Gobierno de Canarias
Presidencia del Gobierno
Agencia Canaria de Investigación,
Innovación y Sociedad
de la Información
Instituto Canario de Ciencias Marinas

# Discolorations of the surf zone diatom *Attheya armatus* (Centrales, Bacillariophyta) on sandy beaches in Gran Canaria (Canary Islands, Spain).

ALICIA OJEDA RODRÍGUEZ & LEOPOLDO O' SHANAHAN ROCA*

*Instituto Canario de Ciencias Marinas. Agencia Canaria de Investigación, Innovación y Sociedad de la Información. Presidencia de Gobierno. Gobierno de Canarias. Apdo. 56 Telde. 35200. Las Palmas.*

September 2012.

**RESUMEN:** En este trabajo damos cuenta de las discoloraciones producidas por acumulaciones de diatomeas en la zona de rompiente de las olas en playas de arena del sur y suroeste de la isla de Gran Canaria, que hemos estudiado entre 2000 y 2004. La diatomea bentónica *Attheya armatus* (T. West) Crawford fue la única especie identificada. En esta publicación se informa por primera vez de la presencia de acumulaciones de diatomeas de rompientes en las islas Canarias. Esta latitud es la más baja en el hemisferio norte (27º 47' N; 15º 43 W) en la que se han observado acumulaciones de diatomeas de rompientes. Anteriormente, Hewson *et al*. (2001) registraron un bloom de diatomeas de rompientes, *Anaulus australis* Drebes et Schultz, en una latitud similar pero en el hemisferio sur (27°55′S; 153°23'E). Anteriormente a nuestro trabajo y al de Hewson *et al*. (2001) solamente se habían reportado discoloraciones por acumulaciones de surf-diatom en latitudes altas. Las discoloraciones preocupan a los usuarios de las playas porque no conocen sus causas y creen que que están originadas por contaminación.

Palabras clave: Diatomeas de rompientes de las olas, *Attheya armatus*, primera cita de acumulaciones, Canarias.

**ABSTRACT**: On the southern coast of Gran Canaria island often appear extensive discolorations of diatoms in the surf zone of sandy beaches, which we have studied along a five years period (2000-2004). *Attheya armatus* (T. West) Crawford was the only species responsible for the discolorations. In this paper we record for the first time the occurrence of surf diatom accumulations in the Canary Islands. On the other hand, this is the lowest

latitude (27º47'N; 15º43W) in the northern hemisphere in which *Attheya armatus* surf diatom accumulations has been reported. Previously, Hewson *et al*. (2001) had reported a low latitude surf-diatom bloom, *Anaulus australis* Drebes et Schultz, in Gold Coast, Queensland, Australia, in the southern hemisphere (27°55′S; 153°23'E). Prior to our work and that of Hewson et al. (2001), discolorations by surf-diatom accumulations were reported only at high latitudes. Discolorations concern people who frequent the bathing beaches because they don't know its causes and believe they are caused by pollution.

Key words: Surf diatoms, *Attheya armatus*, first record of accumulations, Canary Islands.

## INTRODUCTION

The surf ecosystem has been taken to characterize the beach from the swash line to the offshore breaker line (Campbell and Bate, 1997). Surf diatoms are groups of diatoms that occur as accumulations and distinguish a very important community characterized by the tendency to form accumulations of cells, giving a typical dark green to brown colour to the water and surf foam (Lewin and Schaefer, 1983) (Figure 1).

Discolorations are caused by the localized accumulation of diatoms cells into dense patches, usually dominated by one species (du Preez and Campbell, 1997). Surf diatom patches only occur in the surf zones of sandy beaches in medium to high energy and intermediate to dissipative surf-zone. This may be associated to an epipsammic mode of existence at night. At low tide, patches of surf diatom accumulations are deposited on the wet sand of the intertidal zone (Figures 2 and 3).

