Report of phytoplankton species producing coastal water discoloration in Uruguay

Graciela M. Ferrari*
Silvia M. Méndez*

ABSTRACT

According to monitoring studies carried out by the National Fisheries Institute in cooperation with the Air-Naval Military Base Capitán C. Curbelo in Uruguay several algal blooms were detected, causing changes in the water color. In the present work we describe these phytoplankton species which produce discoloration in Uruguayan coastal waters and their temporal and spatial distribution. Water discoloration events are mainly caused by dinoflagellates and diatoms, as well as by cyanophytes and ciliates. Most of the species found in this study were dinoflagellates that appear in spring-summer (November-March), during calm sea and soft wind conditions. In February 1994 a dinoflagellate bloom of *Gyrodinium* sp. and *Gymnodinium catenatum* Graham caused toxicity and water discoloration due to their high abundance (4×10^7 cells.l^{-1}). Most discoloration events were caused by non-toxic species and harmless, although they may cause public alarm because of their possible association with mollusc toxicity.

Key words: phytoplankton, blooms, water discoloration.

RESUMO

Registro de espécies fitoplanctônicas produtoras de descoloração no Uruguay

Em estudos de plâncton costeiro realizados no Uruguai no marco do programa de monitoramento de Maré Vermelha, do Instituto Nacional de Pesca e com a colaboração da Base Aeronaval Capitán C. Curbelo, foram detectadas várias florações de algas com alterações na coloração da água. No presente trabalho descrevem-se as espécies de fitoplâncton que provocan alterações na coloração da água, bem como sua distribuição espacial e temporal. Os eventos de descoloração na água são causados por dinoflagelados, diatomáceas, cianofíceas e ciliados. A maioria das espécies foi de dinoflagelados que ocorreram no primavera-verão (novembro a março), período caracterizado por mar calmo e ventos suaves. Estes episódios, em sua maioria, foram causados por espécies não tóxicas, se bem que provocam uma alerta ao público devido à sua associação com marés

* Instituto Nacional de Pesca. Constituyente 1497, CP 11200, Montevideo, Uruguay – E-mail: gferrari@inape.gub.uy. smendez@inape.gub.uy

vermelhas e a de moluscos tóxicos. Em fevereiro de 1994 floração de *Gyrodinium sp.* e *Gymnodinium catenatum* Graham causou toxicidade em moluscos e a descoloração da água foi devido à grande densidade de dinoflagelados (4 x 10^7 células.litro^{-1}).

Palavras-chave: florações, fitoplâncton, descoloração da água.

INTRODUCTION

Water discolorations produced by phytoplankton organisms have been reported in many areas of the world, e. g. Argentina (Carreto *et al.*, 1981), Chile (Avaria, 1982), Denmark (Kat, 1989), China (Yuzao *et al.*, 1993), Ecuador (Jiménez, 1996), Australia (Hallegraeff, 1993), and Brazil (Odebrecht *et al.*, 1995a). These episodes provoke public alert because they may be associated to the presence of toxic molluscs or other harmful effects. In the present work we describe, for first time, the phytoplankton species that produce discoloration in the Uruguayan coastal waters, their spatial distribution and period of appearance.

MATERIAL AND METHODS

During the period 1991-1997 samples were taken every ten days in five fixed stations located along the coast of Uruguay: Piriápolis, Punta del Este, La Paloma, Punta del Diablo and Chuy (Fig. 1). However, in case discoloration was detected offshore by the Air-Naval Military Base Capitán C. Curbelo during their daily flies along the coast, sent to National Fisheries Institute the information and Local Prefecture (Marine Police) or artesanal fisherman collaborate when necessary in the sampling.

Qualitative phytoplankton samples were taken with a 25 µm net by vertical hauls and fixed with neutral formaldehyde. Quantitative plankton was sampled with plastic bottles, fixed with Lugol solution and analyzed under an inverted microscope Leitz Labovert SF according to the methodology of Utermöhl (1958). Water temperature, salinity, prevailing wind and the state of the sea were also registered at each station.

RESULTS AND DISCUSSION

Comparative analysis between the different locations along the coast, showed that Punta del Este and La Paloma, were the areas mainly affected by water discoloration. Although, diatoms, ciliates, blue-green algae and dinoflagellates are responsible for these phenomena, most of them were caused by dinoflagellates (Fig.1). Soft winds and calm sea conditions were reported during all blooms. These phenomena were more frequently reported (Fig. 2), from November to March (spring-summer) however the highest frequency was observed during summer (January to March).

