

# Foam events due to a *Phaeocystis* bloom along the Catalan Coast (NW Mediterranean)

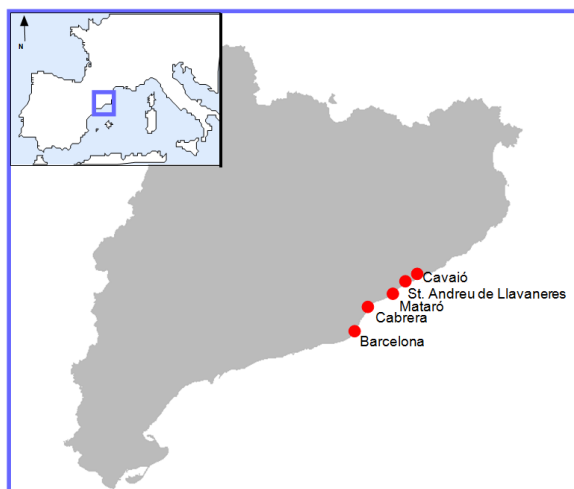


Fig.1. Location of the beaches where foams were observed.

Species of the genus *Phaeocystis* (Prymnesiophyceae) have a world-wide distribution and can produce nearly monospecific blooms. Their life cycle is generally polymorphic with free living non-motile and flagellated cells, and colonies composed of few to thousands of cells embedded in a mucilaginous matrix [1]. Massive blooms of the colonial phase have been observed in nutrient-rich waters such as those of North European coastal zones and polar regions. These blooms may cause problems for local fishing activities (because of clogging fishing nets) and are often associated with an accumulation of foam at the coast, which may have negative consequences for the tourist industry. In addition, some species may produce substances that are toxic to fish [2].

The presence of *Phaeocystis* in the Catalan Sea (NW Mediterranean) has been reported on several occasions. This

genus is an important component of the winter-spring phytoplankton community in offshore waters of the NW Mediterranean, outside of the diatom-dominated patches that develop after deep convection in the Liguro-Provençal region [3]. On the other hand, foam events have been recorded throughout the year along the Catalan coast (especially during autumn and spring), but only one observation in March 1996, off the coast of Montroig (Tarragona) had been related to the presence of *Phaeocystis* (M. Delgado, personal communication). In fact, in most cases, the occurrence of foam on the Catalan coast could not be directly associated with any particular phytoplankton species.

In March 2006, foam was observed at various locations along the central coast of Catalonia (NW Mediterranean). A foam event lasting for one day was first detected on March 19 by five ARGUS video cameras focusing on the Bar-

celona city coast (Fig. 1, 2a). These cameras started to monitor the area in 2001; in addition, since March 2002, water samples are collected regularly (usually once a month) at 8 coastal stations (1.1 to 1.4 and 2.1 to 2.4, Fig. 2a), within the framework of the Coastal Oceanographic Observatory programme (<http://coo.icm.csic.es/content/barcelonaeb>). Phytoplankton counts by inverted microscopy are routinely carried out for the surface samples of Station 1.4. One week later (March 27), the Harmful Algae Monitoring Programme (focusing on harmful and noxious species along the Catalan coast) detected foam on several beaches along approximately 40 km of shoreline to the north of Barcelona (Cabrera, Mataró, St. Andreu de Lllaneres and Cavaíó beaches; Fig. 1, 2b). Phytoplankton samples (fixed with acidic Lugol's solution) taken four days prior to foam detection (March 15) at station A (Fig. 2a), revealed the presence of high *Phaeocystis* abundance, both in surface waters and at depth (decreasing from  $1.64 \times 10^6$  cells  $L^{-1}$  at the surface to  $0.80 \times 10^6$  cells  $L^{-1}$  at 30 m depth; Fig. 3a). One day later (March 16), a phytoplankton sample (fixed with formaldehyde-hexamine) taken at Station 1.4 also revealed a very dense *Phaeocystis* population (Table 1). Similarly, water samples (fixed with Lugol's solution) from the Cabrera, Mataró, St. Andreu de Lllaneres and Cavaíó beaches presented more than  $5 \times 10^6$  cells  $L^{-1}$  of *Phaeocystis* (Table 1). High *Phaeocystis* concentrations remained in coastal waters of Barcelona for more than one month, given that high concentrations of this organism were recorded at station A on April 4, (increasing from  $0.41 \times 10^6$  cells  $L^{-1}$  at the surface to  $1.62 \times 10^6$  cells  $L^{-1}$  at the bottom, Fig. 3b), and at station 1.4 on April 27 (Table 1).



Fig. 2. a) Photography of the Barcelona coast taken with an ARGUS video camera system showing the presence of foams. Location of the sampling stations is indicated by black dots. b) Foams at the Mataró beach (Photo: Catalan Water Agency).

Table 1. Surface concentration of *Phaeocystis* cells and Chlorophyll-a (Chl-a) at sites where formation of foam was observed.