*Figure 1. Accumulations of* ***Attheya armatus*** *suspended in the foam of the waves. San Agustín Beach, southeast of Gran Canaria.*

These features, together with surf-zone hydrodynamics (formation of gyres) (Figure 4) results in the high cell concentrations observed (du Preez and Campbell, 1997). Other physical qualities of the beaches where surf diatom accumulations form are: wide surf-zones (on-offshore direction); gentle slope, fine size of sand grain and an intertidal zone width of several tens of meters (Jijina and Lewin, 1984). Additionally, the surf-zone should be wide enough to generate the gyres required to accumulate the floating diatom cells into brownish green patches (Figures 1- 6).

For all these reasons, the accumulation of diatom cells is the response to physical conditions in the surf zone which concentrate the cells into the foam (Bate and MacLachlan, 1987). This is a consequence of their ability to rise into surface foam by attaching to wave-generated bubbles (Lewin and Schaefer, 1983) and maintain buoyancy in surf foam (Hewson *et al*., 2001).

*Figure 2. Las Burras. (Gran Canaria). Accumulations of* ***Attheya armatus*** *deposited on the sand at low tide. Observe the large width (approximately 100 m) of the intertidal zone at spring tide.*

According to Campbell (2012, personal communication): "The surf diatoms form those bubbles due to two processes: the cells have a thick layer of mucilage that they use to attach to bubbles. This mucilage stabilises the bubbles to some extent. Of course, while the cells are still alive they will photosynthesize and produce oxygen as well".

*Figure 3. View of accumulations of **Attheya armatus** at low tide, showing the characteristic bubbles of gas.*

*Figure 4. The beaches where surf diatom accumulations are formed have a gentle slope and a surf-zone wide enough to generate the gyres required to accumulate the floating diatom cells into brownish green patches (Playa de San Agustín, Gran Canaria).*

*Figure 5. Beaches where surf diatom accumulations formed always had wide surf-zones with medium to high energy surf conditions (San Agustín beach, Gran Canaria)*

*Figure 6. A view of Playa de Las Burras in Gran Canaria at low tide. An important feature for the formation of surf diatom accumulations in this beach is that the beach has a gentle slope and a very wide surf zone.*

According to du Preez & Campbell (1997), only six species of diatoms are involved in accumulations: *Anaulus australis* Drebes *et* Schulz; *Asterionella socialis* Lewin *et* Norris, *Asterionellopsis glacialis* (Castracane) Round; *Aulacodiscus kittonii* Arnott; *Aulacodiscus africanus* Cottam and *Attheya armatus* (T. West) Crawford which is one of the most notorious surf zone diatom (Gayoso & Muglia, 1991).

From many years ago, accumulations of *Attheya armatus* had been observed in several sandy beaches of Gran Canaria. In 2004, we described for the first time the presence of such discolorations in Canary Islands (Ojeda & O' Shanahan, 2004). Therefore, the purpose of this work was to describe the composition of the surf-zone diatoms accumulations observed over several years. In Canary Islands, beaches are the primary recreational destination for domestic and foreign tourists. For that reason, discolorations produce significant attention and concern not only to people who frequent the beaches but also to the local authorities.

On the other hand, surf diatom accumulations occasionally look like patches of oil, with the result that they are often mistaken for oil pollution (Bate *et al*., 1990 in: Du Preez & Campbell, 1997) (Figure 7) and, and also mistaken for faecal pollution (Halcrow, 2000; Hewson *et al*., 2001).

*Figure 7*

## MATERIAL AND METHODS

**Study sites.**

Discolorations were detected and investigated during five years (2000 to 2004), in four sandy bathing beaches located at the southern coast of Gran Canaria (Canary Islands, Spain): Taurito (27º 48’ N; 15º 45’ W); Meloneras (27º 44’ N; 15º 36’ W); San Agustín (27º 46’ N; 15º 32’ W) and Las Burras (27º 46’ N; 15º 33’ W). The four beaches in Gran Canaria where accumulations occur are located at the mouth of ravines that drain sporadically in the winter months (Figures 8 and 9). This beaches are delimited on both sides by a rocky coast. The coastal environment surrounding the beaches is strongly anthropized by tourist facilities like hotels, pools, gardens, etc. (Figure 19). In general, coastal waters near the mouth of the rivers might bring in larges quantities of nutrients of terrestrial origin.