The color of the bloom depends on the cell concentration and the most common color found in Uruguayan waters was brownish, however some discolorations were reddish, purple, pink, beige and green (Tab. 1).

The following information includes a brief description of every species causing water discoloration in Uruguay and complementary data from each event. This is the first report of *Prorocentrum scutellum* Schröder and *Trichodesmium erythraeum* Ehrenberg for the Uruguayan Atlantic coast. Although *Microcystis aeruginosa* (Kützing) Kützing has been reported previously for the coast of Montevideo, this is the first time this species has been cited for a wider extention of the Uruguayan coast of Rio de la Plata.

Dinoflagellates

Gymnodinium catenatum Graham

(Fig. 3)

Naked and small dinoflagellate, size ranges are for solitary cells: length 34-65 µm and wide 27-43 µm and for chain forming cells: length 23-60 µm, transdiameter 27-43 µm, with terminal cells being about the size of solitary cells. The cells form lax and curved chains with 2, 4, 8, 16 cells or longer, but in the Uruguayan coast chains of up to 80 cells were observed. This is the only naked dinoflagellate known to produce PSP toxins. The equatorial girdle describes a descending spiral, which is displaced up to one fifth of the cell length. The sulcus extends from the antapex to apex, which is also surrounded by a semicircular apical ring that serves to junction with the next cell. Nucleus ellipsoidal and central. Numerous greenish chloroplasts with conspicuous pyrenoids (Balech, 1988; Taylor *et al.*, 1995).

This species is commonly associated with toxic events in several parts of the world like Spain and Portugal (Fraga *et al.*, 1993; Moita, 1993), Venezuela (La Barbera-Sánchez *et al.*, 1993), Australia (Hallegraeff *et al.*, 1989), Japan (Ikeda *et al.*, 1989) and the Phillippines (Fukuyo *et al.*, 1993).

It is an estuarine species that has been registered in the Uruguayan plankton since the period January-April (summer-autumn) 1991, associated with mollusc toxicity (Méndez *et al.*, 1993). In February 1994 a high concentration of *Gyrodinium* sp. and *Gymnodinium catenatum* ($4x10^7$ cell.l^{-1}) caused a toxic red tide (125 µg STX eq/100g tissue) near the harbour of Punta del Este, which was visible from the coast during two days.

Gymnodinium sanguineum Hirasaka

(Fig. 4)

Unarmored dinoflagellate, small to medium sized (length 50-60 µm, width 32-40 µm), pleomorphic cell, flattened dorsoventrally; typically pentagonal in shape with a broadly conical epicone and bi-lobed hipocone. Cingulum narrow in equatorial position and slightly descendent. In frontal view conic episome with rounded apex, sulcus not extending throughout the epicone, reaching the antapex forming a groove; laterals lobules are rounded. Spherical nucleus in the center part of the body. Chloroplasts yellowish, elliptical in shape, radiating from center of cell. Periplast smooth and thin (Balech, 1988).

Cosmopolitan from temperate to tropical estuarine and coastal waters. In the northern coast of Chile it has been observed in spring (October), at temperatures of 18° to 20°C (Avaria, 1982). In the Uruguayan coast wine fluff discolorations were observed twice (autumn 1991 and 1993) covering the entire beach of Piriápolis, with a water temperature of 25°C.

Noctiluca scintillans (Macarthey) Kofoid & Swezy

(Fig. 5)

The cells are large (up to 2 mm) and more or less balloon-shaped with tentacle used for phagotrophic activity. A ventral groove contains the flagellum, a tooth, and a tentacle and is connected to a cytostoma. The vacuolate cytoplasm can contain photosynthetic symbionts. Vegetative cells with eukaryotic nucleus. Gametes gymnodinioid, with dinokariotic nucleus. Chloroplasts absent (Steidinger & Tangen, 1996).

Neritic, cosmopolitan found in cold and warm waters. In India (Devassy, 1989) and Indonesia (Adnan, 1989) it has been associated with fish mortality attributed to the ammonia content in the vacuole of *Noctiluca*, such damages were not observed in Uruguay. It is very frequent in Uruguayan coast and it is characterized by its strong bioluminescence during proliferation periods. This species reached its maximum abundance in spring (December) with 10^7 cells.l^{-1} turning the water pink in color and gelatinous in texture, as was observed in China (Yuzao *et al.*, 1993).

