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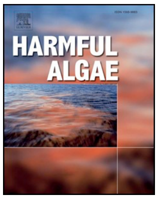

Habitat effects on *Ostreopsis* cf. *ovata* bloom dynamics

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ABSTRACT

In the last few decades, *Ostreopsis* spp., toxic benthic dinolagellates of tropical origin, generated large interest in the Mediterranean Sea, where several bloom events have been observed. Ecology and proliferation dynamics of *O.* cf. *ovata* are driven by complex interactions among biotic and abiotic drivers, and understanding mechanisms triggering bloom events is still far from being complete. The aim of the present study is to highlight the role of different habitat conditions, elucidating the effects of i) exposure to hydrodynamic conditions, ii) macroalgal community and iii) urbanisation level, in driving *O.* cf. *ovata* bloom dynamics. A significant effect of hydrodynamics was observed only for cells in seawater, with higher abundances in sheltered zones, irrespective of the urbanisation level. Similarly, a significant effect of the dominant macroalgal community, with higher abundances in Corallinales and turf dominated communities, and lower ones in *Cystoseira amentacea* canopies, has been recorded, consistently in the differently urbanised sites. Additionally, stretches of the coast suffering from a more intense anthropic exploitation are in general more prone to the proliferation of potentially toxic benthic microalgae. All these results imply a larger risk exposure to toxic effects for humans in urban beaches and sheltered areas, usually more attended by swimmers and bathers. These findings underline the need to preserve, and eventually restore, canopy dominated assemblages, which presently are under regression because of human threats, providing a straightforward example that restoration of relevant habitats implies a cascading improvement of human welfare.

1. Introduction

A large interest on *Ostreopsis* spp., benthic toxic dinoflagellates of tropical origin, increased in the last few decades also in the Mediterranean Sea (Penna et al., 2005; Aligizaki and Nikolaidis, 2006; Mangialajo et al., 2008a; Penna et al., 2010; Rhodes, 2011) as a consequence of the large bloom events that occurred in several coastal areas. The origin of the occurrence of this genus along Mediterranean coasts is controversial: it could have been introduced by human maritime activities (*e.g.* ship's ballast waters, translocation of molluscs through aquaculture practice, fouling) like other dinoflagellates (Hallegraeff, 1993) or could have been already present as a rare species (Totti et al., 2010; Penna, 2014). In both cases, the increase in average seawater temperatures, due to global warming, provided favourable conditions for its proliferation (Occhipinti-Ambrogi, 2007).

In the Mediterranean Sea, three genotypes, corresponding to the morphotypes *O.* cf. *ovata*, *O.* cf. *siamensis* and *O. fattorussoi*, have been recorded to date (Penna et al., 2010, 2012; Accoroni et al., 2016).

The dominant species in the Mediterranean area is *O.* cf. *ovata* (Battocchi et al., 2010; Perini et al., 2011) that, in the last few decades, produced several bloom events, in particular in Spain (Vila et al., 2001), France (Mangialajo et al., 2011; Cohu et al., 2013), Italy (Ciminiello et al., 2006; Mangialajo et al., 2008a; Totti et al., 2010), Croatia (Pfannkuchen et al., 2012) and Greece (Aligizaki and Nikolaidis, 2006). This is an emerging issue also in the southern Mediterranean, where proliferations have occurred along the coasts of Algeria (Illoul et al., 2012), Tunisia (Turki et al., 2006) and Egypt (Ismael and Halim, 2012).

Some of the most noxious events in the Mediterranean Sea have been recorded along Italian coasts and, in particular, the first noteworthy bloom occurred in 2005 along Genoa coastline, causing more than 200 reported intoxication records with symptoms such as skin erythema, respiratory problems, colds, fever, nausea and conjunctivitis (Ciminiello et al., 2006; Mangialajo et al., 2008a). Noxious effects are due to the production of palytoxin-like compounds (ova-toxins), which represent a threat for human health, especially when cells are resuspended from their benthic habitat into surface seawater (Vila et al., 2001; Totti et al., 2010), where they are more likely to affect people via direct contact and inhalation of aerosols.

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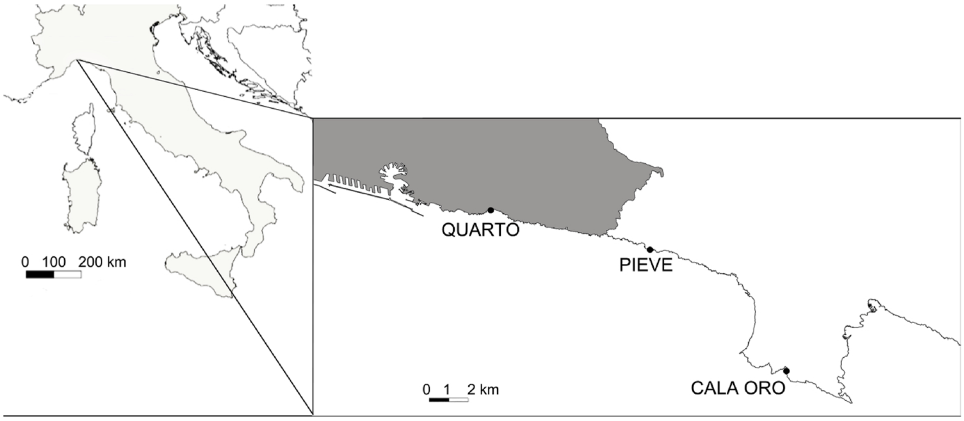

Fig. 1. Sampling sites located along Genoa coastline, Italy – NW Mediterranean.

