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Dinoflagellate cyst production in the north-western Adriatic Sea

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Abstract

A sediment trap study was conducted in the Gulf of Venice, north-western Adriatic Sea, from April to December 2005 to assess relationships between planktonic dinoflagellates and cyst production. Every month, CTD profiles and discrete samplings for phytoplankton, nutrients and particulate matter were conducted. Cyst fluxes spanned from 90 to 127,600 cysts m^{-2} d^{-1} and major peaks were due to a small cyst attributed to cf. *Biecheleria* and to calcareous cysts of *Scrippsiella trochoidea*. A good correspondence between cyst fluxes in sediment traps and the presence of the corresponding vegetative cells in the water column was detected for *Lingulodinium polyedrum,* and species of the genera *Gonyaulax* and *Protoperidinium*. A PCR method applied to surface sediment samples allowed the identification of a number of potentially harmful dinoflagellate cysts (*Alexandrium minutum*, *A. taylorii*, *Lingulodinium polyedrum* and *Protoceratium reticulatum*).

Keywords: Dinoflagellates, cysts, sediment traps, NW Adriatic Sea, *Scrippsiella, Biecheleria*.

Introduction

Many dinoflagellates produce cysts during their life cycle (Head, 1996) and these resting stages often play an important role in population dynamics (e.g., Marcus & Boero, 1998; Dale, 2001; Anderson *et al*., 2014). The switch from actively growing cells to resting cysts can in fact contribute to a bloom termination (e.g., Kremp & Heiskanen, 1999), while the germination of cysts can represent the inoculum for future blooms in the water column (e.g., Anderson *et al*., 2005; Wang *et al*., 2007; Ishikawa *et al*., 2014). The formation of resting cysts might represent an adaptive trait for protists living in highly variable coastal environments. These organisms can grow in the water column during favorable environmental windows and then sink onto surface sediments, where they constitute cyst banks that 'anchor' planktonic species to a specific environment (Anderson & Wall, 1978; Wyatt & Jenkinson, 1997; McGillicuddy *et al*., 2003; Mizushima, 2004; Anderson *et al*., 2005). Cyst banks include populations originating over several years and thus represent a source of phenotypic and genotypic diversity (Alpermann *et al*., 2009). Cysts are surrounded by a thick and decay-resistant cell wall and contain high amounts of reserve materials; these features allow them to remain viable in the bottom sediments for years (Ribeiro *et al*., 2011). These resting stages can survive in ballast waters or in shellfish stocks traded over long distances, and can thus represent a way of dispersal through space and time. This is particularly relevant in the case of harmful species, where efforts have been made to elucidate the role of resting stages in the apparent spreading of harmful algal blooms (e.g., Joyce *et al*., 2005; Bolch & De Salas, 2007).

Factors controlling cyst production and the physiological mechanisms involved have not been clearly defined, and laboratory experiments at times produced results that do not match with field observations. Research carried out with cultured strains suggested that encystment is related to the onset of stress conditions (Pfiester & Anderson, 1987), in particular nutrient limitation (e.g., Anderson & Lindquist, 1985; Figueroa *et al*., 2005). However, field and laboratory studies could not always find a link between cyst production and nutrient limitation (Anderson *et al*., 1983; Zonneveld *et al*., 2009). Other factors, such as day length (Sgrosso *et al*., 2001), temperature shifts (Kremp *et al*., 2009), a combination of these factors (Pospelova *et al*., 2010) or, in heterotrophic species, food limitation (Nagai *et al*., 2002; Saito *et al*., 2007) might trigger or modulate the formation of resting cysts.

Many studies reported qualitative and quantitative information on dinoflagellate cysts in marine sediments and extensive distribution maps, covering broad geographic ranges, are now available (e.g., Zonneveld *et al*., 2013). However, much fewer are the studies that estimated cyst fluxes along the water column in coastal areas (e.g., Fujii & Matsuoka, 2006; Pospelova *et al*., 2010;