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# NOTE

# Drifting plastic debris as a potential vector for dispersing Harmful Algal Bloom (HAB) species*

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SUMMARY: Macroscopic observations of floating plastic debris collected at several places along the Catalan coast (northwestern Mediterranean) showed conspicuous green-yellow patches adhered to them. The microscopic examination of these patches showed that they were constituted mainly of benthic diatoms and small flagellates (<20 µm). Potential harmful dinoflagellates such as *Ostreopsis* sp. and *Coolia* sp., resting cysts of unidentified dinoflagellates and both temporary cysts and vegetative cells of *Alexandrium taylori* were also found. Plastic debris is considered to be one of the most serious problems affecting the marine environment. We suggest drifting plastic debris as a potential vector for microalgae dispersal.

*Key words*: dinoflagellates, *Alexandrium*, temporary cyst, HAB, plastic debris, Mediterranean.

RESUMEN: LOS PLÁSTICOS FLOTANTES SON POTENCIALES VECTORES DE DISPERSIÓN DE ESPECIES FORMADORAS DE PROLIFERACIONES ALGALES NOCIVAS. – La observación macroscópica de la superficie de una serie de restos de plásticos flotantes recogidos en diversas localidades de la costa catalana (Mediterráneo noroccidental) reveló la presencia de conspicuas manchas amarillo-verdosas. La observación microscópica de dichas manchas mostró que estaban constituidas principalmente por diatomeas bentónicas y pequeños flagelados (<20 µm). También se detectó la presencia de dinoflagelados potencialmente tóxicos como *Ostreopsis sp* y *Coolia* sp, quistes de resistencia de dinoflagelados no identificados, así como quistes temporales y células vegetativas de *Alexandrium taylori.* Los plásticos están considerados en la actualidad como uno de los problemas mas serios que afectan el medio marino. Se sugiere que los restos de plásticos flotantes podrían ser vectores de dispersión de microalgas nocivas.

*Palabras clave*: dinoflagelados, *Alexandrium*, quistes temporales, proliferaciones algales nocivas, plásticos, Mediterráneo.

Over the past 50 years, there has been an increase in the record of plastic pollution in the world's oceans and its negative impact on the marine environment. The problems are not only aesthetic, as many fish, birds, turtles and mammals become entangled in or ingest plastic debris (see *Marine Pollution Bulletin* 18, 1987). Likewise, a relationship between drifting plastic debris and the expanding distribution of non-indigenous marine invertebrates has been established (Winston, 1982; Minchin, 1986, Barnes 2002). Major inputs of plastics to the ocean are from land (rivers and drainage systems), ship-generated litter and beachgoers (Pruter, 1987). In the Mediterranean, plastic pollution is very high due to maritime activities, tourism and growing human demography (Morris, 1980; Gabrielides *et al.*, 1991; Galgani *et al.*, 1995). Along the Catalan coast (northwestern Mediterranean) in the period 1995-2000, plastic ranged between 23 and 42% of the floating litter volume (organic matter, wood, oil, glass, paper and cloth) collected by cleaning ships. Floating plastics were always the most abundant