On the other hand, in march 2008, samples of *Attheya armatus* discolorations were taken at Las Gaviotas beach (28º 30’ 48” N; 16º 10’ 78” W) located in Santa Cruz de Tenerife island (Canary Islands), about 100 km north west of Gran Canaria.

*Figure 8. Mouth of a ravine in Playa de Las Burras. After some days of activity, the waters have already become clear.*


*Figure 9. San Agustín Beach. The brown arrows indicate the mouth of two separate ravines.*

**Samples.**

As surf diatoms are irregular in occurrence (Lewin and Norris, 1970) samples were taken from the green brownish coloured foam (a visual indicator of large accumulation of cells) or from patches deposited on the sand at low tide (Figures 10 and 11).

*Figure 10. San Agustín Beach. Accumulations remain suspended in the surf foam of from which samples can be taken.*

*Figure 11. Appearance of a patch of Attheya armatus after several hours of exposure to air. Taurito beach, southwest of Gran Canaria.*

Table I shows the occurrence of accumulations in four beaches of Gran Canaria. As the discolorations persisted several days, appearing in the early morning and disappearing in the late afternoon *(diel* periodicity), samples were collected at approximately at 12 pm.

Table 1. Distribution of the occurrence of accumulations of *Attheya armatus* in sandy beaches of the S and SW of Gran Canaria (Canary islands) during the years 2000 to 2004.

| | Meloneras | Taurito | San Agustín | Las Burras |
|---|---|---|---|---|
| Aug-2000 | + | | | |
| Jan-2001 | | | + | + |
| July-2001 | | + | | |
| July-2002 | | + | | |
| July-2003 | | + | | |
| Jan-2004 | | | + | + |
| Feb-2004 | | | + | + |
| Mar-2004 | | | + | + |

*Attheya armatus* accumulations did not show seasonal variations. In Las Burras and San Agustín, accumulations were recorded during three successive months (January, February and March, 2004) and in Taurito, during three successive years (July 2001, 2002 and 2003) (Table I). For this reason, according to Campbell (1996), the accumulations of *Attheya armatus* may be considered as a semi-permanent feature of a number of beaches in south Gran Canaria. In fact, Table I shows only accumulations obtained between 2000 and

2004. But in almost all subsequent years up to the present, accumulations have persisted in these beaches and other beaches of Gran Canaria (Playa de Gando) and Tenerife (Playa de Las Gaviotas, in May 2008).

The identity of discolorations forming species was confirmed by light microscopy under an Olympus BX41 microscope at 40X, 60X and 100X magnification provided with an Olympus Camedia digital photo camera adapted to the microscope. Identification was based on published descriptions (Round *et al*., 1990; Crawford *et al*., 1994; 2000**).** In order to obtain the biometric data, diatom slides were examined with an inverted Zeiss research microscope, provided with a program (MICROIMAGE) which allows the acquisition of the image as well as the evaluation of the quantity and dimensions of the cells.

## RESULTS AND DISCUSSION

### Identity of discolorations.

The discolorations were composed almost exclusively by a massive aggregation of *Attheya armatus* (T. West) Crawford. Cells were rectangular in girdle view and elliptical or oval in valve view, forming chains of 7 to 14 cells, with an average of 10 cells and with two lobed plates plastids. Valves faces were a little elevated in the centre and at margins. The apical axes ranged from 23 to 32 µm and the transapical axis from 11 to 15 µm (Figures 12 and 13).

