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Alexandrium catenella cyst accumulation by passive and active dispersal agents: Implications for the potential spreading risk in Chilean Patagonian fjords

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ABSTRACT

The dinoflagellate *Alexandrium catenella* is responsible for paralytic shellfish poisoning and negative socio-economic impacts on the fishing industry and aquaculture. In Chilean Patagonia, the reasons underlying the significant increase in the geographical extension (from south to north) of *A. catenella* blooms during the last five decades are not well understood. To assess the potential spreading risk of *A. catenella* during an intense austral summer bloom, we conducted an *in situ* experiment in a "hotspot" of this dinoflagellate in southern Chile. The objective was to assess the accumulation of *A. catenella* resting cysts in passive (fishing nets) and active (mussels) dispersal agents during the phase of bloom decline. Large numbers of resting cysts were detected in fishing nets (maximum of 5334 cysts net^{-1} per month) at 5 m depth and in mussels (maximum of 16 cysts g^{-1} of digestive gland) near Vergara Island. The potential of these vectors to serve as inoculum sources and the implications of our findings for *A. catenella* population dynamics are discussed.

1. Introduction

The toxin-producing microalgae *Alexandrium catenella* is responsible for paralytic shellfish poisoning (PSP) and the formation of recurrent harmful algal blooms (HABs) in the fjords and channels of Chilean Patagonia (Guzmán et al., 2002; Molinet et al., 2003; Díaz et al., 2014; Díaz et al., 2018; Álvarez et al., 2019). During nearly five decades, the geographical extension (from south to north) of *A. catenella* HAB events has increased significantly. The last intense bloom event in the region occurred off Chiloé island coast (42°S) reaching the Valdivian coast (39°S) in the late summer of 2016 (Hernández et al., 2016; Díaz et al., 2019). PSP outbreaks have also become a major threat to public health, artisanal fisheries and the mussel industry in the Los Lagos region (northern Patagonia), which seeks to become a renowned area of mussel cultivation and is currently home to > 95% of the mussel production in Chile (30×10^4 t y^{-1}) (Sernapesca, 2017; Díaz et al., 2019).

The development of measures to prevent, or at least minimize, HABs and their negative consequences requires a detailed understanding of the factors that trigger these proliferations (Anderson et al., 2012). In the case of *Alexandrium*, its sexual life cycle includes a dormant benthic stage, or resting cyst (Bravo et al., 2006), that plays an important role in bloom initiation and termination as well as in the dispersal of several important HAB-forming species (Anderson et al., 2005).

Dinoflagellate cysts can be transported in the ballast water of ships, which enables the geographic dispersal of non-indigenous species of microalgae (Hallegraeff, 2003). Hallegraeff and Bolch (1991) demonstrated the important role of ballast water in the transport of

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