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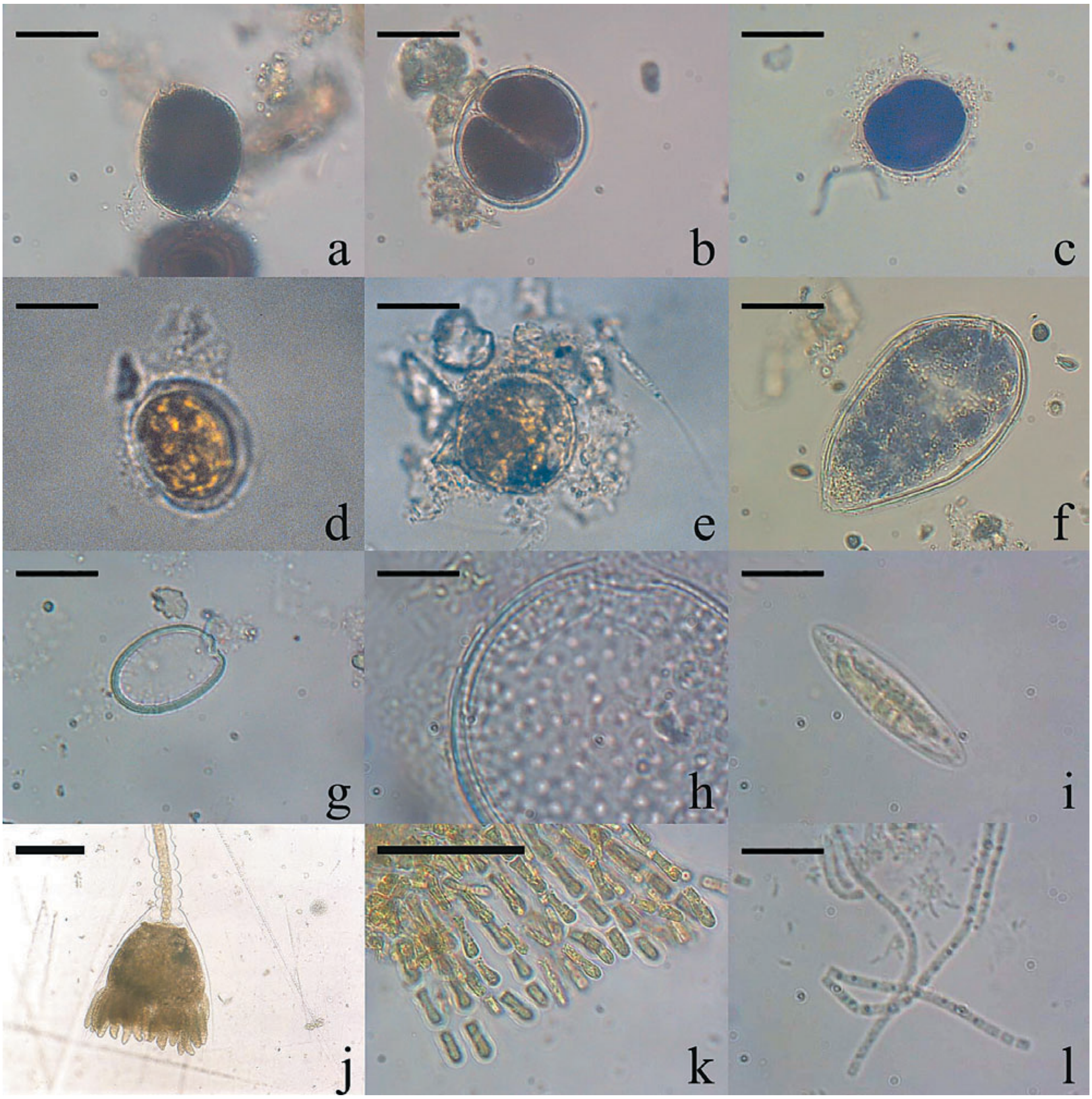


FIG. 1. – Organism attached to plastic debris. *Alexandrium taylori*: a, vegetative cells; b, division of temporary cysts; c, temporary cyst; d, e, resting cysts of unidentified dinoflagellates; f, vegetative cell of *Ostreopsis* sp.; g, empty theca of *Prorocentrum* sp.; h, i, diatoms; j, hydrozoan polyp; k, macroalgae; l, cyanobacteria. Scale bars: a,b,c,e,f,g,h,i,k,l=10 µm; d=5 µm; j=100 µm.

items (Flo and Camp, 2001). An average of 0.2 $m^3 \cdot day^{-1}$ was collected on the Costa Brava (the northern part of the Catalan coast, approx. 100 km) during this period with a maximum of 2.2 $m^3 \cdot day^{-1}$. Floating plastic debris has become one of the main environmental problems of this tourist area.

Macroscopic observations of plastic debris collected at several places along the Costa Brava have shown several organisms attached (hydropolyps, macroalgae; Figs. 1j, k) and conspicuous green-yellow patches (Fig. 2c). A detailed microscopic examination of the patches identified benthic diatoms and small flagellates (<20 µm) as the principal organisms attached (Figs. 1h, i, l). Potential harmful dinoflagellates such as *Ostreopsis* sp. and *Coolia* sp. (Fig. 1f) were also recorded as well as resting cysts of unidentified dinoflagellates (Figs. 1c, d, e). In summer 2000 during a bloom of the HAB species *Alexandrium taylori* Balech, 1994, we collected plastic (<25 $cm^2$) that littered the waterfront of La Fosca beach (Costa Brava) (Figs. 2a, b). The plastic debris were covered by vegetative cells and temporary cysts of this dinoflagellate, some of the latest undergoing cell division (Figs. 1a, b).

