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Potentially toxic species of the diatom genus *Pseudo-nitzschia* in Argentinian coastal waters

by

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With 25 figures and 2 tables

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Abstract: A taxonomic study of potentially toxic *Pseudo-nitzschia* species present in Argentinian coastal waters was carried out using light and scanning electron microscopy. *Pseudo-nitzschia australis* Frenguelli, *P. multiseries* (Hasle) Hasle, *P. pungens* (Grunow) Hasle and *P. pseudodelicatissima* (Hasle) Hasle were found and their temporal and spatial distribution along the Buenos Aires coast line is described. *Pseudo-nitzschia pseudodelicatissima* is reported for the first time for Argentina. The species *Pseudo-nitzschia delicatissima* (Cleve) Heiden and *P. seriata* (Cleve) Peragallo, which had been previously recorded for the country, and whose identification is likely to have been erroneous, were not found during this study. Although the other four species identified have been reported to produce domoic acid, no toxic events have been noted in samples from the Argentinian coast.

Key words: Toxic diatoms; *Pseudo-nitzschia*; morphology; distribution; Argentinian coast.

Introduction

The first human illness caused by a diatom bloom was described by Bates et al. (1989). The neurotoxin domoic acid, which was responsible for the event, was produced by *Pseudo-nitzschia multiseries* (Hasle) Hasle (Subba Rao et al. 1988). Later,

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other species of *Pseudo-nitzschia* H. Peragallo were also identified as producers of domoic acid, e.g. Martin et al. (1990) reported a toxic bloom of *Pseudo-nitzschia pseudodelicatissima* (Hasle) Hasle. In addition, Buck et al. (1992), Fritz et al. (1992) and Work et al. (1993) related the mortality of pelicans and cormorants to the presence of a *Pseudo-nitzschia australis* Frenguelli bloom. The history of toxic *Pseudo-nitzschia* blooms, the geographical occurrence of the events, and related human illnesses have been summarized by Villac et al. (1993a and b).

Later, attempts to detect the production of domoic acid in unialgal cultures of several *Pseudo-nitzschia* species also yielded some positive results. Thus, some clones of *P. delicatissima* (Cleve) Heiden, some strains of *P. seriata* (Cleve) Peragallo, *P. pungens* (Grunow) Hasle and *P. turgidula* (Hustedt) Hasle could produce small amounts of the phycotoxin (Smith et al. 1991, Lundholm et al. 1994, Rhodes et al. 1996). Other producers mentioned in the literature include seaweeds from the family Rhodomelaceae (Villac et al. 1993a, Horner & Postel 1993), and a benthic diatom *Amphora coffeaeformis* (Shimizu et al. 1989, Maranda et al. 1990).

The genus *Pseudo-nitzschia* was created by Peragallo in 1900 and published by Peragallo & Peragallo (1897-1908). Hustedt (1958) and Hasle (1965) reduced it to sectional status in the genus *Nitzschia* Hassall (*nomina conservanda* according to VanLandingham 1978). However, Hasle (1993, 1994) re-introduced *Pseudo-nitzschia* as a genus, emended the generic description and transferred 15 species and 2 forms from the genus *Nitzschia* to *Pseudo-nitzschia.* One form, *P. pungens* f. *multiseries* Hasle was raised in rank from form to species by Hasle (1995).

The genus *Pseudo-nitzschia* now includes 20 marine species and one form. Five of the six known toxigenic species have been reported for the coast of Argentina. Some of these records are reliable, such as *P. australis* described by Frenguelli (1939) based on material from the Golfo San Matías, and *P. multiseries* described by Hasle (1965) under the name of *Nitzschia pungens* f. *multiseries* Hasle based on material from Puerto Quequén and other localities.

Pseudo-nitzschia delicatissima was recorded under the name *Nitzschia delicatissima* by Carreto et al. (1974) and Verona et al. (1974), and *P. pungens* was noted by Balech (1976) and by Lange (1985). *Pseudo-nitzschia seriata* reported as being limited to the northern hemisphere (Hasle 1965, 1972), was erroneously recorded on many occasions at different points on our shores (Ferrario & Galván 1989). Taking into account the subtle morphological differences among the species of the *P. delicatissima* group and those of the *P. seriata* group, and considering that the early determinations were by light microscopy, we believe that a detailed survey of the genus *Pseudo-nitzschia* in Argentinian coastal waters was necessary.

The present study focuses on the systematics of the toxigenic species, their temporal and spatial occurrence along the Buenos Aires Province coast, and their geographical distribution in Argentina.

Materials and methods

The material studied was collected seasonally at several locations along the Buenos Aires Province coast (Fig. 1), at San Clemente del Tuyú, Santa Teresita, La Lucila del Mar, Mar de Ajó, Nueva

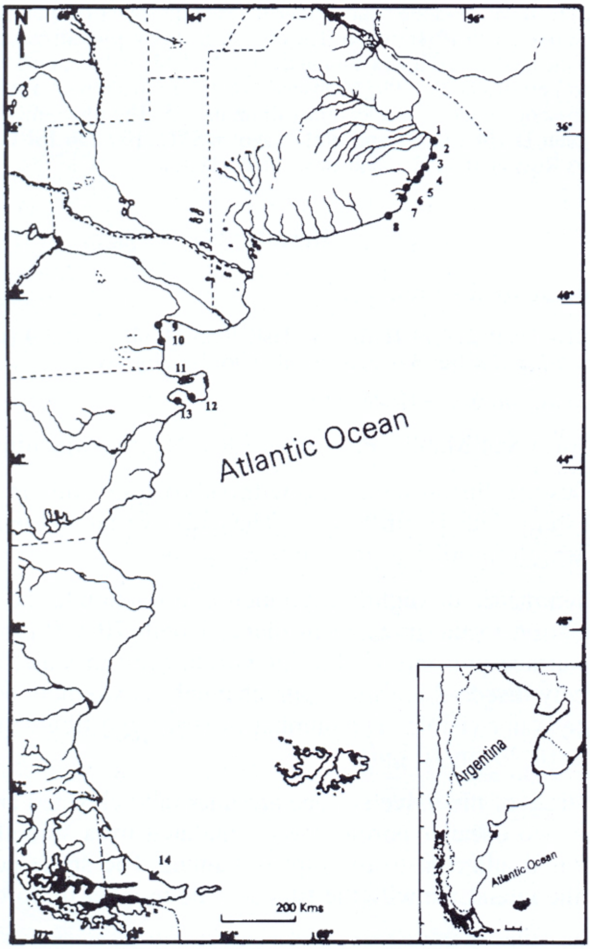

Fig. 1. Location of sampling points: 1, San Clemente del Tuyú; 2, Santa Teresita; 3, La Lucila del Mar; 4, Mar de Ajó; 5, Nueva Atlantis; 6, Pinamar; 7, Villa Gesell; 8, Mar del Plata; 9, San Antonio Oeste; 10, Las Grutas; 11, Golfo San José; 12, Puerto Pirámides; 13, Puerto Madryn; 14, Bahía Golondrina.

