Stability of the generic names *Alexandrium* Halim and *Gessnerium* Halim at risk because of *Peridinium splendor-maris* Ehrenberg, the first documented bloom of *Alexandrium* (Dinophyceae)

M. Elbrächter, *Alfred-Wegener-Institut, Helmholtz-Zentrum für Polar- und Meeresforschung Sylt, Hafenstr. 43, 25992 List/Sylt, Germany* (melbraechter@awi-bremerhaven.de)

M. Hoppenrath, *Senckenberg am Meer, German Centre for Marine Biodiversity Research (DZMB), Südstrand 44, 26382 Wilhelmshaven, Germany* (mhoppenrath@senckenberg.de)

R. Jahn, *Botanic Garden and Botanical Museum Berlin, Freie Universität Berlin, Königin-Luise-Str. 6-8, D-14195 Berlin, Germany* (r.jahn@bgbm.org)

W.-H. Kusber, *Botanic Garden and Botanical Museum Berlin, Freie Universität Berlin, Königin-Luise-Str. 6-8, D-14195 Berlin, Germany* (corresponding author: w.h.kusber@bgbm.org)

Stein (1883: 21) described *Blepharocysta splendor-maris* (Ehrenberg) F.Stein as a dinoflagellate without any apparent cingulum which he believed to be conspecific with the organism Ehrenberg had described (Ehrenberg 1860a, b) and illustrated (Ehrenberg 1873) as "*Peridinium Splendor Maris*" Ehrenberg. Ehrenberg (1873: 4) postulated that this species should be assigned to a new genus: *Blepharocysta*, but he did not explicitly introduce a new combination. There are some important discrepancies between the description and figures of Ehrenberg and those of Stein (1883). Ehrenberg clearly described and depicted a cingulum. Nevertheless, since Stein (1883) this taxon is classified as member of the *Podolampaceae* and is well-known in the sense of Stein. Re-investigation of the original material of *Peridinium splendor-maris* preserved by Ehrenberg shows that Stein misinterpreted Ehrenberg and described a hitherto unknown species. Ehrenberg stored material and preparations for almost all his novelties (Ehrenberg 1838). Besides the original drawings which he presented at the Prussian Academy of Sciences, his daughter Clara prepared an index to the species studied by her father (Lazarus & Jahn 1998).

Examination of Ehrenberg's original material clearly shows that this taxon belongs to the Gonyaulacales and to the genus now well known as *Alexandrium* Halim. We here present the lectotype of the entity described by Ehrenberg as *Peridinium splendor-maris* as representing the first documentation of a bloom of an *Alexandrium* species from the Mediterranean Sea.

The Ehrenberg collection (**BHUPM**) includes dried material on mica preparations and original drawings by C.G. Ehrenberg. Up to five micas may be glued on a mica strip. The following micas have been investigated **BHUPM** 290101-1 to 290101-5, 290102-1 to 290102-4 (numbering according to Jahn & Kusber 2004).

Drawing sheet **BHUPM** 957 named "Peridinium? Splendor maris Neapel 1859 [sic!]. Augusto." Ehrenberg's (1860a) statement identifying these objects as original material as of 8 December 1859 reads: "*Auf Glimmer zahlreich angetrocknete Exemplare des Peridinium konnten noch jetzt unter dem Mikroskop sammt den Zeichnungen der lebenden vorgelegt werden*" [Numerous dried specimens of the *Peridinium* on mica could be presented still now under the microscope together with drawings of the living specimens].

The description in Ehrenberg (1860b: 791) reads: "*Peridinium Splendor Maris. Testula ovata aut subglobosa ecorni, areolata, fragili, crystallina, cribrosa aut granulosa nec apiculata, sulci medii transversi marginibus elatis, duos dentes marginales laterales referentibus. Areolae ad sulcum utrinque 5 et frontales 3 minores. Diameter 1/96-1/40'''; hinc sponte dividuum videtur. Minora*

specima pulli alius generationis modi esse videntur." ["*Peridinium splendor-maris*. Envelope ovate or sub-spherical, without horns, areolate, fragile, crystalline, [and] cribriform or granulate [but] not pointed. Transversal sulcus elevated [description of the cingulum '7, 8, 10' in drawing 957, see Fig. 5], two marginal teeth [description of the ventral view '14' in drawing 957, see our Fig. 5]. Apical three minor areolae and 5 areolae near to the sulcus [here: cingulum, description of '11' in drawing 957, see our Fig. 5]. Diameter 1/96-1/40‴: i.e., Paris lines 23.5-56.4 µm; seems to be able to divide itself on one side. Smaller specimens seem to be a different generation."]