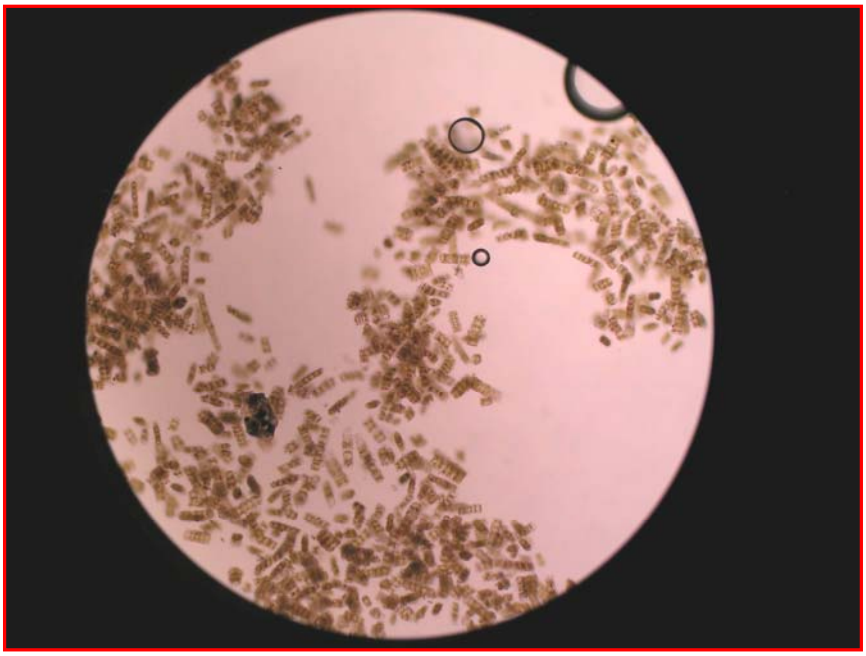

*Figure 12. Aggregations of* ***A. armatus*** *cells forming chains (microscopic view at 100X)*

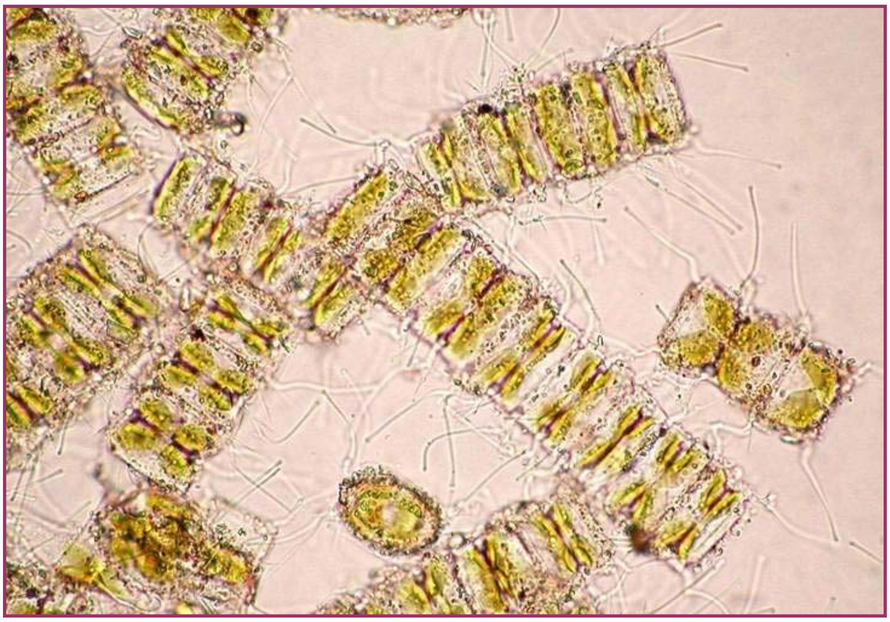

*Figure 13. Chains of* ***A. armatus*** *(1000X). Girdle view with two plastids in each cell and a single cell in valve view.*

**Global distribution**

For several decades *Attheya armatus* was thought to form accumulations only in Australia, New Zealand and the west coast of USA, but in 1991, Gayoso and Muglia reported accumulations of *A. armatus* from the east coast of South America (Campbell, 1996). A few years later, new accumulations were reported from North East Atlantic coast (Scotland and France) (Halcrow, 2000; Ifremer, 2003) and, more recently (Ojeda & O' Shanahan, 2004; 2005), accumulations were reported from Central East Atlantic (Canary Islands). Thus, Gran Canaria (27º 47' N; 15º 43' W) is the lowest latitude in the North Hemisphere where *Attheya armatus* accumulations have been reported to date. Our works (Ojeda & O' Shanahan, 2004 and 2005) are the first records of the presence of accumulations in Canary Islands. Figure 14 shows the overall distribution worldwide of the earliest records of *Attheya armatus* accumulations.