Atlantis, Pinamar, and Villa Gesell during October 1994-1996, and fortnightly at Mar del Plata during July 1995-June 1996. Additional collections along the Patagonian coast at San Antonio Oeste, Las Grutas, Golfo San Matías, Puerto Pirámides, Puerto Madryn, Tehuelche (Golfo San José) and Bahía Golondrina were used to complete the morphological analysis.

Type material of *Pseudo-nitzschia australis* Frenguelli, deposited in the collection of Argentine diatoms of Dr. J. Frenguelli [1] was analysed and compared with the collected material.

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Qualitative samples were taken in the near surface layer of the water column (between 0 and 5 m) with a 30 µm net and fixed with 4% formalin. The organic matter was oxidized according to Hasle & Fryxell (1970), and cleaned material was mounted for light (LM) and scanning electron microscopy (SEM) according to Ferrario et al. (1995). Observations were made with a Wild M20 and Nikon Microphot FX microscope under phase contrast illumination. The photomicrographs were taken with a Zeiss Axioplan D-7082 (LM) and with a Jeol JSMT 100 and ISI-DS 130 (SEM). The terminology follows Ross et al. (1979) and Hasle et al. (1996).

Results

Pseudo-nitzschia australis Frenguelli Figs 2-10

References: Frenguelli 1939: 217, pl. II, fig. 13. Hasle 1965:11, pl. 4, figs 3-4 ; pl. 5, figs 1-6 ; pl. 6, fig. 1. Villac et al. 1993a: 217, figs 3-5. Hasle et al.1996: 143, figs 51-54.

Synonym: *Nitzschia pseudoseriata* Hasle 1965

Type locality: Golfo San Matías, Province of Río Negro, Argentina.

LM. The frustules are linear-lanceolate with subrostrate ends in valve view and lanceolate with sharp ends in girdle view. The cells overlap in their tips for about a fourth of their length in order to form linear colonies.

The valves are symmetric or slightly asymmetric in relation to the apical plane and symmetric in relation to the transapical plane, length 70-110 µm, width 7.1- 8.6 µm. The valve surface presents visible interstriae even in water mounts, and the fibulae are scarcely discernible. The raphe channel is extremely eccentric, and the central interspace is not visible. The number of striae and fibulae is approximately the same, (11)12-16(20) in 10 µm.

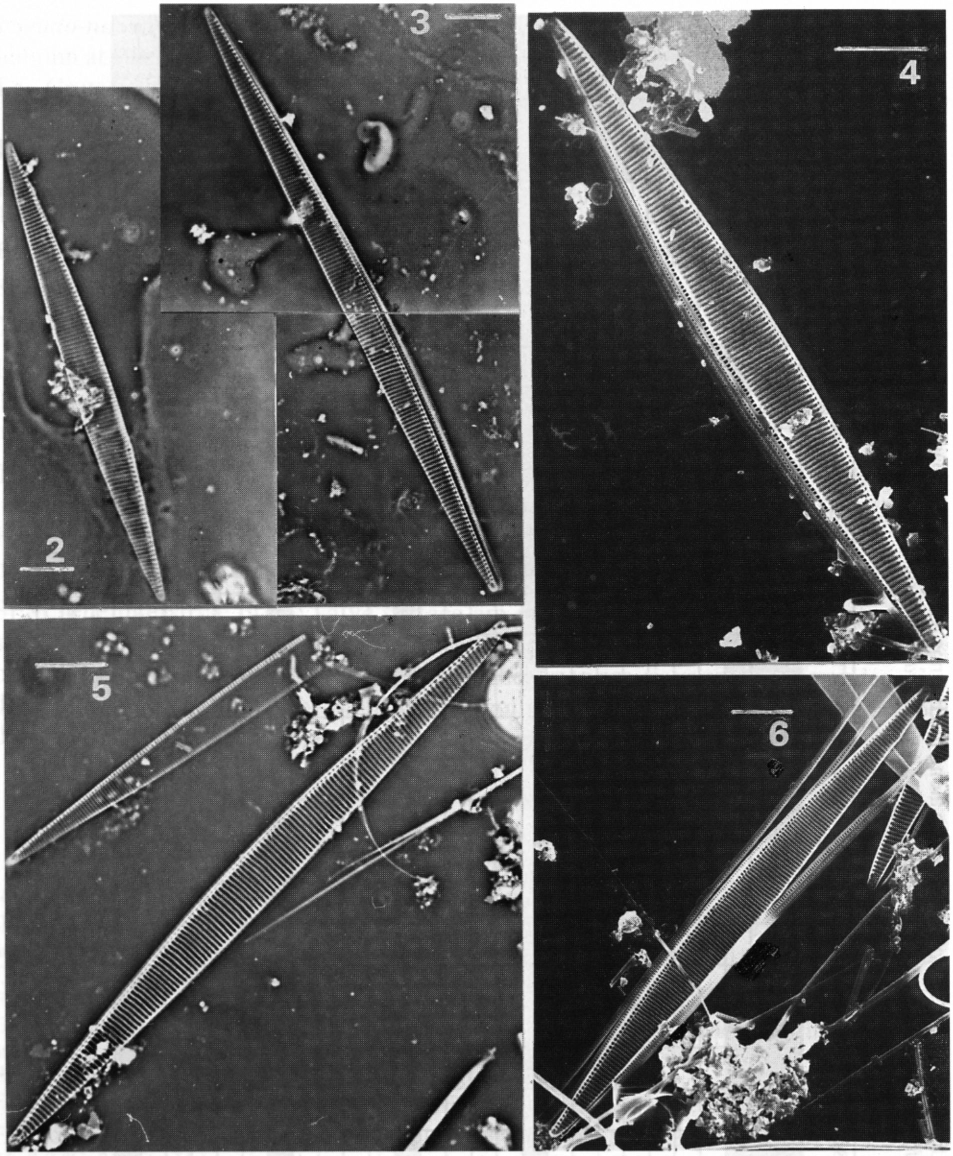
SEM. The interstriae of the valve surface are internally elevated and alternate with striae containing two circular poroid rows, separated by a smooth space. A third poroid can be found adjacent to the raphe channel. The striae coincide with the interspaces and the interstriae with the fibulae. The number of poroids is 4-5.5 in 1 µm.

