), as has also been established in protected areas of the Beagle Channel (Santelices & Ojeda, 1984). However, the wave-protected populations of *M. pyrifera* in the northern limit (41–44°S) of the archipelago area of southern Chile show a different trend (Buschmann, 1992; Vásquez & Buschmann, 1997). These are annual, raising several questions regarding factors that produce these unusual patterns and how these populations

manage to recruit successfully year after year. In consequence, wave-protected and exposed kelp populations have important ecological differences that have not yet received attention for a more comprehensive understanding of *M. pyrifera* population dynamics.

This study outlines the annual population dynamics and reproductive patterns in areas with different water movement regimes that represent different reproductive strategies. We describe the reproductive strategy of *Macrocystis pyrifera* with respect to the size of the parent plants, indicating size of first reproduction and reproductive effort in relation to different (annual and perennial) population dynamics.

Material and methods

Study areas

This study was carried out in southern Chile (40–41°S) where different water movement regimes can be found as a consequence of the presence of channels, fjords and wave-protected bays (Figure 1). In this region a wave exposed locality (Bahía Mansa; 40°34′S, 73°44′W) and a protected locality (Metri; 41°36′S, 72°43′W) were identified on the basis of carbonate-block dissolution rates, as described by Buschmann et al. (2004). The study was carried out, within each locality, at two sites separated by <500 m to assure the representation of the variability of each locality. The exposed area, Bahía Mansa (Figure 1), is characterized by variable depths between 0 to 12 m, with a substratum mostly composed of compact rock and boulders and where carbonate dissolution rates varied from 0.6 to 0.9 g h^{-1}. At exposed localities, the giant kelp *Macrocystis pyrifera* populations are perennial, but show fluctuations in abundance due to increased water movement in winter (Westermeier & Möller, 1990). This kelp is the only subtidal canopy-forming species in the area, while the main understory species are *Ulva* sp. and *Sarcothalia crispata*. In wave-protected locations, such as Metri (Figure 1), *M. pyrifera* forests are present from the low intertidal down to 10 m depth and have typical annual population dynamic (Buschmann, 1992). Carbonate dissolution rates at Metri varied from 0.12 to 0.18 g h^{-1}, which is significantly lower ($P < 0.001$) than the exposed locality. The bottom is mainly granite-consolidated rock, with some boulder patches. The most abundant understorey species are the red alga *Sarcothalia crispata* and the green alga *Ulva* sp. At both Bahía Mansa and Metri the most conspicuous grazer

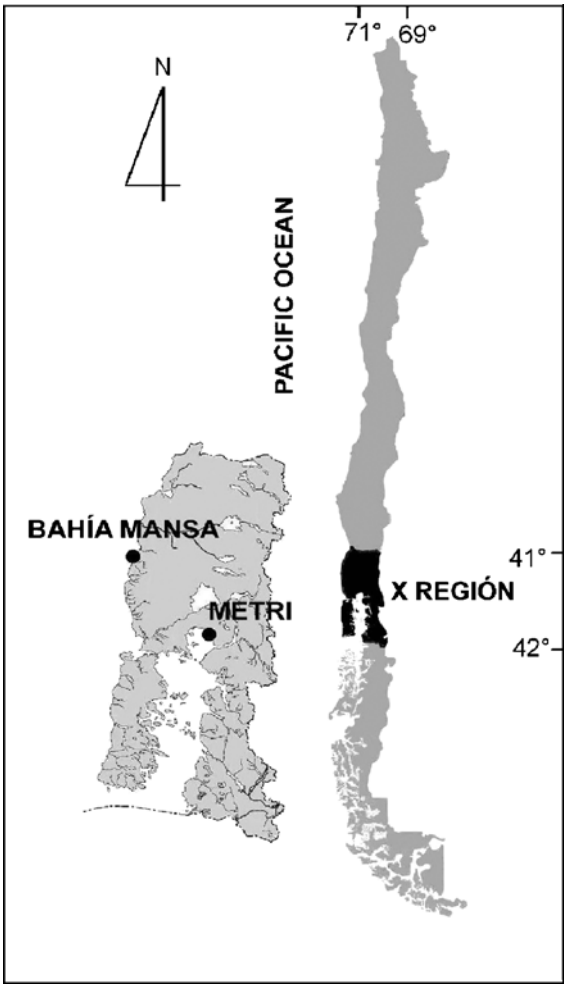

Figure 1. Map showing the study sites in southern Chile. Bahía Mansa is an exposed area and Metri is a protected area.

is the snail *Tegula atra*, but a lower number of sea urchins, chitons and limpets are also found. In general, it has been demonstrated that *Tegula* has no effect on the population dynamics of *Macrocystis*, but does have a moderate effect on the abundance of understory algal species (Moreno & Sutherland, 1982). The main difference between these areas is the absence in the protected areas of the kelp *Lessonia*, lower species diversity, and high abundance of the filter-feeding gastropod *Crepidula*.

Population and reproduction patterns

In each study area, eighteen 0.25 m^2 random samples (9 per location) were taken by scuba diving, to include a range of depths. Each location had a coastline length of