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Seasonal and vertical distributional patterns of siphonophores and medusae in the Chiloé Interior Sea, Chile

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ABSTRACT

The horizontal and vertical distribution of jellyfish was assessed in the Chiloé Inland sea, in the northern area of the Chilean Patagonia. A total of 41 species of cnidarians (8 siphonophores, 31 hydromedusae, 2 scyphomedusae) were collected. Eleven jellyfish species were recorded for the first time in the area. Species richness was higher in spring than in winter (37 vs. 25 species, respectively). Species such as *Muggiaea atlantica*, *Solmundella bitentaculata*, and *Clytia simplex* were extremely abundant in spring. The total abundance (408,157 ind 1000 m^{-3}) was 18 times higher in spring than in winter (22,406 ind 1000 m^{-3}).

The horizontal distribution of the most abundant species (four in winter, five in spring) showed decreasing abundances in the north–south direction in winter and spring. Peak abundances occurred in the northern microbasins (Reloncaví Fjord, Reloncaví and Ancud gulfs), where the water column stability, phytoplankton and zooplankton abundance were higher, compared with the southern microbasins (Corcovado Gulf, Boca del Guafo). During the spring higher jellyfish abundance season, the vertical distribution of the dominant species (except *M. atlantica*) showed peak values at mid-depth (30–50 m) and in the deepest sampled layer (50–200 m). This vertical distribution pattern reduced seaward transport in the shallowest layer through estuarine circulation and also limited mortality by predation in the more illuminated shallow layers. Thus, jellyfish were able to remain in the interior waters during the season of maximum biological production.

1. Introduction

In recent decades, a notorious increase of gelatinous predator populations (cnidarians and ctenophores) has been observed in several marine ecosystems (Brodeur et al., 2002; Mills, 2001). These organisms are known to be voracious predators that may affect the web structure and dynamics of the pelagic community by consuming a wide variety of herbivorous zooplankters and fishes in early life stages and, on some occasions, by competing with the latter for food (Boltovskoy, 1999; Matsakis and Conover, 1991; Purcell, 1997). Jellyfish are also prey for a number of predators such as ctenophores, medusae, fishes, and turtles (Mills, 1995). However, studies on these gelatinous plankton groups have been scarce in some southern high-latitude areas due to an overall scarcity of oceanographic information on the region and difficult access that limits research, especially during periods of harsher environmental conditions. Interestingly, the pristine waters in some of these zones (e.g., the Chilean Patagonia) have attracted new ventures in aquaculture activities in recent years. Information on the presence and seasonal variability of gelatinous zooplankton groups in these areas, which are also spawning and nursery areas for economically important demersal fishes, prior to and during the current massive development of human settlements and aquaculture farms is necessary to elucidate the role gelatinous organisms play in ecosystem functioning at different times of the year, especially considering the contrasting primary productivity observed between seasons.

The complex fjord and channel system in austral Chile extends from Reloncaví Fjord (41°31′S) to Cape Horn (55°S); these 84,000 km of coastline encompass the contours of more than 3300 islands (Silva and Palma, 2008). The area from the northern part of this region (Reloncaví Fjord) to Boca del Guafo passage (43°30′S) farther south, and from Chiloé Island (8350 km^2) eastward to the continent is known as the Chiloé Interior Sea. This area has a surface of around 15,800 km^2 and maximum depths reaching down to 480 m in Comau Fjord (Silva et al., 2009). Two microbasins exist in this interior sea: the northern one is made up of Reloncaví Fjord and Reloncaví and Ancud gulfs, and the southern one by Corcovado Gulf and Boca del Guafo. These microbasins are interconnected by narrow passages between

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islands, some of which constitute bathymetric constrictions and sills. One of the main constrictions is the Desertores passage (5 km wide, and 200 m maximum depth). The Chiloé Interior Sea exchanges waters with the adjacent Pacific Ocean through the narrow (4 km), shallow (50 m depth) Chacao Channel to the north and through the wide (66 km), deeper (150 m depth) Boca del Guafo passage to the south (Fig. 1).

The environmental conditions in the microbasins to the north and south of the Desertores Islands are different. The northern microbasin has a highly stratified water column due to a conspicuous low salinity layer at the surface (<30 m) resulting from rain, freshwater runoff, rivers, and melting ice. As this upper layer flows out of the Chiloé Interior Sea towards the ocean, it also exports a large fraction of the primary production that occurs in the interior sea. In turn, sea water enters the northern microbasin through a subsurface flow that is also capable of importing zooplankton organisms from the adjacent oceanic shelf waters (Palma and Silva, 2004). This two-layer estuarine system affects the taxonomic composition, horizontal and vertical plankton distribution, and diel vertical migration of different cnidarian species (Palma et al., 2007b). North of the Desertores Islands, chlorophyll-*a* and plankton production are high, phytoplankton blooms are recurrent (Iriarte et al., 2007), and reports indicate high biomass of copepods, euphausiids, and gelatinous plankton groups. South of these islands, in the southern microbasin, the vertical stratification is less pronounced and chlorophyll-*a* values are usually lower (Palma and Silva, 2004; Ramírez and Pizarro, 2005).