The interstriae present different types of distribution at the ends of the valve.

The type material of the species does not differ from the other analysed material.

DISTRIBUTION IN ARGENTINA: This species was described by Frenguelli (1939), based on material from the Golfo San Matías. Hasle (1965) mentioned its presence at Puerto Quequén and north of Golfo San Matías as *N. pseudoseriata,* based on samples collected in June 1929 and August 1961. Lange (1985) also identified it as *N. pseudoseriata* in netplankton samples collected at different depths (40 to 1000 m) between April and December 1981, along a transect off the Argentine coast (38°12′S, 57°15′W to 39º59′S, 54°11′W). Samples containing *P. australis* occurred at water temperatures between 6.0-15.9°C and salinities from 33.45-34.16‰.

In the monitored area the species was found at San Clemente del Tuyú, Nueva Atlantis, Villa Gesell and Mar del Plata (Table 1). Water temperature in Mar del Plata samples was 7.8-8.8°C in winter and 21.7°C in summer, and the salinity 33.6-33.8‰ during both seasons (Fig. 25).



Figs 2-6. *Pseudo-nitzschia australis.* Figs 2-3. (LM).Type material. Golfo San Matías. Valve view of two specimens. Fig. 4. (SEM) Mar del Plata (38º00'1 S-57º32'5 W), 15-8-95, 8.8ºC; 33.8‰. Frustule showing the valve surface and part of the girdle with areolated band. Fig. 5. (LM) Las Grutas (Golfo San Matías), 5-6-85. Valve view. Figs 6. (SEM). Frustule in valve view and girdle bands.
Figs 2-6: scale = 10 µm.

Table 1. Temporal and spatial distribution of *Pseudo-nitzschia* spp along the Buenos Aires Province coast. a - *Pseudo-nitzschia australis*, b - *Pseudo-nitzschia multiseries*, c - *Pseudo-nitzschia pungens*, d - *Pseudo-nitzschia pseudodelicatissima*.

Station / Date	San Clemente del Tuyú				Santa Teresita				La Lucila del Mar				Mar de Ajó				Nueva Atlantis				Pinamar				Villa Gesell				Mar del Plata			
31-Oct-94						b																										
6-Jan-95																																
27-Mar-95						b	c	d						b		d	a	b	c	d		b	c	d		b	c	d				
15-Jul-95																													a		c	
30-Jul-95																													a	b	c	
15-Aug-95																													a	b	c	
31-Aug-95																															c	d
15-Sep-95																															c	
30-Sep-95																															c	
09-Oct-95																																
31-Oct-95							c				c	d						b	c	d			c				c					
15-Nov-95																																
30-Nov-95																															c	
18-Dec-95																																
29-Dec-95																																d
15-Jan-96						b				b				b				b	c			b									c	d
31-Jan-96																																
15-Feb-96																													a			d
29-Feb-96																															c	
15-Mar-96																															c	
31-Mar-96		b	c			b	c			b	c			b				b	c	d											c	
16-Apr-96																																
31-Apr-96																															c	d
15-May-96																																d
30-May-96																															c	
15-Jun-96																															c	
30-Jun-96	a		c																						a		c			b	c	

Present: a b c d

Absent

Not sampled

Pseudo-nitzschia australis was also found sporadically in summer in Tehuelche, in autumn at Puerto Pirámides, Puerto Madryn and Bahía Golondrina, and in winter at Las Grutas.

Pseudo-nitzschia multiseries (Hasle) Hasle Figs 11-14

References: Hasle 1965: 14-15, pl. 2, figs 1-2; pl. 5, figs 10-12; pl. 6, fig. 4; pl.7, figs 9-11. Hasle 1995: 428-435. Villac 1993a: 215, figs 1-2. Hasle et al. 1996: 140-142, figs 2, 7-9, 38-44.

Basionym: *Pseudo-nitzschia pungens* f. *multiseries* (Hasle) Hasle 1993.

Synonym: *Nitzschia pungens* f. *multiseries* Hasle 1974.

Type locality: Drøbak, Oslofjord, Norway.

LM. The frustules are narrow and lanceolate in valve view as well as in girdle view. The colonies have a staggered outline because ends of neighbouring cells overlap for about one-third to one-fourth of their total length.

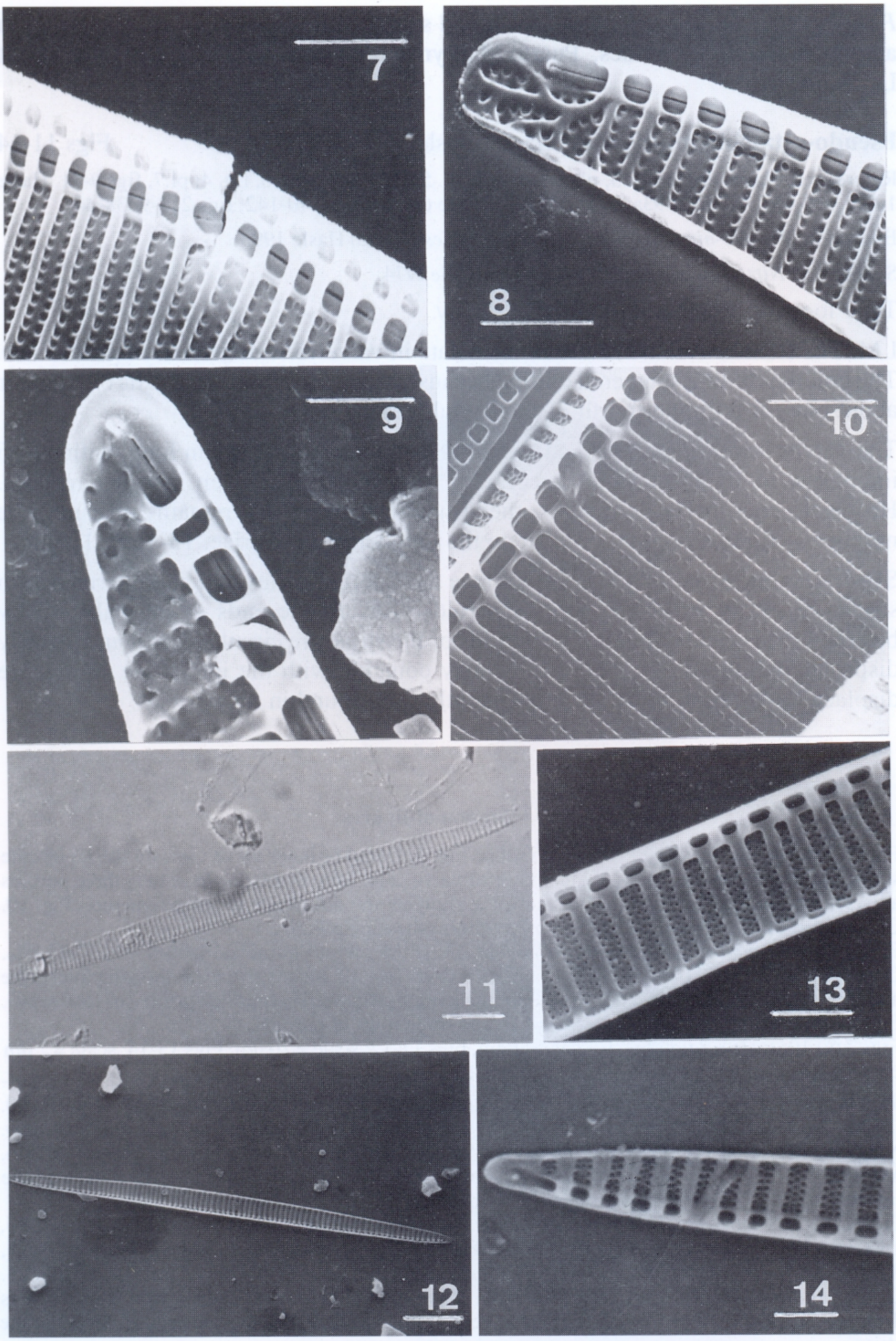
The valves have sharp ends, and are 2.8-4.7 μm wide, 60-110 μm long, with 12-16 interstriae in 10 μm, clearly discernible from the fibulae even in water mounts. However, even in Hyrax mounts, the structure of the striae remains obscure. The number of fibulae is equal or close to the number of interstriae, 13-16 in 10 μm.