The genus *Blepharocysta* was established by Ehrenberg (1873: 4) with a brief diagnosis, the reference to *Peridinium splendor-maris*, and a copper-plate engraving, showing specimens that have been drawn by Ehrenberg in "1859" 1858, but not actually published in Ehrenberg (1860b) where *Peridinium splendor-maris* was described.

Ehrenberg's generic diagnosis reads (1873): "*Eine solche lösbare Hülle kann man nicht zu den Cystenbildungen rechnen, sie bleibt aber ein so wichtiger Charakter, dass dergleichen frei in einer Schaale lebende Formen als besondere generische Typen zu betrachten sein werden, wofür ich den Namen* Blepharocysta *vorschlage*". ["A removable envelope is not a cyst. This envelope is such an important character, that forms, living freely in an envelope, belongs to its own genus for which I propose the name *Blepharocysta*."] This diagnosis does not allow a clear identification of which taxa may belong to Ehrenberg's genus, but the reference to *Peridinium splendor-maris* gives a clear indication of which taxon the genus was based, *i.e.* the type of the name of the genus. Ehrenberg did not formally introduce a new combination.

Several micas of Ehrenberg's material of *Peridinium splendor-maris* were studied in **BHUPM**, each of them is crowded with dinoflagellates, which are of different sizes but all apparently belonging to the same species. We did not discover any individual that could be attributed with certainty to a similar but different species. In particular, no cell was discovered that can be attributed to *Blepharocysta* in the sense of F. Stein. In cells showing the precingular plates in ventral view (Fig. 1a, c) a strong resemblance to *Alexandrium balechii* (Steidinger) Balech is apparent. Several cells could be identified as clearly belonging to the genus *Alexandrium*, subgenus *Gessnerium*, as plate 1′ is not connected to the apical pore (Figs 3, 4). The plate 1‴ is also characteristic and looks like that in *A. balechii* (Fig. 2). For comparison see Steidinger (1971, fig. 1).

Peridinium splendor-maris Ehrenberg in *Monatsberichte der Königlich Preussischen Akademie der Wissenschaften zu Berlin* 1859: 732, 792, 1860.
Lectotype (designated here): **BHUPM** 290102-1 (the cells representing the lectotype are Figs 1, 2).
Isolectotype (designated here): **BHUPM** 290102-4 (the cell representing the isolectotype is Fig. 3, 4).
Label information for both micas: "Mare Neapolit. Meeresleuchten. Aug 1858."
Further original material: **BHUPM** drawing no. 957 (see Fig. 5).
Locus typicus (according to Ehrenberg 1860b): "*In mari neapolitano ad Neapolim splendidissimum Augusto*" [1858].
Nomenclatural act registered as http://phycobank.org/100149