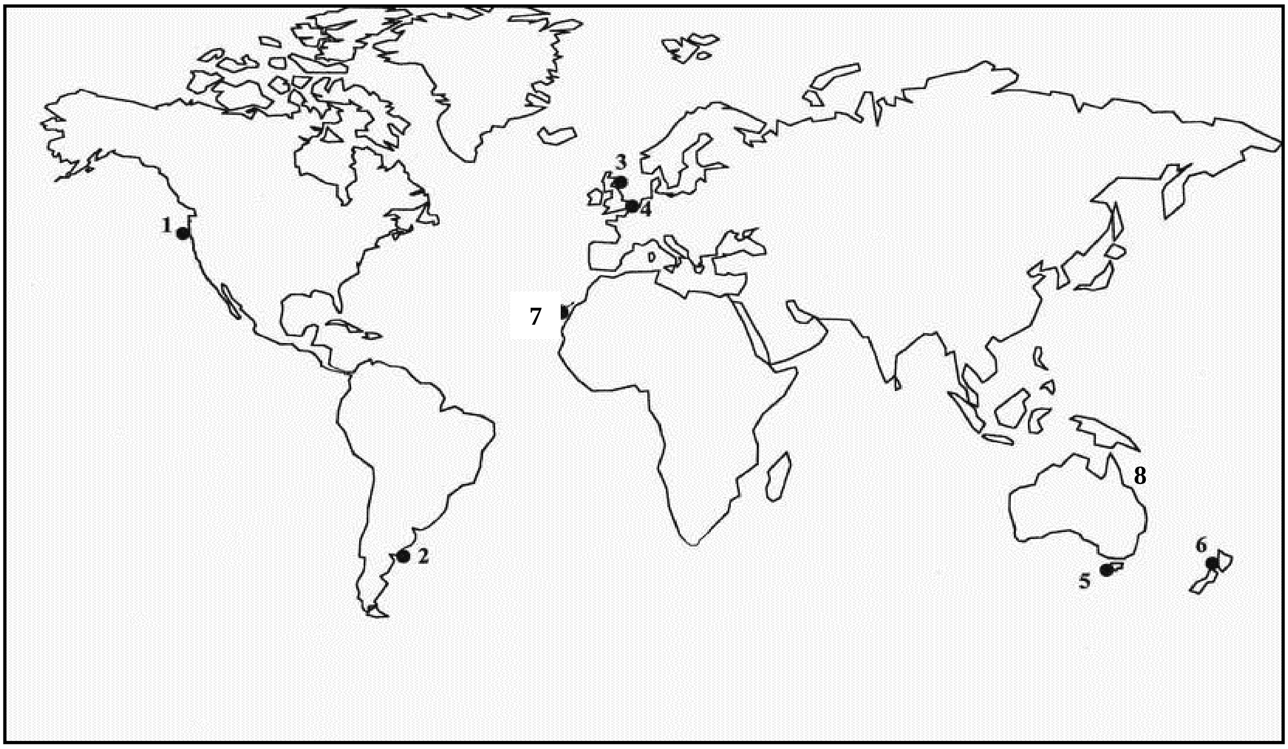


*Figure 14. Global distribution of Attheya armatus accumulations. Earliest reports (adapted from Campbell, 1996): 1. New Zealand (Rapson, 1954), 2. Oregon and Washington States (USA) (Lewin & Norris, 1970), 3. Tasmania (Lewin & Schaefer, 1983), 4. Argentina (Gayoso & Muglia, 1991), 5. Scotland (Halcrow, 2000), 6. France (French Britain) (Ifremer, 2003); 7. Canary Islands (Ojeda & O' Shanahan, 2004); 8. Accumulations of Anaulus australis on the coast of Southern Queensland (Australia) (Hewson et al., 2001)*

## Conclusions.

For many decades, accumulations of surf-diatoms had been described and registered throughout the world, both in the northern and southern hemispheres, only at high latitudes. Later, Hewson *et al*. (2001) and Ojeda & O 'Shanahan (2004) recorded accumulations at lower latitudes: 28 ° S (Queensland, Australia) (*Anaulus australis*) and 28 º N (Canary Islands) (*Attheya armatus*).