SEM. The interstriae of the valve surface are internally elevated and alternate with striae, generally with 3-4 rows of poroids. Toward the ends of the valve a few biseriate striae can be found. The poroids of the striae are circular, small and densely disposed, 4-6 in 10 μm. The fibulae may coincide with the interstriae or may be displaced. No central interspace and nodule were found in this species.

Explatation of figures

Figs. 7-10. (SEM) *Pseudo-nitzschia australis.* Fig. 7. Detail of inner valve view on the raphe side showing proximal mantle. Fig. 8. Inner view of valve pole. Note that striae have may three poroids adjacent to the raphe. Fig. 9. End of one valve showing the difference in striae structure. Fig. 10. Central part of the valve with part of the cingulum, showing poroids.
Figs 11-14. *Pseudo-nitzschia multiseries.* Fig. 11. (L.M.). Pto. Pirámides, 19-9-83, 11ºC-33.8‰. General view. Figs 12-14. (S.E.M.). Pinamar, 28-3-95. Fig. 12. Inner valve view showing interstriae and fibulae. Fig. 13. Central part of valve showing multiseriate striae (poroids in three or four rows). Fig. 14. Valve pole showing striae with two and three rows of poroids.
Figs 7-8, 10: scale = 2 μm; Fig. 9: scale = 1 μm, Figs 11-12: scale = 10 μm; Figs 13-14: scale = 2 μm

Figs 15-20. *Pseudo-nitzschia pungens.* Fig. 15. (LM). Mar del Plata (38º00'1S-57º32'5W), 31-8-95, 8.8 ºC; 33.8‰. Valve view showing interstriae barely discernible from the fibulae. Figs 16-20. (SEM). Fig. 16. Bahía San Antonio, 2-10-95, 13°C; 34,19‰. Valves, internal and external view. Note biseriate striae. Fig. 17. Villa Gesell, 28-3-95. Detail of the outer valve surface. Figs 18-20. Pto. Madryn, 14-4-83. Figs 18-19. Poles of one valve. Note the small differences in the shape of the interstria. Fig. 20. Central part of the valve with biseriate striae (two rows of poroids).
Figs 21-24. *Pseudo-nitzschia pseudodelicatissima.* Fig. 21. (LM). Bahía San Antonio, 2-10-95, 13°C; 34,19‰. Valve view. Note the fibulae. Figs 22-24. (SEM). Fig. 22. Mar del Plata, 31-8-95, 8.8ºC; 33.8 ‰. Internal valve view showing the central interspace, fibulae and interstriae. Fig. 23. Golfo San Matías, 26-9-92, 10.8°C; 34.01‰. Valve end. Note rectangular poroids. Fig. 24. Las Toninas, 28-3-95. Part of the valve showing central interspace and central nodule. Note uniseriate striae.
Figs. 15-16, 21-22: scale = 10 μm; Figs. 17-20, 23-24: scale = 2 μm; Figs. 18-19: scale = 1 μm.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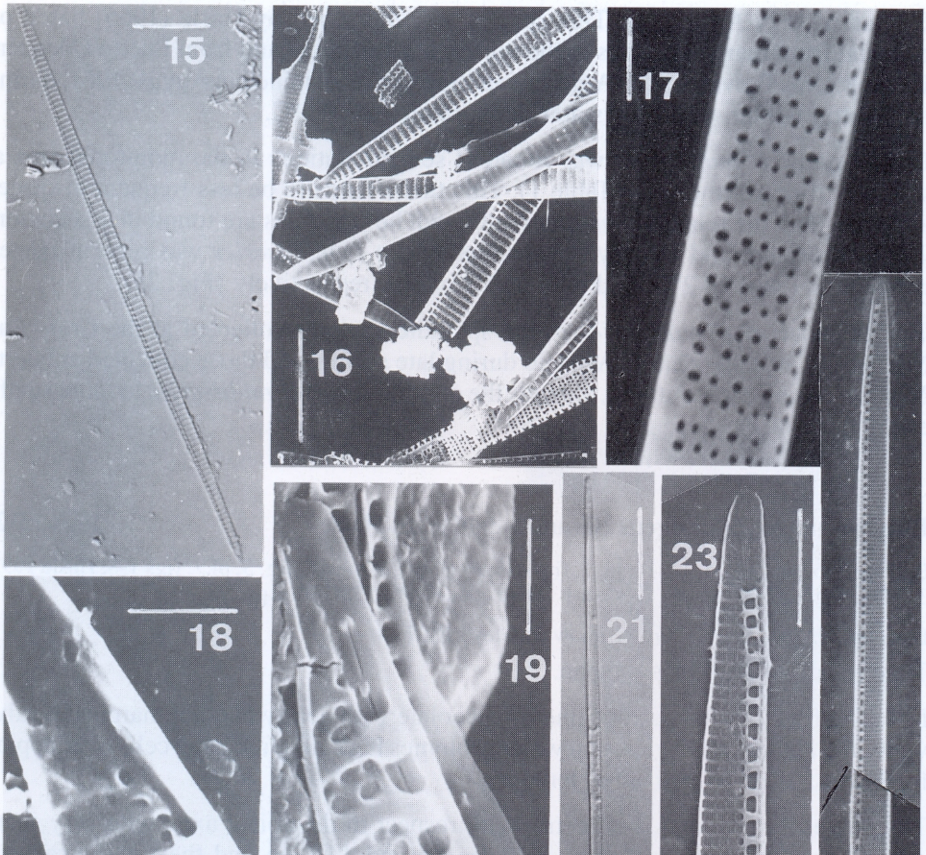
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Distribution in Argentina: This species was described by Hasle (1965) based on material from many localities in the northern hemisphere and from Puerto Quequén, Buenos Aires Province. The Argentinian sample was obtained in August 1961, during the austral winter, when the water temperature was 9.5°C.