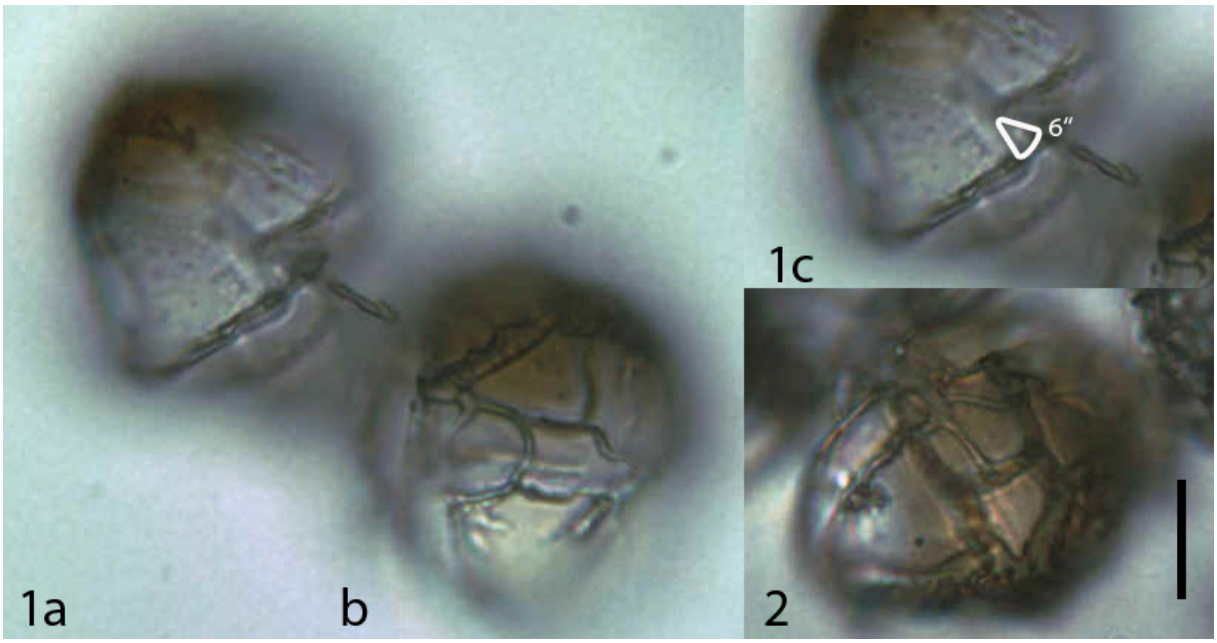

Fig. 1-2. *Peridinium splendor-maris*. Lectotype **BHUPM** 290102-1. Fig 1a, c. Epitheca in right ventral view, (cell upper left corner) showing the very small plate 6″ (bordered by white colour in Fig. 1c), plate 1′ not connected to the apical pore is situated above. Fig. 2. Ventral antapical view of an hypotheca, showing the characteristic shape of plate 1‴ (upper right margin), in addition to the sulcal plates sp, sd and ss in the centre of the image. Scale bar = 10 µm.

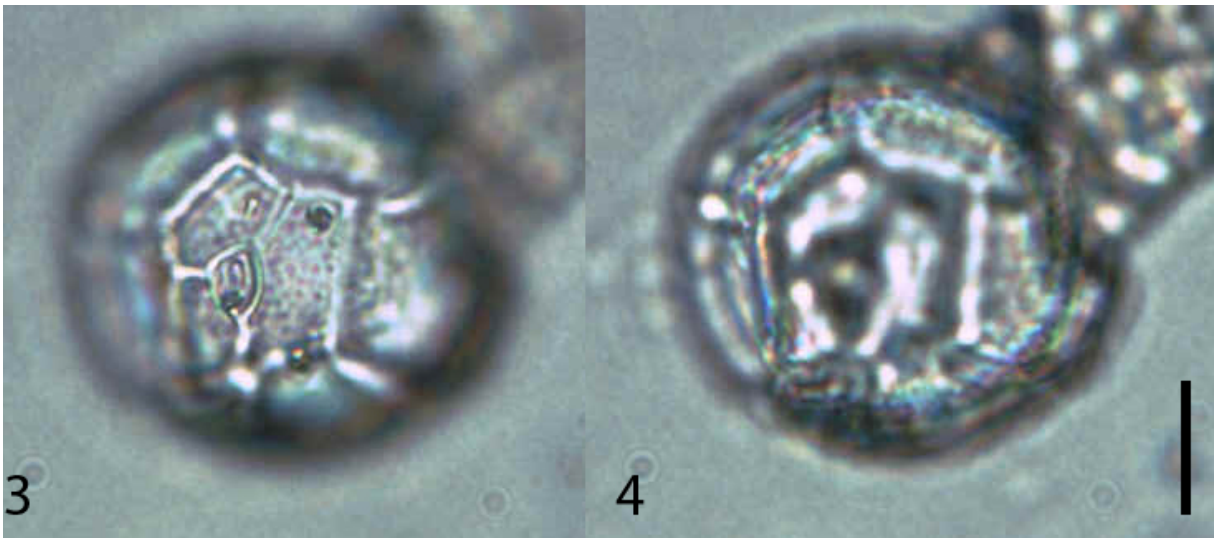

Fig. 3-4. *Peridinium splendor-maris*. Isolectotype **BHUPM** 290102–4. Apical view of *Peridinium splendor-maris* showing the typical gonyaulacoid apical pore plate (APC) and the disconnection of plate 1′ from the apical pore. Plate 2′ is right of the APC. Two planes of focus of the same cell. Scale bar = 10 µm.