In the Chiloé Interior Sea ecosystem, gelatinous organisms constitute an important fraction of the plankton biomass in the shallower 200 m layer in spring (Palma and Rosales, 1997; Villenas et al., 2009a). No information is available on their taxonomic composition, abundance, or distribution in other seasons, when environmental conditions change drastically. In this study, we compare the composition, abundance, and distribution of jellyfish in winter with those in the springs of the same (2006) and previous years. This information constitutes a baseline for future comparisons, as environmental conditions are expected to vary, either due to the effect of anthropogenic impacts or to larger scale environmental changes.

2. Materials and methods

Oceanographic data and zooplankton samples were obtained from the CIMAR 12 Fiordos cruise carried out in winter (8–24 July) and spring (3–13 November) 2006 between Reloncaví Fjord (41°31′S) and Boca del Guafo (43°39′S). During each cruise, we analyzed a longitudinal transect that included 14 (winter) and 18 (spring) oceanographic stations (Fig. 1). The oceanographic data compiled included temperature, salinity, and dissolved oxygen measured with a Seabird 25 CTDO. Bathymetric information was obtained from the nautical charts of the hydrographic and oceanographic service of the Chilean navy (charts 7400, 7410, 7330, 7320, 7300).

Zooplankton samples were collected from three strata (surface: 0–25 m, middle: 25–50 m, and deep: 50–200 m, depending on bottom depth) through oblique tows with a Tucker trawl net (300 μm mesh; 1 m^2 mouth opening) equipped with a flowmeter. Depth strata were selected considering the two-layer hydrographic structure that characterizes the interior waters (Silva et al., 1997, 1998). The zooplankton samples were preserved immediately on board in 5% buffered formaldehyde.

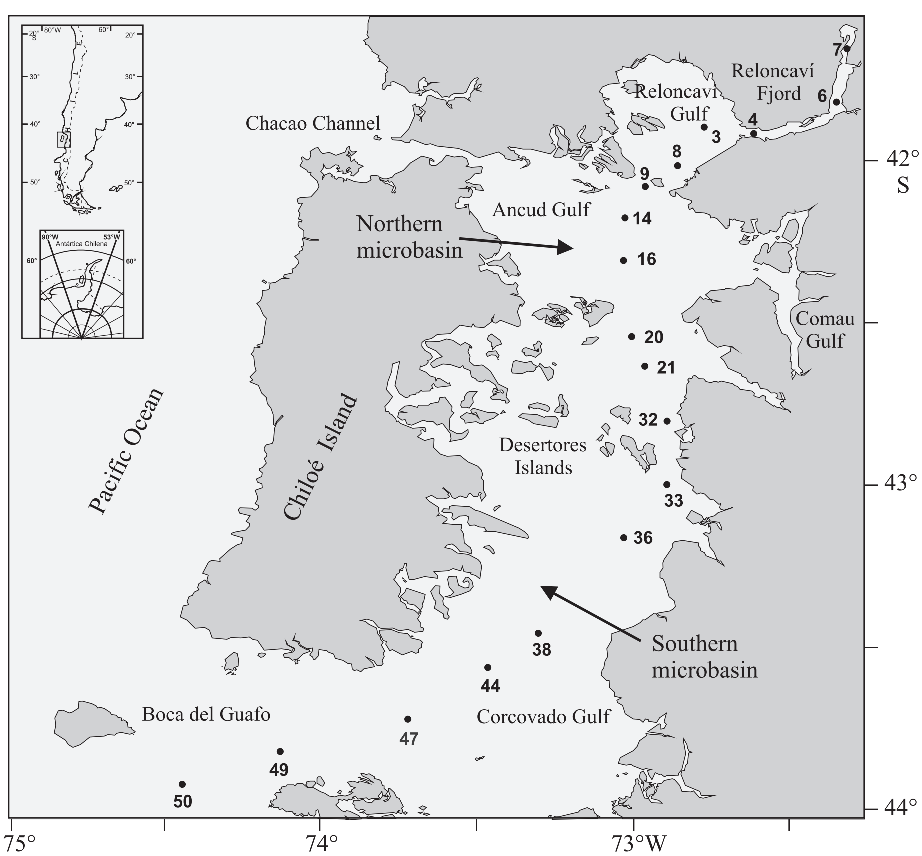

Fig. 1. Study area and locations of sampling stations in a longitudinal section between Reloncaví Fjord and Boca del Guafo (CIMAR 12 Fiordos cruise).