The formation of accumulations of surf-diatom requires a high concentration of nutrients in the surf-zone, not available in the seawater. A number of authors suggest that effluents from various sources and coastal aquifers may be the cause of surf zone diatoms accumulations (Bate and McLachlan, 1987; Campbell and Bate, 1996). Increased urban and agricultural pollutions of coastal will result in an increased nutrient loading into surf-zones (Campbell, 1996). On the other hand, Bate and McLachlan (1987) believed that the presence and growth of surf-diatom was not a consequence of eutrophication resulting from industrial or sewage effluent although coastal areas close to stream river outlets might bring in larges quantities of nutrients of terrestrial origin. Campbell and Bate (1991; 1996; 1998) showed that coastal aquifers can provide enough concentration of nutrients to support a high algal biomass at sandy beaches where human impacts are minimal.

The beaches studied in this work did not showed evidence of pollution produced by sewage or other sources (O' Shanahan, 2004), that would deliver a high level of nutrients, required to sustain a high algal concentration. So, according to Campbell (1996), it is probable that increased urbanisation is resulting in increased nutrient input into coastal systems and that beaches that were nutrient poor, are now able to maintain a larger biomass of primary producers. Nitrogen stable isotope analysis of surf diatoms may indicate anthropogenic nutrient inputs in this environment (Hewson *et al*., 2001)..

According to some authors, it is also possible that the presence of ravines and the proximity of anthropized areas around the sandy beaches have associated aquifers that bring nutrients to the surf-zone (Campbell and Bate, 1991). The existence of aquifers results in fresh water flowing into the surf zone. This aquifer water often contains high concentration of nutrients (Campbell and Bate, 1991) that may be the source of most of the surf diatom requirements for the maintenance of standing stocks. Without sufficient nutrients, the biomass may be too low for accumulations to be observed (Campbell and Bate, 1997).

## REFERENCES

BATE, G. C. & A. McLACHLAN (1987). Surf Zone Discoloration by Phytoplankton: the Consequence of Pollution?.- *Marine Pollution Bulletin*. 18 (2): 65-67.

CAMPBELL, E. E. (1996). The global distribution of surf diatom accumulations.- *Rev. Chil. Hist. Nat.*, 69: 495-500.

CAMPBELL, E. E. & G.C. BATE (1991). Groundwater in the Alexandria dune field and its potential influence on the adjacent surf-zone.- *Water SA*, 17:155-160.

CAMPBELL, E. E. & G.C. BATE (1996). Groundwater as a possible controller of surf diatom biomass.- *Rev. Chil. Hist. Nat.*, 69: 503-510.

CAMPBELL, E. E. & G.C. BATE (1997). Coastal features associated with diatom discoloration of surf-zones.- *Bot. Mar*. 40:179-185.

CAMPBELL, E. E. & G.C. BATE (1998). Tide induced pulsing of nutrient discharge from an unconfined aquifer into an *Anaulus australis*-dominates surf-zone.- *Water SA*, 24: 365-370.

CRAWFORD, R.M., C. GARDNER & L.K. MEDLIN (1994). The genus *Attheya* I. A description of four new taxa and the transfer of *Gonioceros septentrionalis* and *G. armatus*.- *Diatom Research* 9(1): 27-51.

CRAWFORD, R.M., F. HINZ & P. KOSCHINSKI (2000). The combination of *Chaetoceros gaussi* (Bacillariophyta) with *Attheya*.- *Phycologia* 39(3): 238-244.