In this study, *P. multiseries* was found at several stations in the monitored area at different times of the year (Table 1). This taxon tends to be less frequent in space and time than the related *P. pungens*, although both species are found in association. The temperature and salinity for samples where *P. multiseries* was present ranged between 8.7 and 10.2°C, and 33.6 and 33.75‰, respectively (Fig. 25).

The presence of *P. multiseries* in the sporadic samples collected at the Golfo San Matías and at Bahía de San Antonio during late spring, and those collected at Puerto Madryn during early autumn, extends the distribution of *P. multiseries* to more southern regions of the Argentine coast.

Pseudo-nitzschia pungens (Grunow ex Cleve) Hasle Figs 15-20

References: Hasle l965: 12-14, pl. 1, figs 4-5; pl. 5, figs 7-9; pl.6, fig. 3; pl.7, figs 1-8. Hasle 1993: 319. Hallegraeff 1994: 401, figs 3 a-i. Hasle et al. 1996: 138-140, figs 3-6, 30-37.

Basionym: *Nitzschia pungens* Grunow ex Cleve 1897

Type locality: Yeddo Bay, Japan.

LM. The frustules are narrow, linear-lanceolate with nearly parallel margins in valve view and lanceolate in girdle view. The colonies have neighbouring cells overlapping for about a third of their total length.

The valves are isopolar, symmetric with respect to the apical axis, with very sharp ends. The apical axis measures between 86 and 145 µm and the transapical axis between 2.8 and 4.5 µm.

The valve surface has 10 to18 striae in 10 µm, scarcely discernible from the fibulae in water mounts. The striae have 2 rows of poroids, visible in Hyrax mounts. The number of fibulae in 10 µm varies from 12 to18.

SEM. The interstriae are internally elevated and alternate with striae with 2 rows of poroids. The poroids of the striae are large, circular and irregularly distributed close to the interstriae, leaving a free and unperforated central space. The number of poroids in 1 µm is (2) 3-4.

The number of fibulae and interstriae is approximately the same. The ends of the valves present little differences in the form of the interstriae and in the distribution of the poroids. No central interspace and nodule were found in this species.

Distribution in Argentina: This species was doubtfully recorded by Balech (1976: 48) in two samples collected during the 1973 Convergencia field trip at 40°42′3″S and 54°44′W when the water temperature was 12.24°C and the salinity was 34.14‰.

Lange (1985) found *N. pungens* in netplankton samples collected at different depths (40 to 4000 m) between April and December 1981, along a transect off the Argentine coast (38°12′S, 57°15′W to 39°59′S, 54°11′W). Samples containing this species occurred in water at temperatures between 6 and 17°C and a salinity of 33.45 to 34.14‰.

In this study, *P. pungens* was found during the entire year at several stations along the coast of Buenos Aires Province (Table 1). The temperature and salinity for the area of Mar del Plata ranged between 7.8 and 21.8°C, and 33.60 and 33.87‰, respectively (Fig. 25).

Pseudo-nitzschia pungens was also found sporadically in summer at Tehuelche, in autumn at Puerto Madryn and Puerto Pirámides, and in spring at Bahía San Antonio and Golfo San Matías.

Pseudo-nitzschia pseudodelicatissima (Hasle) Hasle Figs 21-24

References: Hasle 1993: 319. Hallegraeff 1994: 405-407, figs 6 a-l. Hasle et al. 1996: 149-150, figs 26-29, 76-81.

Basionym: *Nitzschia pseudodelicatissima* Hasle 1976: 103-104.

Synonym: *Nitzschia delicatula* Hasle 1965. Hasle in Hasle & Mendiola 1967: 115.

Type locality: Denmark Strait.

LM. The frustules are very narrow and linear. The colonies have a staggered outline because ends of neighbouring cells overlap for about an eighth of their total length. The cells measure 48-110 μm in length and 1.2-2.5 μm in width.

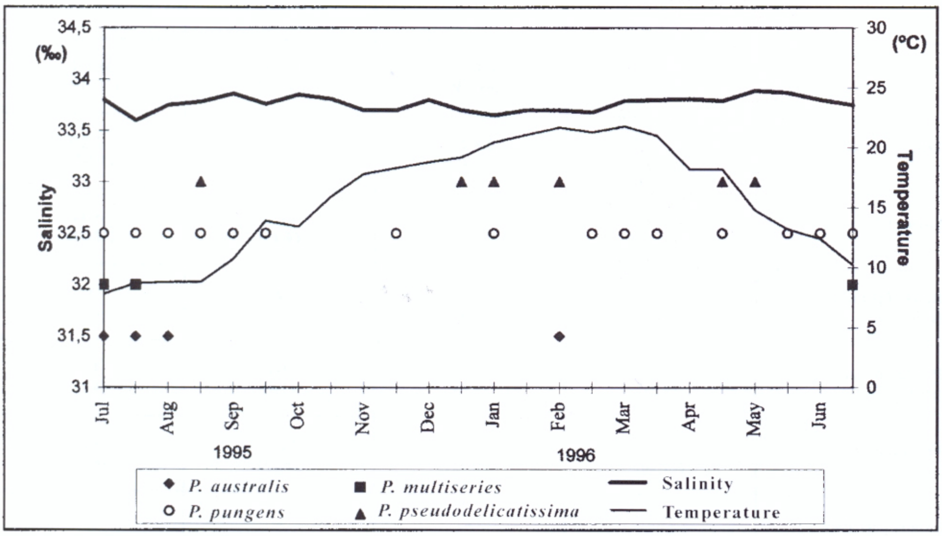

Fig. 25. Temperature and salinity conditions for *Pseudo-nitzschia* spp in Mar del Plata.
◆ ■ ○ ▲ : cells present for each species.