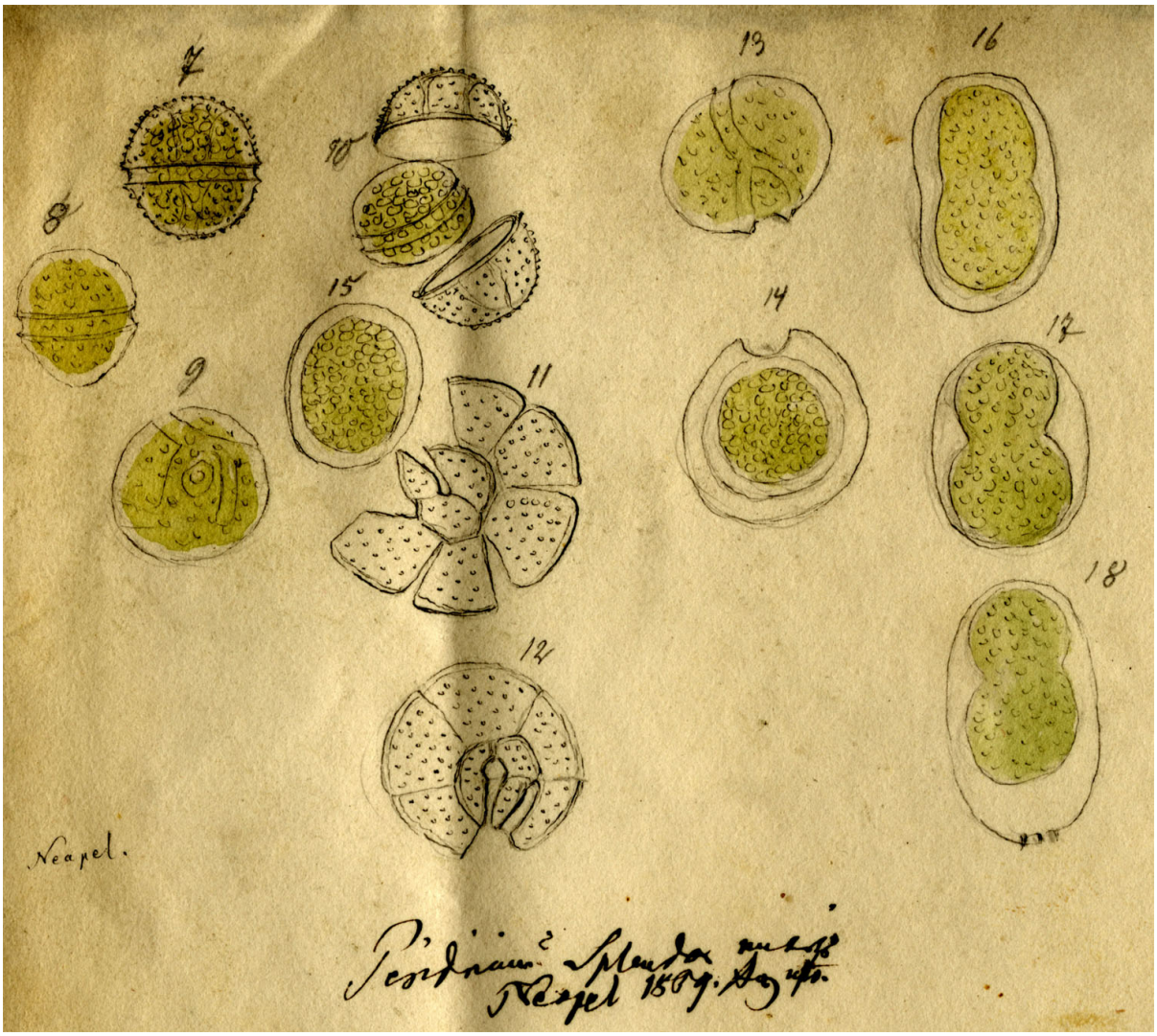

Fig. 5. **BHUPM** 957. C.G. Ehrenberg's drawing of "Peridinium? Splendor maris" as basis of the published copper-plate engraving.