Polykrikos kofoidii Chatton

Unarmored organisms of elongated shape, living in colonies of 4, 6, 8, 16 individuals per chain. Each length zooid 25-45 µm and transdiameter

70-90 μm. The epicone and hypocone almost equal, the sulcus forms a continuos furrow in the ventral part of the chain, extending in a slightly sinuous line from near the apex of the first zooid to the antapex of the last one. Girdle of each zooid is submedian, displaced 0.15 transdiameter. Surface of hypocone ribbed. Spherical nucleus near the center, usually every two zooids. The cytoplasm is translucent, finely granular, and filled with numerous nematocysts and vacuoles. This species is heterotrophic, an omnivorous feeder, eating crustacean larvae, copepod eggs, dinoflagellates. The epicone surface is smooth; the hypocone is striate and furrowed. Easily distinguishable from *Polykrikos schwartzii* which lacks ridges in the hypocone and has an almost equatorial cingulum (Kofoid & Swezy, 1921).

Polykrikos schwartzii Bütschli

(Fig. 6)

Colonial naked organism, composed of 4, 6, 8, 16 *Gymnodinium*-like zooids. Each individual zooid 15 μm; transdiameter 65 μm, diameter of nucleus 20 μm and length of nematocyst 10-20 μm. Epicone and hypocone almost equal. Girdle median, without displacement, the sulcus extending length of body. The number of spherical nuclei usually equals half the number of zooids of the colony. Surface smooth. Plasma is finely granular, nematocysts present, color green to rose.

Differs to *P. kofoidii* mainly by the absence of distinct longitudinal striae in the hypocone surface and the absence of girdle displacement. In *P. kofoidii* the cingulum has a displacement of 0.15 transdiameter. In addition, the cyst of these two species is different (Kofoid & Swezy, 1921). Both *Polykrikos* are marine, pelagic and neritic warm waters species. They occurred along the Uruguayan Atlantic coast during the summer-autumn period (February 1992, March 1993). It produced brownish water discolorations immediately after outbreak, changing the water viscosity and producing a gummy sensation to tact.

Scrippsiella trochoidea (Stein) Steindinger & Balech

Small thecate dinoflagellate (length 30-39 μm and transdiameter 18-23 μm), conical epitheca with short, convex apical process, collar and small neck and round hypotheca. Presence of pore plate, 4 apical lists, 3 intercalar, 7 precingular, 6 cingular lists, 5 postcingular, 2 antapical and 4 sulcal. This species has an accessory sulcal list and the 1' plate is very narrow and slightly asymmetrical. Produces a calcareous cysts (Balech, 1988).

Neritic, wide distribution that appears in summer period. This species produced water discoloration in Chile (Muñoz & Avaria, 1983), and it was associated with fish mortality by anoxia in Australia (Whitelegge in Hallegraeff, 1987). In the Uruguayan coast it formed brownish stains and cell density reached its maximum of 14×10^6 cell.l^{-1} in January 1993.

Prorocentrum scutellum Schröder

(Fig. 7)

Small to medium sized cell (large 60 µm). Rounded, heart-shaped, in the valvar surface pores has a radial distribution. Broadly curved winged anterior spine in the periflagellar area (Steidinger & Tangen, 1996).

Its distribution encompassed the Uruguayan coast from Piriápolis to Chuy forming a shallow reddish-brown coloration two nautical miles off Chuy during autumn of 1994.

Prorocentrum minimum (Pavillard) Schiller

(Fig. 8)

Small cell (large almost equals width 14-18 µm), heart-shaped, lenticular in lateral view, flattened in side view. Anterior edge with slight depression in the pore zone. Short apical spine sometimes visible. Valves with short, evenly shaped broad-based spine that can appear as rounded papillae depending on angle of view. Two sized pores present, smaller pores scattered, larger pores at bases of some peripheral spines, pores appear hooded (Balech, 1988).

Planktonic, estuarine and neritic, distributed in the whole South Western Atlantic coast. This species has been associated to mollusc toxicity in Sweden (Tangen, 1980). In Argentina (Akselman *et al.*, 1986) and in Uruguayan waters its toxicity has not been proven, although abundance of *P. minimum* reached numbers of 10^6 cell.l^{-1} in winter at La Paloma.