The fibulae of the raphe channel can be observed in valve view even in water mounts, while the striae are generally imperceptible even in Hyrax mounts. The central interspace, where the conspicuous central nodule is located, is wider than in other species.

SEM. The interstriae, 35-48 in 10 µm, are narrow and scarcely internally elevated. The striae have 1 row of rectangular poroids.

The fibulae, 17-28 in 10 µm, are considerably less numerous than the interstriae. The central interspace occupies the space of four striae and a central nodule is visible just in the middle.

Distribution in Argentina: *Pseudo-nitzschia pseudodelicatissima* is a new record for Argentina. It was found at different times of the year and at several points off the coast of Buenos Aires Province (Table 1). The temperature and salinity for the samples obtained in Mar del Plata ranged between 8.8 and 21.7°C, and 33.70 and 33.79‰, respectively (Fig. 25).

Table 2. Morphometrical and morphological data of the analised taxa.

Features \ Especies	*Pseudo-nitzschia australis*	*P. multiseries*	*P. pungens*	*P. pseudodelicatissima*
Valve view	linear lanceolate, subrostrate poles (linear lanceolate, poles sligthly rostrate)	linear lanceolate (linear to lanceolate, symmetric)	linear lanceolate (linear to lanceolate, symmetric)	linear (narrow to linear, pointed poles)
Chains overlap of the end cells	1/4 (1/3-1/4)	1/3-1/4 (1/3)	1/3 (1/3-1/4)	1/8 (1/5-1/6)
Apical axis	70-110 (75-144)	60-110 (68-140)	86-145 (74-142)	48-110 (77-108)
Transapical axis	7.1-8.6 (6.5-8)	2.8-4.7 (3.4-5)	2.8-4.5 (2.9-4.5)	1.2-2.5 (1.3-2)
Striae in 10 µm	12-16 (13-16)	13-16 (10-15)	10-18 (9-15)	35-48 (32-44)
Rows of poroids (striae)	2 (2)	3-4 (3-4)	2 (2)	1 (1)
Poroids in 1 µm (striae)	4-5.5 (4-5)	4-6 (4-6)	3-4 (3-4)	4-5 (4-5)
Fibulae in 10 µm	12-16 (13-16)	13-16 (10-15)	12-18 (9-15)	17-28 (18-24)
Central interspace	-	-	-	+

( ) Hasle et al. 1996

This taxon was also found sporadically in late spring at Bahía San Antonio and at Golfo San Matías.

Morphometrical and morphological characteristics about all species analysed are summarized in the Table 2.

Discussion and conclusions

Pseudo-nitzschia australis is morphologically similar in shape and dimensions to *P. seriata*. The most conspicuous difference between these taxa is the type of striae, biseriate in *P. australis* and between tri- and pentaseriate in *P. seriata*. Rivera (1985) proposed *Nitzschia pseudoseriata* as synonym of *N. seriata*, nevertheless the difference in the type of striae is a sufficient ultrastructural character to maintain both taxa separately.

Hasle (1965, 1972) pointed out that *P. seriata* has only been found in the northern hemisphere. On the other hand *P. australis* was described for the southern hemisphere and Hasle (1972) doubted about two reports of *P. australis* for the west coast of the USA. The presence of *P. australis* has recently been confirmed for San Diego, California (Villac et al., 1993b; Lange et al. 1994), Monterey Bay, California (Buck et al. 1992), and Washington State (Horner & Postel 1993).

Considering both the distribution reported for *P. seriata* and our own observations, we suggest that *P. seriata* and *P. australis* do not coexist in the southern hemisphere and the numerous records of *P. seriata* for Argentina are likely to be erroneous.

Another species of the *P. seriata* group with similar morphology to *P.australis is P. fraudulenta*, which is frequent along the shore off Buenos Aires Province. Both taxa have appreciable morphological differences even with the light microscope: *P. fraudulenta* has a conspicuous central interspace, it is narrower than *P. australis*, it has a greater number of interstriae and fibulae, and has bi- or triseriate striae.

Pseudo-nitzschia australis was reported for Argentinian shores at every season of the year, and under a wide range of temperatures (6.0-21.7°C) and salinities (33.45-34.16‰). Data collected by Buck et al. (1992), Walz et al. (1994) and Lange et al. (1994) allow us to conclude that seasonal and environmental conditions under which the species is found on the west coast of North America are similar to those described for the southern hemisphere, although somewhat more restricted (temperatures 11.0-14.5°C and salinities 33.3-33.5‰).

Pseudo-nitzschia pungens and *P. multiseries* are members of the *P. seriata* group, but have somewhat narrower valves, between 2.8-5.0 µm in width. This character, along with the general outline of the cells and/or the number of interstriae in 10 µm, can be observed with the light microscope. Thus, it is easy to distinguish these taxa from the rest of the species in the *P. seriata* group present on our shores.

Pseudo-nitzschia pungens is similar in shape and dimensions to *P. multiseries*, from which it can be distinguished with the phase-contrast light microscope by its more pointed ends. The biseriate striae, however, may not be observed at the light microscope level, thus requiring SEM analysis for definitive identification. In SEM, *P. pungens* shows striae with 2 rows of poroids, 2-4 in 1 µm, and *P. multiseries* striae with 3 or more rows of poroids, 4-6 in 1 µm. Rivera (1985) considered the striae of *P. pungens* as being variable, and presented Figs 9 and 13 of his work as photographic evidence. Both photos show some striae with 2 rows of poroids with a few poroids located between the main rows, but never constituting a third row as in *P. multiseries*. In populations off the Argentinian coasts, these supplementary poroids have rarely been observed in the SEM. We have only found them illustrated in Horner & Postel (1993) and illustrated and described in Hasle & Fryxell (1995) and Hasle et al. (1996). According to the criteria of these authors and of ours, the occasional presence of these isolated poroids does not devalue the importance of the type of striae as a diagnostic of *P. pungens*. Other differential characters between both species were analysed by Hasle (1995) and by Hallegraeff (1994).

Pseudo-nitzschia multiseries and *P. pungens* were reported as cosmopolitan and associated species by Hasle (1995), although they seemed to differ slightly in their seasonal occurrence. Fryxell et al. (1990) indicate that *P. multiseries* prevails in winter in Texas, and that *P. pungens* is more abundant in summer. Similar observations were made by Smith et al. (1990). Our results support this characterization for the Mar del Plata station but not for the rest of the Buenos Aires Province coast, were both species generally co-occurred at the same location. In Mar del Plata, the temperature range was more restricted for *P. multiseries* (8.7-10.2°C) than for *P. pungens* (7.8-21.8°C).