DU PREEZ, D. & E. E. CAMPBELL (1997). Surf zone Diatoms. http://www.upe.ac.za/botany/surfdiat/surfd.htm

GAYOSO, A. M. & V. H . MUGLIA (1991). Blooms of the surf-zone diatom *Gonioceros armatus* (Bacillariophyceae) on the South Atlantic coast (Argentina).- *Diatom Research,* 6 (2): 247-253.

HALCROW, W. (2000). *Scottish Environmental Protection Agency. East Region Progress Report: October 2000. East Region Board Meeting 12 0ctober 2000. 3. Environmental Issues.3.1 Aquatic Environment.* http:/www.sepa.org.uk/board/main/2000/papers/7200.pdf

HEWSON, I.; J.M. O'NEIL & E. ABAL (2001). A low latitude bloom of the surf-zone diatom *Anaulus australis* (Centrales, Bacillariophyta) on the coast of Southern Queensland (Australia).- *J. Plankton Research* 23(11): 1233-1236.

IFREMER (2003). Des eaux brunes en baie d'Audierne. http://ifremer.fr/envlit/actualite/20040121.htm

JIJINA, J. G. AND J. LEWIN (1984). Persistent blooms of surf diatom (Bacillariophyceae) along the Pacific coast, U.S.A. III. Relationships between diatom populations and environmental variables along Oregon and Washington beaches (1977 and 1978). *Phycologia* 23: 471-483. In: CAMPBELL, E. E. & G.C. BATE (1997). Coastal features associated with diatom discoloration of surf-zones.- *Bot. Mar*. 40:179-185.

LEWIN, J. & R. E. NORRIS (1970). Surf zone diatom off the coasts of Washington and New Zealand (*Chaetoceros armatus* and *Asterionella* sp.).- *Phycologia* 9: 143-149. En: BATE, G. C. & A. McLACHLAN (1987). Surf Zone Discoloration by Phytoplankton: the Consequence of Pollution?.- *Marine Pollution Bulletin*. 18 (2): 65-67.

LEWIN, J. & C. T. SCHAEFER (1983). The role of phytoplankton in surf ecosystem. In: Sandy Beaches as Ecosystems. (A. McLachlan and T. Erasmus, eds), 381-389. Dr W. Junk Publishers, The Hague. En: GAYOSO, A. M. & V. H . MUGLIA (1991). Blooms of the surf-zone diatom *Gonioceros armatus* (Bacillariophyceae) on the South Atlantic coast (Argentina).- *Diatom Research,* 6 (2): 247-253.

OJEDA, A. & L. O' SHANAHAN, (2004). Discoloraciones por acumulaciones de la diatomea bentónica *Attheya armatus* (Centrales, Bacillariophyta) en playas de arena del S y SW de Gran Canaria (Canarias, España). *XIII Simposio Ibérico de Estudios del Bentos Marino. Las Palmas de Gran Canaria, 21 a 24 de septiembre de 2004.*

OJEDA, A. & L. O' SHANAHAN, (2005). Discoloraciones por acumulaciones de la diatomea bentónica epipsámica *Attheya armatus* (Centrales, Bacillariophyta) en playas de arena del S y SW de Gran Canaria (Canarias, España). *Vieraea*, 33:51-58.

O' SHANAHAN, L. (2004). Calidad bacteriológica de playas del sur de Gran Canaria durante el año 2003. (Report :*Bacteriological quality of southern beaches of Gran Canaria during 2003*). - *Instituto Canario de Ciencias Marinas.* Nº Registro de Salida 363, Fecha: 4 de mayo de 2004.

RAPSON, A. M . (1954). Feeding and control of toheroa (*Amphidesma ventricosum* Gray) (Eulamellibranchiata ) population in New Zealand. *Australian Journal of Marine and Freshwater Research* 5:486-512. En: CAMPBELL, E. E. (1996). The global distribution of surf diatom accumulations.- *Rev. Chil. Hist. Nat.*, 69: 495-500.

ROUND, F. E., R. M. CRAWFORD, D. G. MANN (1990). *The Diatoms. Biology and Morphology of the Genera*.- Cambridge University Press, 747 pp.