Diatoms

Asterionellopsis glacialis Castracane

(Fig. 9)

Cells united in dashed spiral colonies. In the southern Brazilian surf-zone conspicuous dark brown patches of this diatom were reported especially from summer to winter after rainy periods and southerly winds, tending to disappear by mid-spring (Gianuca, 1983 in Odebrecht *et al.*, 1995b). Chlorophyll *a* concentration was significantly related to south-southwesterly winds and not to rainfall nor salinity, indicating that physical accumulation of cells due to the action of onshore winds was probably the main factor controlling their abundance and variability (Odebrecht *et al.*, 1995b). Under conditions of high turbulence offshore, diatoms would grow and be accumulated in the surf-zone by the same action of southerly winds and the daily variability suggest this diatoms exhibits a diel rhythm of surface abundance.

Three of five diatoms genera (*Asterionellopsis, Chaetoceros* and *Anaulus*) have been reported to form patches in the surf-zone of exposed sandy beaches at the south-west Atlantic coast (Talbot *et al.* 1990). *Anaulus* was observed in Santa Catarina beach (Rörig *et al.*, 1997). Coastal Uruguayan outbreaks of *A. glacialis* frequently occured at Chuy beach with concentrations up to 10^9 cells.l^{-1} in spring (Baysée *et al.*, 1989). One of the bloom of this species occurred during the September to March period.

Chaetoceros spp., *Skeletonema costatum* (Greville) Cleve, *Thalassiothrix heteromorpha* var. *mediterranea* (Pavillard) Hallegraeff

Neritic and oceanic species of wide distribution, common in Uruguayan coastal waters. *Chaetoceros* is one of the largest marine planktonic genera, recognized by hedges with siliceous setae and cell forming chains. The spherical cells of *Skeletonema costatum* form narrow and long chains, separeted by processes (Fig. 10), while the fine and long cells of *Thalassiothrix* are joined forming dashed colonies. Due to their form, these three species are known to cause damages in marine cultures, like fish mortality due to the gill-nuts damage (Muñoz & Aguirre, 1989). Outbreaks of these species observed in Uruguayan coastal waters in summer and spring turned the water to a whitish color, but no harmful effects were noticed.

Otherwise *Thalassiothrix* sp. bloom was reported in September 1993 producing brownish discoloration.

Cyanophytes

Microcystis aeruginosa (Kützing) Kützing

(Fig. 11)

Microcystis is a freshwater genus, which occasionally occurs in brackish waters. It is a irregular, lobulated colony wich forms a long heavy water blooms. The cells are spherical (4-5 µm) and have many aerotopes, which result in a granular appearance (Komárek, 1991).

Yunes *et al.* (1994) observed in different regions of the Patos Lagoon (Brazil), during the summer-autumn months several outbreaks of *M. aeruginosa,* some of them associated with toxicity.

A *Microcystis* green tide was registered in Río de la Plata waters in summer, though discontinued staining was observed throughout its entire coast (Colonia-Punta del Este). In 1997, toxin bioassay analysis of a bloom in the Rio de la Plata gave positive results. This species produces microcystin (peptide toxin) which usually produces liver damage and may promote tumors.

Trichodesmium erythraeum Ehrenberg *ex* Gomont

(Fig. 12)

The colonies of this cyanobacteria consists of many trichomes (cells diameter 6-22 µm) which are bundled together parallel or twisted. The trichomes are more or less straight or curved, slightly motile (Anagnostidis & Komarek, 1988). A large fraction of the population may have trichomes in a radial or spherical form. Colonies are about 1 x 3 mm and are usually buoyant.

Broad geographical distribution. In Uruguayan waters *Trichodesmium* was registered blooming together with diatoms (*Chaetoceros* and *Skeletonema)* in La Paloma (Tab. I), floating in brown small conglomerates, as it is characteristic for this genus since oil globules and gas vesicles enable their flotation.

Ciliates

Mesodinium rubrum (Lohmann) Hamburger & Buddenbrock

(Fig. 13)

Fast swimming species (large 35-60 µm, width 50 µm) with great swimming power due to the wreath of cilias around its body. It has been observed on several occasions along the coast of Chile (Avaria, 1982), Perú (UNESCO, 1982), México (Cortés-Altamirano, 1984), Australia (Hallegraeff, 1987), China (Yuzao *et al.*, 1993), South Africa (Pitcher *et al.*, 1993), Brazil-Lagoa dos Patos (Odebrecht & Abreu, 1997). In Uruguay a brownish discoloration was observed in autumn 1993 and 1995.