Location	Station	Date (dd/mm/yy)	<i>Phaeocystis</i> (10 <sup>6</sup> cells L <sup>-1</sup> )	Chl-a (µg L <sup>-1</sup> )	Programme/Projects
Barcelona	1.4	16/03/06	0.77	2.61	Coastal Oceanographic Observatory
Barcelona	1.4	27/04/06	0.01	0.76	Coastal Oceanographic Observatory
Barcelona	A	15/03/06	1.64	2.14	MicroRol
Barcelona	A	04/04/06	0.41	1.22	MicroRol
Cabrera	Coastal line	27/03/06	15.4		Harmful Algae Monitoring
Mataró		27/03/06	11.0		
St. Andreu de Llavanes		27/03/06	8.18		
Cavaíó		27/03/06	5.94		

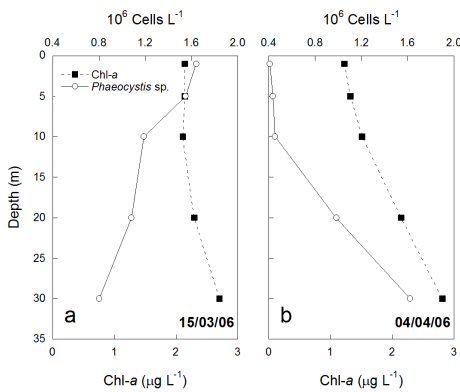


Fig. 3. Vertical profile of *Phaeocystis* sp. abundances (cells L<sup>-1</sup>) and chlorophyll-a (Chl-a) concentrations (µg L<sup>-1</sup>) at Station A (Barcelona) for a) March 15, 2006 and b) April 4, 2006.

The bloom of *Phaeocystis* was not monospecific, since high concentrations of diatoms were also found (between 10<sup>4</sup> and 10<sup>6</sup> cells L<sup>-1</sup>), mainly species of *Bacteriastrium*, *Rhizosolenia*, *Pseudonitzschia* and *Chaetoceros*. It is not clear what caused the termination of the

*Phaeocystis* sp. bloom on the Catalan Coast; potential mechanisms include colony sedimentation, microzooplankton and viral infection. A bloom of ciliates (predominantly *Laboea* sp.), observed in April 2006 on the Barcelona coast [4], suggests that ciliate grazing could have been one of the main causes for the *Phaeocystis* bloom termination.

Based on colony morphology (Fig. 4a), *Phaeocystis* sp. was first identified as *Phaeocystis globosa* [5]. However, scanning and transmission electron microscopy observations revealed neither the typical body scales described for the flagellate stage of this species (Fig. 4b and c) nor filaments of any kind. The morphological characteristics of both the colonies and the flagellated and non-flagellated free cells agree with those of a new species of *Phaeocystis* found in Mediterranean waters (*Phaeocystis* sp. 2 in [6]). However, genetic information is needed to confirm whether

the *Phaeocystis* from Catalonia is conspecific with *Phaeocystis* sp. 2.

The occurrence of the *Phaeocystis* bloom on the central coast of Catalonia was probably due to an intrusion of surface offshore aged Atlantic waters into the zone, a phenomenon related to the hydrographic changes observed in the whole NW Mediterranean during 2005 and 2006 as a consequence of two consecutive unusually dry, cold and windy winters. Information on how this hydrographic forcing affected the nutrient and phytoplankton dynamics on the Barcelona coast, as well as more details related to the bloom conditions, can be found in [7].

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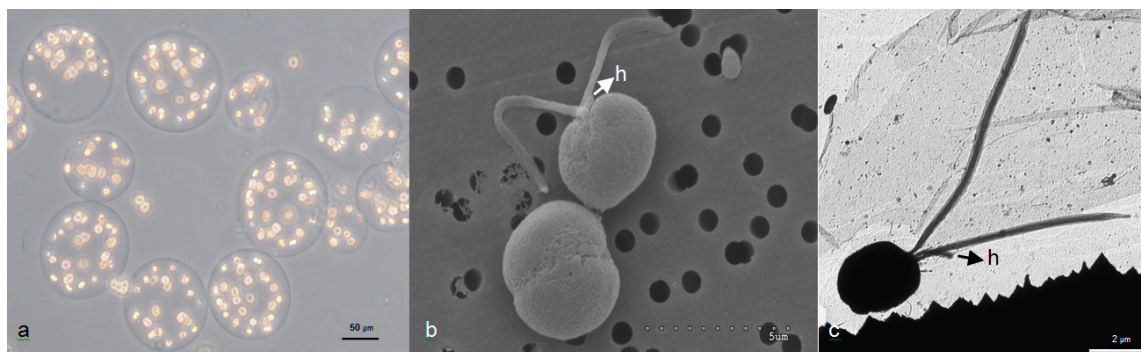


Fig. 4. *Phaeocystis* sp. colonies and cells observed at different magnifications a) Small new colonies, Light microscopy; b) Free non-flagellate and flagellate cells, SEM (Photo: Fortuño and Arin); c) Free flagellate cell, TEM (Photo: Forlani); h = haptonema.