Experimental work on *A. taylori* cultured in plastic flasks demonstrates the tendency of the temporary cyst to attach to plastic surfaces. Its sticky nature causes the formation of rows attached to the flask walls at the medium-air interface. The culture was obtained by vegetative cell isolation from the population (strain AV7) located at La Fosca beach. The culture was maintained in f/2 medium without silica and grown at 25ºC in rooms equipped with cool-white fluorescent tubes (photon flux rate 150 $\mu E\ m^{-2}\ s^{-1}$) with a 12:12h light:darkness cycle. During a 25-day period, the increase in the number of

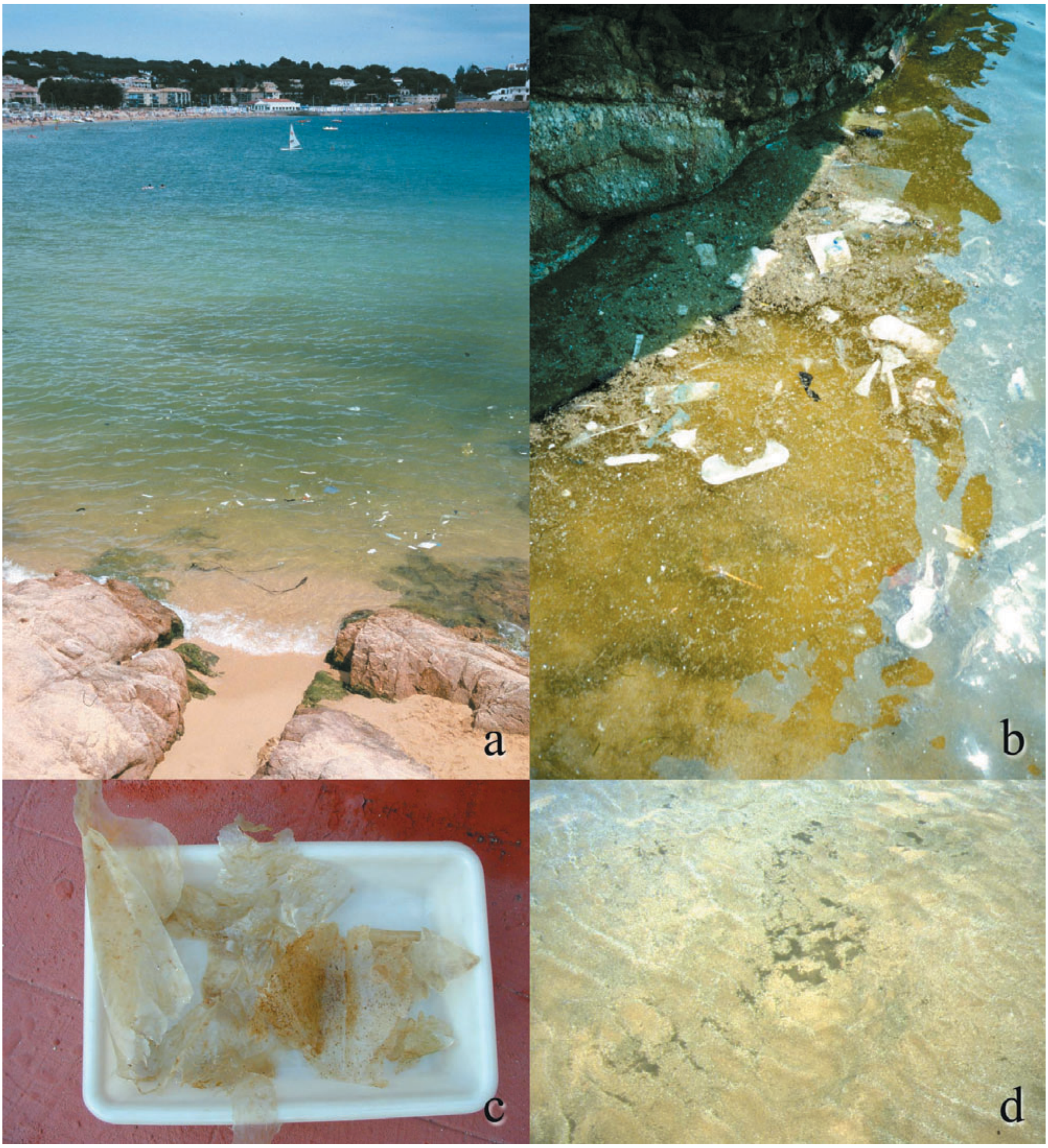

FIG. 2. – a, general view of a beach affected by a bloom of *Alexandrium taylori*; b, accumulation of plastic debris at La Fosca beach in August 2000 during the bloom of *A. taylori*; note the occurrence of floating plastic on the shoreline; c, plastic littering collected at several places along the Costa Brava showing the characteristic yellowish patches of adhered micro-organisms; d, aggregates of temporary cysts at the bottom (1 m depth) of La Fosca beach.