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TABLE 1 – Water discoloration events observed in Uruguayan coastal waters (1991-1997), temperature, salinity and causing organisms density (cells.l^{-1}). n/d = not determinated

Date	Place	Location	Colour	T °C	Salinity ‰	Causing Organism	Density (cells.l^{-1})
15/3/91	Piriapolis	Beach	Dark red	25,0	28,0	*Gymnodinium sanguineum*	18.830.000
24/2/92	P. del Este	Beach	Brownish	25,0		*Polykrikos schwartzii* *Polykrikos kofoidii*	1.000.000
16/3/92	Montevideo	Beach	Green	-	-	*Microcystis aeruginosa*	n/d
24/2/92	La Paloma	Beach	Brown	25,0	25,0	*Polykrikos kofoidii* *Polykrikos schwartzii*	135.468
1/4/92	La Paloma		Purple	22,5	25,0	*Gymnodinium sanguineum*	n/d
24/10/92	La Paloma	Harbour	Pink	-		*Noctiluca scintillans*	1.260.000
12/11/92	La Paloma	Beach	Beige	18,0	27,5	*Chaetoceros* spp.	n/d
4/12/92	La Paloma	Harbour	Red	-	-	*Noctiluca scintillans*	9.600.000
8/1/93	Piriapolis	Beach	Brownish	21,0	28,0	*Scrippsiella trochoidea*	14.000.000
5/2/93	La Paloma		Whitish with black spots	25,0	32,0	*Chaetoceros* spp., *Skeletonema costatum*, *Trichodesmium erythraeum*	n/d
11-17/3/93	La Paloma	Beach	Whitish	24,5	31,0	*Chaetoceros* spp., *Skeletonema costatum*, *Thalassiothrix mediterranea*	n/d
12/3/93	Punta del Este	1MN from the coast	Brownish	-	-	*Mesodinium rubrum*	2.500.000

TABLE 1 (cont.)

Date	Place	Location	Colour	T °C	Salinity ‰	Causing Organism	Density (cells.l⁻¹)
25/3/93	Piriapolis	Beach	Brown	25,0	18,0	*Polykrikos schwartzii* *Polykrikos kofoidii*	n/d
28/4/93	P. del Este	Beach	Reddish	17,8	17,0	*Protoperidinium* sp.	n/d
23/9/93	Piriapolis	Beach	Brownish	13,0	25,0	*Thalassiothrix* sp.	n/d
24/9/93 14/3/94	Chuy	Beach	Brownish	14,0-23,0	18,0-30,0	*Asterionellopsis glacialis*	n/d
27/1/94	Mdeo-P.del Este	Beach	Bright green	23,0	2,0	*Microcystis aeruginosa*	n/d
20-23/2/94	Punta del Este	Harbour and beach	Red	24,0	22,5	*Gyrodinium* spp. *Gymnodinium catenatum*	$4x10^7$ 3600
14/5/94	Chuy	From 1 MN to the coast	Brown	19,0		*Prorocentrum scutellum*	460.000
30/1/95	La Paloma	Beach	green	23.5	29.2	*Trichodesmium erythraeum*	n/d
2/5/95	La Paloma	Beach	red	18.5	29.1	*Mesodinium rubrum*	n/d
7/8/95	Piriápolis	Beach	greenish	11.5	20.4	*Prorocentrum minimum*	10^5
30/1/96	35°40'LS 54°26'LW		green	18,0	–	*Trichodesmium erythraeum*	n/d
16/8/96	La Paloma		redish	12.0	–	*Noctiluca scintillans*	55.600
30/1/97	Colonia-P.del Este	coast	green	–	–	*Microcystis aeruginosa*	n/d