Pseudo-nitzschia pseudodelicatissima is frequently found along our shores. It is morphologically similar to *P. delicatissima*. The presence of the latter species could not be confirmed in this study, and their identification is likely to have been erroneous. There are slight differences between both taxa in valve outline and in morphology. However, this may be not enough for a reliable identification. A much more reliable character to separate these species is the type of striae, uniseriate with 4-5 poroids in 1 µm in *P. pseudodelicatissima* and biseriate with 10 to 12 poroids in 1 µm in *P. delicatissima*. Differences may be based on valve outline, on morphometric data series and on the type of velum, according to Hasle et al. (1996).

In this study, *P. pseudodelicatissima* was found at several stations of the Buenos Aires Province shores in all seasons of the year. This seasonal pattern of distribution coincides with data given for Monterey Bay by Walz et al. (1994) and for the Bay of Fundy by Martin et al. (1993). However, the temperature ranges do not coincide exactly: 10-16°C in Monterey, 0-18°C in the Bay of Fundy and 8.8-21.7°C in Mar del Plata.

The four potentially toxigenic species analysed in this study are components of the coastal plankton of Argentina. Although so far no domoic acid toxicity has been demonstrated for these species in Argentina, we believe that monitoring *Pseudo-nitzschia* species is important in anticipation of an eventual toxic bloom.

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References

BALECH, E. (1976): Fitoplancton de la Campaña Convergencia 1973. - Physis, Sec. A **35** (90): 47-58.

BATES, S.S., C.J. BIRD, A.S.W DE FREITAS, R. FOXALL, M. GILGAN, L.A. HANIC, G.R. JOHNSON, A.W. MCCULLOCH, P. ODENSE, R. POCKLINGTON, M.A. QUILLIAM, P.G. SIM, J.C. SMITH, D.V. SUBBA RAO, E.C.D. TOOD, J.A. WALTER & J.L.C. WRIGHT (1989): Pennate diatom *Nitzschia pungens* as the primary source of domoic acid, a toxin in shellfish from eastern Prince Edward Island, Canada. - Can. J. Fish. Aquat. Sci. **46**: 1203-1215.

BUCK, K.R.L., L. UTTAL-COOKE, C. H. PILSKALN, D.L. ROELKE, M.C. VILLAC, G.A. FRYXELL, L. CIFUENTES & F.P. CHAVEZ (1992): Autoecology of the diatom *Pseudonitzschia australis*, a domoic acid producer, from Monterey Bay, California. - Mar. Ecol. Prog. Ser. **84**: 293-302.

CARRETO, J.I., C.A. VERONA, A.B. CASAL & M.A. LABORDE (1974): Fitoplancton, pigmentos y condiciones ecológicas del Golfo San Matías III. - Comisión de Investigaciones Científicas de la Provincia de Buenos Aires. Contribución 237. Inst. Biol. Mar. Mar del Plata. Informe **10**: 49-76.

CLEVE, P.T. (1897): A treatise on the phytoplankton of the Atlantic and its tributaries and on the periodical changes of the plankton of Skagerrak. Nya Tidnigs Aktiebolags Tryckeri, Uppsala, 27 pp.

FERRARIO, M.E. & N.M. GALVÁN (1989): Catálogo de las diatomeas marinas citadas entre los 36° y los 60°S con especial referencia al Mar Argentino. - Dirección Nacional del Antártico, Inst. Ant. Arg. Publ. **20**: 1-327.

FERRARIO, M.E., E.A. SAR & S.E. SALA (1995): Metodología básica para el estudio del fitoplancton con especial referencia a las diatomeas. - In: Alveal, K., M.E. Ferrario, E.C. Oliveira & E. Sar (eds): Manual de Métodos Ficológicos: 1-23. Universidad de Concepción , Editora A. Pinto, Chile.

FRENGUELLI, J. (1939): XV Contribución al conocimiento de las diatomeas argentinas. Diatomeas del Golfo San Matías (Río Negro). - Rev. Mus. La Plata (n. s.) **2**, Bot.: 201-226.

FRITZ, L., M.A. QUILLIAM, J.L.C. WRIGHT, A.M. BEALE & T.M. WORK (1992): An outbreak of domoic acid poisoning attributed to the pennate diatom *Pseudonitzschia australis*. - J. Phycol. **28**(4): 439-442.

FRYXELL, G.R., M.E. REAP & D.L. VALENCIC (1990): *Nitzschia pungens* Grunow f. *multiseries* Hasle: observations of a known neurotoxic diatom. - Nova Hedwigia, Beih. **100**: 171-188.

HALLEGRAEFF, G.M. (1994): Species of the diatom genus *Pseudonitzschia* in Australian waters.- Bot. Mar. **37**: 397-411.

HASLE, G.R. (1965): *Nitzschia* and *Fragilariopsis* species studied in the light and electron microscopes. II. The group *Pseudonitzschia*. - Skr. Norske VidenskAkad. Mat.- Naturvidensk. Kl. N.S. **18**: 1-45.

HASLE, G.R. (1972): The distribution of *Nitzschia seriata* Cleve and allied species. - Nova Hedwigia, Beih. **39**: 171-190.

HASLE, G.R. (1974): Validation of the names of some marine planktonic species of *Nitzschia* (Bacillariophyceae). - Taxon **23**: 425-428.

HASLE, G.R. (1976): Examination of diatom type material: *Nitzschia delicatissima* Cleve, *Thalassiosira minuscula* Krasske, and *Cyclotella nana* Hustedt. - Br. Phycol. J. **11**: 101-110.

HASLE, G.R. (1993): Nomenclatural notes on marine planktonic diatoms. The family Bacillariaceae. - Nova Hedwigia, Beih. **106**: 315-321.

HASLE, G.R. (1994): *Pseudo-nitzschia* as a genus distinct from *Nitzschia* (Bacillariophyceae).- J. Phycol. **30**: 1036-1039.

HASLE, G.R. (1995): *Pseudo-nitzschia pungens* and *P. multiseries* (Bacillariophyceae) nomenclatural history, morphology and distribution. - J. Phycol. **31**: 428-435.

HASLE, G.R. & G.A. FRYXELL (1970): Diatoms: cleaning and mounting for light and electron microscopy. - Trans.Amer. Microsc. Soc. **89**: 460-474.

