DINOFLAGELLATE RESTING CYSTS FROM SURFACE SEDIMENTS OF THE NORTH-EASTERN ADRIATIC AND THEIR POTENTIAL SPREADING PATTERNS

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Abstract
Dinoflagellate resting cysts from surface sediments of the North-Eastern Adriatic were studied and their potential spreading pattern hypothesised. Each taxa was associated with one of the two potential spreading pattern, natural or anthropogenic.

Keywords: Dinoflagellates, Phytobenthos, NIS, Circulation, Adriatic Sea

Benthic cysts play a vital role in dinoflagellates' ecology as they allow survival through adverse environmental conditions (nutrient depletion, temperature decrease, high turbulence). Ballast waters (BW) are a proven vector of spreading phytoplankton species over large distances across oceans. The Adriatic (Fig.1.), a basin located in the northernmost part of the Mediterranean, is an important inter/national seaway subjected to intense maritime traffic, and its ports, potential hotspots of non-indigenous species (NIS) introductions.

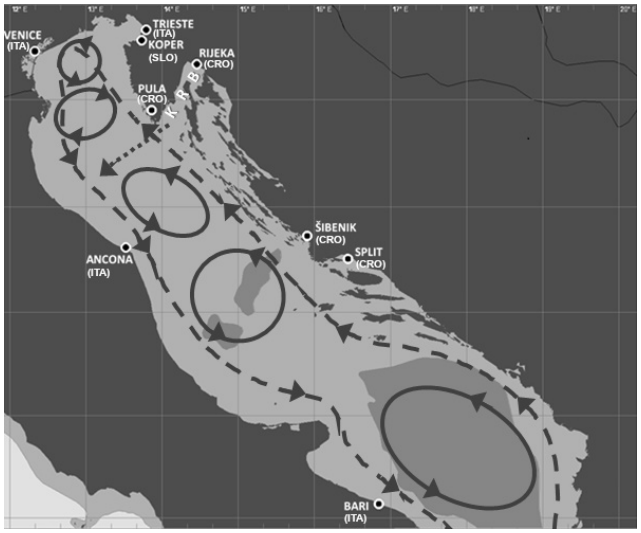

Fig. 1. Map of the Adriatic with investigated ports and Kvarner and Rijeka Bay (KRB) and schematics of Adriatic surface circulation pattern [2]; general circulation (dashed line), gyres (solid), Bora induced current in KRB (dotted).

In 2014 and 2015, a study of dinoflagellate cysts was included in Port Baseline Surveys (PBS), conducted in 9 Adriatic ports (Fig. 1.). Here we present an inventory of dinoflagellate cysts observed in the ports of Pula and Rijeka, and Kvarner and Rijeka Bay (KRB) [North-Eastern Adriatic (NEA)], during surveys in 2011 (May, August), 2014 (September, December) and 2015 (February, April, May, July, November) [1,2]. Only taxa determined to the species level are discussed.

Dinoflagellate cyst inventory (Tab. 1.) includes 20 taxa. Upon investigation of their presence in other 7 ports [1] and available literature [references in 1], we hypothesised their introduction to be either natural - by circulation pattern - or anthropogenic - by BW. Accordingly, we allocated each taxa to one of the following six groups (Tab. 1.). (1) Inconclusive - cysts are widespread across the Adriatic. (2) Natural - from NE region (including ports of Trieste and/or Koper) as cysts were observed in KRB; points to recent spread as not observed in ports of Pula nor Rijeka. (3) Natural - from NE region or the port of Split as cysts were observed in NEA. (4) Either – natural, into port of Rijeka over the KRB from NE region or anthropogenic, followed by spreading from port of Rijeka over KRB further into NE region, as cysts were observed in KRB and port of Rijeka. (5) Anthropogenic - as cysts were absent from KRB where would potentially remain during natural spread. (6) Almost certainly anthropogenic - as no observation anywhere else in the Adriatic was reported.

Tab. 1. Check-list of observed taxa in the ports of Pula (P) and Rijeka (R), and Kvarner and Rijeka Bay (B) with indication of potential toxicity (large T). Taxa were checked for presence in literature (LIT.) in Adriatic regions (Reg.) in vegetative stage (veg.), and as cysts observed in other ports. Regions, with endorsing ports, are abbreviated as follows: north-western (NW) - Venice (V), mid-western (MW) - Ancona (A), south-western (SW) - Bari (B), north-eastern (NE) - Trieste (T) and Koper (K), mid-eastern (ME) - Split (S) and Sibenik (Si), and south-eastern (SE) - no PBS data. Grey field indicates presence. According to hypothesised introduction, each taxa is allocated to one of six groups (G).

TAXA	LIT. veg. G	LIT. veg. Reg.	PBS cysts Reg.	P	B	R
Alexandrium affine T	6			■		■
A. minutum / affine / tamutum T	5	NW NE MW ME SW	V T,K A S,Si B -	■		■
A. tamarense / catenella T	5	NW NE SW SE	T,K S,Si B -	■		■
Gonyaulax scrippsae	4	NW NE MW SW	T S,Si -		■	■
Gonyaulax spinifera T	4	NW NE MW ME SW SE	V T,K S,Si B -		■	■
Gyrodinium impudicum T	4	NE	T,K S -		■	■
Lingulodinium polyedra T	1	NW NE MW ME SW SE	V T,K A S,Si B -	■	■	■
Polykrikos hartmanii	6		 B -	■		■
P. schwartzii / kofoidii	2	NW NE MW ME SW SE	T,K -		■	
Preperidinium meunieri	6		S B -			■

TAXA	LIT. veg. G	LIT. veg. Reg.	PBS cysts Reg.	P	B	R
Protoceratium reticulatum T	4	NW NE SW	T,K S -		■	■
Protoperidinium claudicans	4	NW NE	 B -		■	■
Protoperidinium compressum	3	NW NE MW SW	 S B -	■	■	■
Protoperidinium conicum	5	NW NE MW ME SW SE	T,K S -	■		■
Protoperidinium oblungum	5	NW NE MW SW SE	T -	■		
Pyrodinium cf. *bahamense* T	6	MW	 -		■	
Pyrophacus steinii (cf.)	4	NE SW SE	 -		■	■
Scrippsiella acuminata T	4	NW NE MW ME SW SE	T,K S,Si -		■	■
Scrippsiella crystallina	2	NE	T,K -		■	
Scrippsiella lachrymosa	2	NW NE MW SW	T,K B -		■	

Conclusion

Alexandrium affine and *Pyrodinium* cf. *bahamense*, two NIS and potentially toxic taxa were observed in the investigated area (the latter was reported before in MW region). Further 2 taxa were identified as NIS, *Polykrikos hartmanii* and *Preperidinium meunieri*, and 7 as potentially toxic. As such, NEA poses threat to the remainder of the Adriatic. BW facilitate spreading of potentially harmful species to more distant areas where natural spread would be doubtful.

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References

1 - Di Poi E., Kraus R., Cabrini M., Finotto S., Flander-Putrle V., Grego M., Kuzat N., Nincevic Gladan Z., Pezzolesi L., Riccardi E., Bernardi Aubry F. and Bastianini M., 2019. Dinoflagellate resting cysts from surface sediments of the Adriatic Ports: distribution and potential spreading patterns. *Mar. Pollut. Bull.* In press.

2 - Brajkovic A., 2017. Temporal and spatial distribution of dinoflagellate cysts in the Rijeka Bay. Juraj Dobrila University of Pula, Seminar Paper. In Croatian.