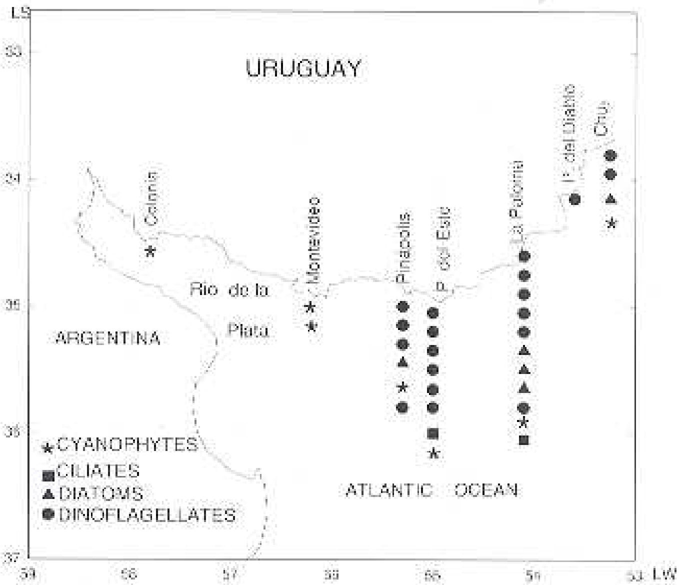


Fig. 1. Water discoloration frequency and phytoplankton taxa in each study location.