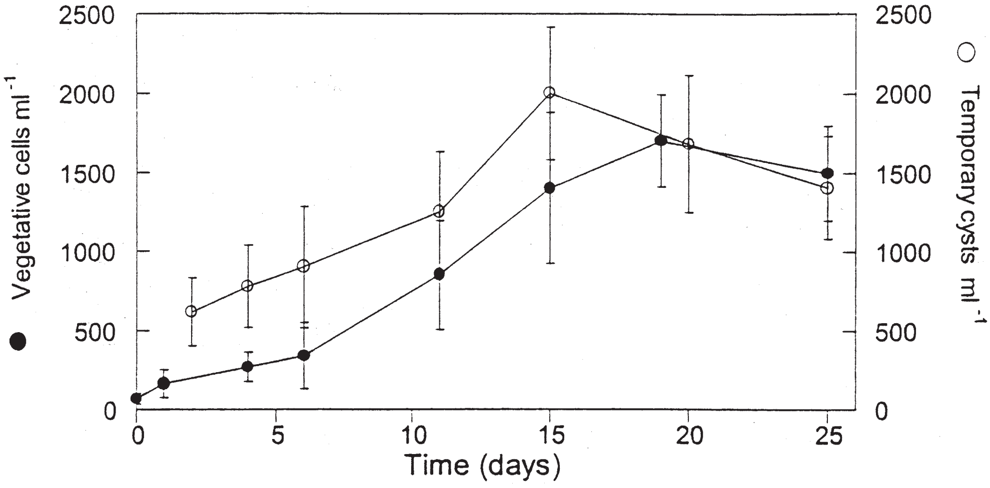


FIG. 3. – Density of vegetative cells and temporary cysts of *Alexandrium taylori* in culturing rooms at 25°C. Error bars correspond to duplicate cultures.

temporary cysts, in duplicate cultures, was assessed every 2-3 days by counting the new cells in the row. During the first 15 days, the formation of temporary cysts increased concomitantly with the number of vegetative cells (Fig. 3), but the former were more abundant (mean=62 %, min=48 %, max=74 %, n=7). Over the subsequent 10 days both stages tended to have similar densities.

Temporary cyst formation has usually been associated with unfavourable environmental conditions but for *A. taylori* the temporary cyst is an intrinsic stage of its life cycle (Garcés *et al.*, 1998). The sticky nature of the temporary cyst of *A. taylori* facilitates the formation of clusters (Fig. 2d), that permit the population to remain at the bottom and overcome short-term unfavourable meteorological conditions (Garcés *et al.,* 2002). However, stickiness could also play a relevant role in the dispersal of phytoplankton species with an adhesive stage in their life cycle (i.e. temporary cyst of *A. taylori*, resting cyst of some species or benthic dinoflagellates). Potential harmful benthic dinoflagellates are known to attach to several biological substrates such as patches of detritus (Faust and Gulledge, 1996), floating mangrove and macroalgae (Besada *et al.*, 1982; Bomber *et al.*, 1988). Some observations of plastic debris both in beaches not affected by a bloom event and in plastic debris collected offshore (20-40 m bottom depth) revealed the presence of temporary cysts of *A. taylori* among the other phytoplankton species mentioned above.

One of the recognised factors in the world-wide increase in HABs is the increase in the geographical dispersion due to the introduction of non-indigenous aquatic species by anthropogenic factors (transport of cyst in ballast water or movement of mollusc stocks from one area to another) (Scholin, 1996; Hallegraeff, 1998; Nehring, 1998; Laabir and Gentien, 1999). However, biological invasions are multiphase processes with other relevant phases, among them dispersal. Life stages that enhance species survival at the dispersal phase can greatly contribute to the success of invasion.

Waters both affected by bloom events and susceptible to litter accumulation might become meaningful sources of seed pool. We suggest that the increase in plastic debris in the marine environment (Douglas, 1987) could favour the probability of success in microalgae dispersal. Nevertheless, this hypothesis is valid only if such species are able to survive adhered to a plastic. More studies (percentage of survival, detailed studies of the biofilm adhered to the plastic, quantitative data, routes of dispersal) are necessary. It is critical in this context to evaluate the role of drifting plastic debris for dispersing HAB species in comparison with natural means (such as currents or natural debris) or other anthropogenic vectors.

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