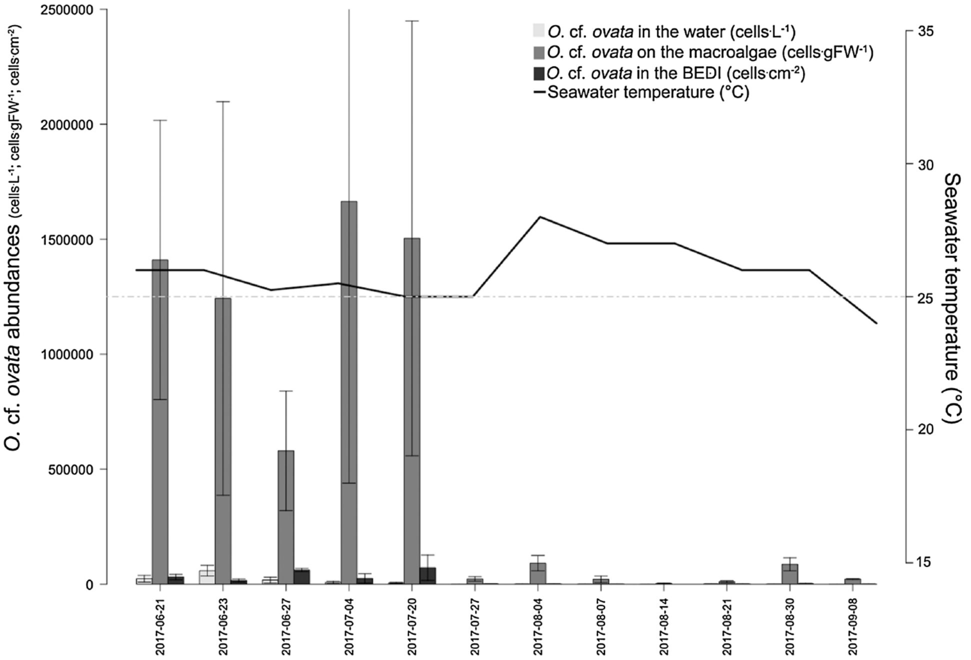

Fig. 2. *Ostreopsis* cf. *ovata* abundances in Quarto dei Mille during summer 2017 for the three matrices: cells in the water (pale grey), cells on macroalgae (grey) and potentially resuspended cells (dark grey); black line reports seawater temperature.

For this reason, techniques applied for monitoring and risk assessment usually focus on quantification of cells in the water (cells × L^{-1}), often named planktonic pool, and alarm thresholds are generally set for the water matrix (Tichadou et al., 2010; Lemée et al., 2012; Vila et al., 2012; Funari et al., 2015). Nevertheless, since *O.* cf. *ovata* is a benthic dinoflagellate, which proliferates on shallow sea bottoms, in particular on macrophytes, invertebrate shells and pebbles (Totti et al., 2010; Accoroni et al., 2015; Accoroni and Totti, 2016), the quantification of cells in the biofilm over these substrates (expressed as cells × gFW^{-1} of macrophyte or cells × cm^{-2} of shell/pebbles surface) is more representative of the actual stock (see GEOHAB et al., 2012; Tester et al., 2014; Jauzein et al., 2016). A specific sampling strategy and the definition of benthic alarm thresholds are still debated and a general consensus is strongly needed (Giussani et al., 2017).

Ecology and proliferation dynamics of *O.* cf. *ovata* are driven by complex interactions among biotic (intra and inter-specific relationships) and abiotic drivers (environmental and meteorological variables). In particular, the mechanisms underlying its detachment from the benthic substrate are still unclear and difficult to describe: cells can move into the water column due to mechanical actions (e.g. waves, anchoring and trampling) or physiological dynamics (e.g. high densities, growth phase).

Several environmental parameters have been recognized to strongly drive bloom dynamics, such as hydrodynamics, water temperature and nutrients (Vila et al., 2001; Shears and Ross, 2009; Totti et al., 2010; Mabrouk et al. 2012; Mangialajo et al., 2011; Cohu et al., 2013). The role of seawater temperature has been largely addressed and this variable is acknowledged as one of the main drivers of bloom occurrence (Accoroni et al., 2012; Selina et al., 2014; Ottaviani et al., 2015; Asnaghi et al., 2017), with marked differences at the basin level for the Mediterranean Sea: in the Northern Mediterranean Sea, bloom generally occur when seawater temperature exceeds 24–26 °C in the Western basin (Mangialajo et al., 2008a; 2011; Cohu et al., 2013), or, conversely, in the Adriatic Sea, when temperature is in the range of 17–22 °C (Totti et al., 2010). Differently, the role of nutrients is controversial: some authors did not find any relationship between *O.* cf. *ovata* abundances and nutrients (Vila et al., 2001 and Cohu et al., 2011 for the NW Mediterranean Sea; Shears and Ross, 2009 in NE New Zealand), while others observed a possible positive correlation with phosphates (Accoroni et al., 2015 in the N Adriatic Sea; Asnaghi et al., 2012 in the NW Mediterranean Sea). Conversely, a depletion of nitrites and nitrates has been observed as a consequence of bloom events

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