HASLE, G.R. & G.A. FRYXELL (1995): Taxonomy of diatoms. In: Hallegraeff, G.M., D.M. Anderson & A.D. Cembella (eds): Manual on harmful marine microalgae. Intergovernmental Oceanographic Commission of UNESCO Manuals and Guides 33, UNESCO: 339-364.

HASLE, G.R. & B.R.E. DE MENDIOLA (1967): The fine structure of some *Thalassionema* and *Thalassiothrix* species. - Phycologia **6**: 107-125.

HASLE, G.R., C.B. LANGE & E.E. SYVERTSEN (1996): A review of *Pseudo-nitzschia*, with special reference to the Skagerrak, North Atlantic, and adjacent waters. - Helgoländer Meeresuntersuchungen **50**: 131-175.

HORNER, R.A. & J.R. POSTEL (1993): Toxic diatoms in western Washington waters (USA, west coast). - Hydrobiologia **269/ 270**: 197-205.

HUSTEDT, F. (1958): Phylogenetische Untersuchungen an Diatomeen.- Öst. Bot. Z. **105**: 193-211.

LANGE, C. (1985): Spatial and seasonal variations of diatom assemblages off the Argentinian coast (South Western Atlantic). - Oceanol. Acta **8**: 361-370.

LANGE, C.B., F.M.H. REID & M. VERNET (1994): Temporal distribution of the potentially toxic diatom *Pseudonitzschia australis* at a coastal site in southern California. - Mar. Ecol. Prog. Ser. **104**: 309-312.

LUNDHOLM, N., J. SKOV, R. POCKLINGTON & Ø. MOESTRUP (1994): Domoic acid, the toxic amino acid responsible for amnesic shellfish poisoning, now in *Pseudonitzschia seriata* (Bacillariophyceae) in Europe. - Phycologia **33**: 475-478.

MARANDA, L., R. WANG, K. MASUDA & Y. SHIMIZU (1990): Investigation of the source of domoic acid in mussels. In: Granéli, E., B. Sündstrom, L. Edler & D.M. Anderson (eds): Toxic marine phytoplankton: 300-304. Elsevier, New York.

MARTIN, J.L., K. HAYA, L.E. BURRIDGE & D.J. WILDISH (1990): *Nitzschia pseudo-delicatissima* - a source of domoic acid in the Bay of Fundy, eastern Canada. - Mar. Ecol. Prog. Ser. **67**: 177-182.

PERAGALLO, H. & M. PERAGALLO (1897-1908): Diatomées marines de France et des district maritimes voisins. M. J. Tempère, Micrographe-Editeur, Grez-sur-Loing.

RIVERA, P. (1985): Las especies del género *Nitzschia* Hassall, sección *Pseudonitzschia* (Bacillariophyceae) en las aguas marinas chilenas. - Gayana Botánica. **42**: 9-38.

RHODES, L., D. WHITE, M. SYHRE & M. ATKINSON (1996): *Pseudonitzschia* species isolated from New Zealand coastal waters: domoic acid production in vitro and links with shellfish toxicity. In: Yasumoto, T., Y. Oshima & Y. Fukuyo (eds): Harmful and toxic algal blooms: 155-158. Intergovernmental Oceanographic Commission of UNESCO, Paris.

ROSS, R., E.J. COX, N.I. KARAYEVA, D.G. MANN, T.B. PADDOCK, R. SIMONSEN & P.A. SIMS (1979): An amended terminology for the siliceous components of the diatom cell. - Nova Hedwigia, Beih. **64**: 513-533.

SHIMIZU, Y, S. GUPTA, K. MASUDA, L. MARANDA, C.K. WALKER & R. WANG (1989): Dinoflagellates and other microalgal toxins: chemistry and biochemistry. - Pure Appl. Chem. **61**: 513-516.

SMITH, J.C., P. ODENSE, R. ANGUS, S.S. BATES, C.J. BIRD, P. COMIER, A.S.W. DE FREITAS, C. LÉGER, D. O'NEIL, L. PAULEY & J. WORMS (1990): Variation in domoic acid levels in *Nitzschia* species: implications for monitoring programs.- Bull. Aquacult. Assoc. Can. **90**: 27-31.

SMITH, J.C., K. PAULEY, P. CORMIER, R. ANGUS, P. ODENSE, D. O'NEIL, M.A. QUILLIAM & J. WORMS (1991): Population dynamics and toxicity of various species of *Dinophysis* and *Nitzschia* from the southern Gulf of St. Lawrence. - In: Gordon, D.C. Jr. (ed.): Proceedings of the Second Canadian Workshop on Harmful Marine Algae. Can. Tech. Rep. Fish. Aquat. Sci. 1799: 25.

SUBBA RAO, D.V., M.A. QUILLIAM & R. POCKLINGTON (1988): Domoic acid - a neurotoxic amino acid produced by the marine diatom *Nitzschia pungens* in culture. - Can. J. Fish. Aquat. Sci. **45**: 2076-2079.

VANLANDINGHAM, S.L. (1978): Catalogue of the fossil and recent genera and species of diatoms and their synonyms. Part. VI: 2964-3605. J. Cramer, Vaduz.

VERONA, C.A., J.I. CARRETO & A. HINOJAL (1974): Fitoplancton, pigmentos y condiciones ecológicas del Golfo San Matías II-Campaña SAO II (marzo 1971). - Comisión de Investigaciones Científicas de la Provincia de Buenos Aires, Contrib. 236, Inst. Biol. Mar. Mar del Plata. Informe **10**: 23-49.

VILLAC, M.C., D.L. ROELKE, T.A. VILLAREAL & G.A. FRYXELL (1993a): Comparison of two domoic acid-producing diatoms: a review. - Hydrobiologia **269/270**: 213-224.

VILLAC, M.C., D.L. ROELKE, F.P. CHAVEZ, L.A. CIFUENTES & G.A. FRYXELL, (1993b): *Pseudonitzschia australis* Frenguelli and related species from the west coast of the U.S.A.: occurrence and domoic acid production. - J. Shellfish Res. **12**: 457-465.

WALZ, P. M., D.L. GARRISON, W.M. GRAHAM, M.A. CATTEY, R.S. TJEERDEMA. & M.W. SILVER (1994): Domoic acid-producing diatom blooms in Monterey Bay, California: 1991-1993. - Natural Toxins **2**: 271-279.

WORK, T.M., A.M. BEALE, L. FRITZ, M.A. QUILLIAM, M. SILVER, K. BUCK & J.L.C. WRIGHT (1993): Domoic acid intoxication of brown pelicans and cormorants in Santa Cruz, California. - In: Smayda, T.J. & Y. Shimizu (eds): Toxic phytoplankton blooms in the sea: 643-649. Elsevier, New York.

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