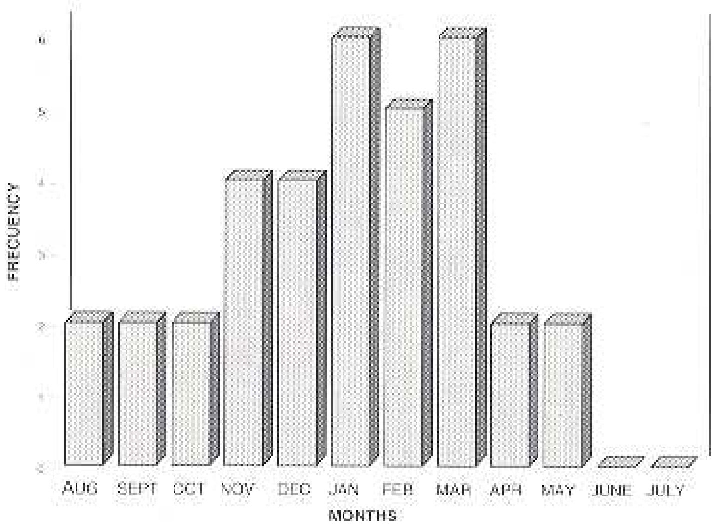
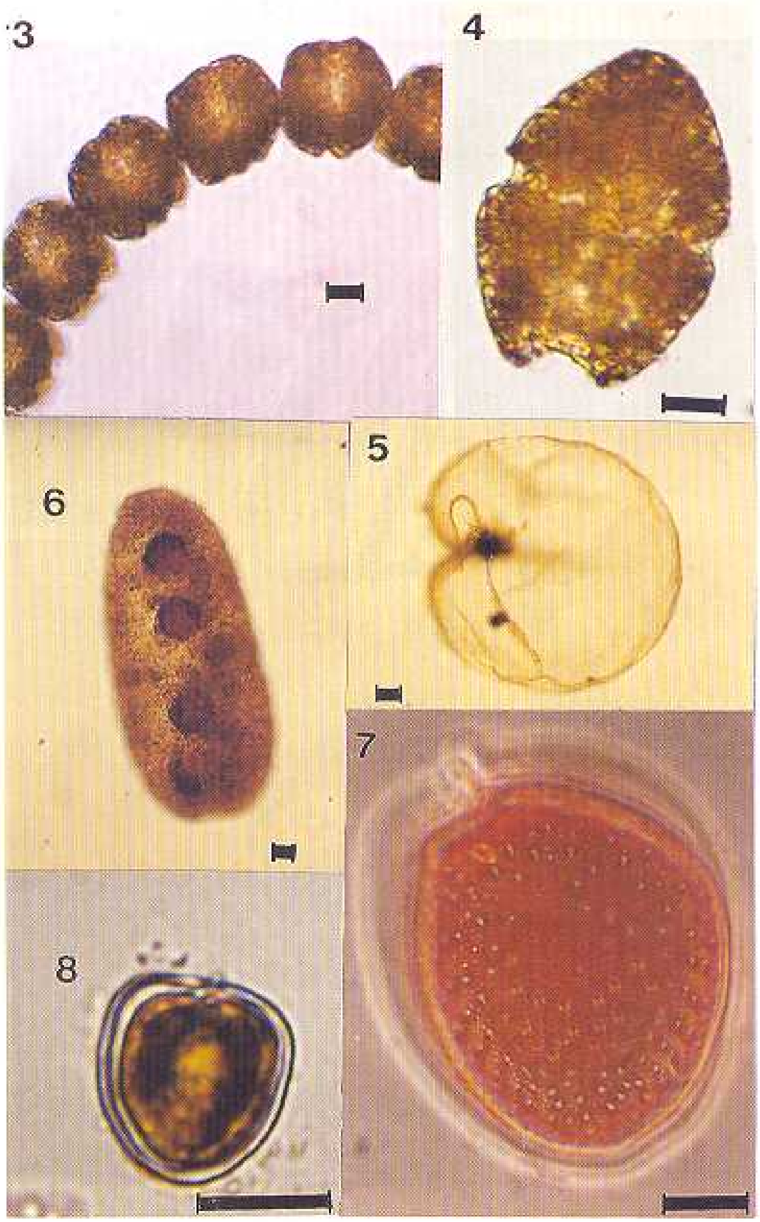
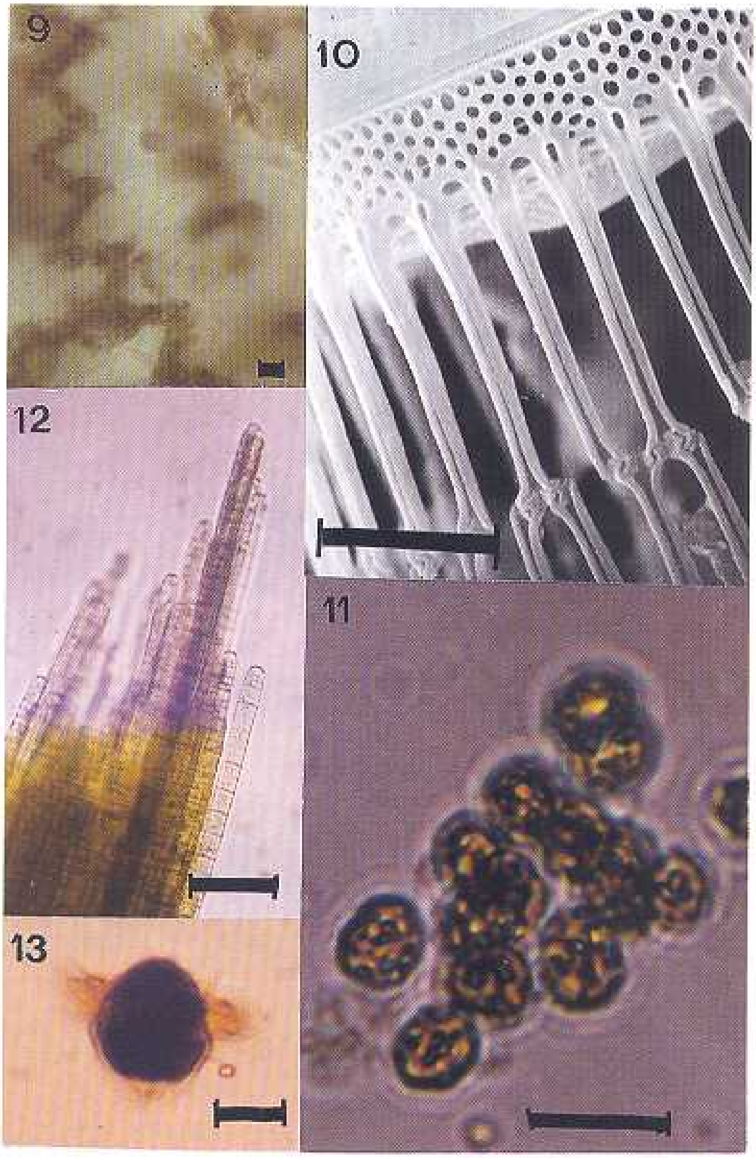


Fig. 2. Monthly occurrence frecuency of discolorations between 1991-1997 in Uruguayan coastal waters.



Figs. 3-8. 3. *Gymnodinium catenatum*; **4.** *Gymnodinium sanguineum*; **5.** *Noctiluca scintillans*; **6.** *Polykrikos schwartzii*; **7.** *Prorocentrum scutellum*; **8.** *Prorocentrum minimum*. Scale bars = 10 µm



Figs. 9-13. 9. *Asterionellopsis glacialis* (bloom); **10.** *Skeletonema costatum* (detail SEM); **11.** *Microcystis aeruginosa;* **12.** *Trichodesmium erythraeum;* **13.** *Mesodinium rubrum.* Scale bars = 10 µm, except: SEM photo (10) = 1 µm