The specimens Ehrenberg had to hand when publishing *Peridinium splendor-maris* give more precise information (e.g. the small plate 6″ in Fig. 3) on the identity of Ehrenberg's taxon than the drawing (Fig. 5). The line-drawings were misidentified as *Lingulodinium polyedra* (F.Stein) J.D.Dodge (≡ *Gonyaulax polyedra* F.Stein) by some later authors (see Carbonell-Moore 2018). Ehrenberg documents a monospecific bloom of a dinoflagellate, which is clearly a species of the genus *Alexandrium* subgenus *Gessnerium*, except for some cells of *Prorocentrum lima* (Ehrenberg) F.Stein. This is the first documented bloom of an *Alexandrium* species, based on deposited preparations (Figs 1-4). The species described by Ehrenberg as *Peridinium splendor-maris*, for which he later created the genus *Blepharocysta*, is very similar or even identical to the species now known as *Alexandrium balechii* (Steidinger) Balech (≡ *Gonyaulax balechii* Steidinger). Blooms of *Alexandrium balechii* were described from this region some 120 years later by Montresor *et al.* (1990). For taxonomic clarity it would be useful to epitypify *Peridinium splendor-maris* and *Alexandrium balechii* from their respective type localities, including molecular sequences and deposited preparations made of clonal cultures.

Applying the current rules of the ICN (Turland *et al.* 2018), *Blepharocysta*, based on its type *Peridinium splendor-maris* would have priority over *Alexandrium* and *Gessnerium*. The formal naming of Ehrenberg's *Peridinium splendor-maris* within the genus *Alexandrium* would have far-reaching nomenclatural consequences. In order to preserve name stability for *Alexandrium,*

Gessnerium, and *Blepharocysta*, we here refrain from recombining Ehrenberg's *Peridinium splendor-maris* (≡ *Blepharocysta splendor-maris*) formally with the genus *Alexandrium* subg. *Gessnerium*. The genus name *Alexandrium* is well established, particularly as several of its species are toxic and thus the genus name is used not only in the biological scientific community but also by chemists, toxicologists and veterinarians as well as by administrators and policy-makers (see, for example, Hallegraeff *et al.* 2003). Because of our findings, Carbonell-Moore (2018) has proposed conservation of the name *Peridinium splendor-maris* Ehrenberg with Stein's (1883: pl. 7: fig. 17) image of *Blepharocysta splendor-maris* to align Stein's and the current taxonomic concept of the genus *Blepharocysta* Ehrenberg. The conservation of the name *Peridinium splendor-maris* with a conserved type using one of Stein's published images as proposed by Carbonell-Moore (2018) would guarantee name stability, but the generic description of *Blepharocysta* by Ehrenberg continues to remain in conflict with its current concept; nevertheless, complex circumstances in nomenclature and taxonomy cannot be solved in an entirely satisfactory manner by simple solutions (see Gottschling *et al.* 2018).

To summarise, *Peridinium splendor-maris* was described by Ehrenberg (1860a, b) and first depicted (Ehrenberg 1873) as a species with a cingulum, causing bright bioluminescence in the Gulf of Sorrento, Naples, Italy, Mediterranean Sea. Later, Ehrenberg (1873) introduced the new genus *Blepharocysta*. Stein (1883) formally combined *Blepharocysta splendor-maris*, linking it to Ehrenberg's name, but in reality describing a new taxon with figures showing no cingulum, which led to the classification of *Blepharocysta* within the *Podolampaceae*. We reinvestigated the original material sampled by Ehrenberg in 1859 in the Gulf of Sorrento in the Ehrenberg Collection, Berlin. The preparations clearly show that *Peridinium splendor-maris* is a species of *Alexandrium* Halim, subgenus *Gessnerium*. The species is very similar or perhaps identical to *Alexandrium balechii* (Steidinger) Balech. Carbonell-Moore (2018) proposes to supersede Ehrenberg's original material with a conserved type representing Stein's taxonomic concept. In a contribution to *Taxon*, we will propose another solution focusing on name stability of *Alexandrium* and *Gessnerium*. Whatever the decision of the nomenclatural committee will be, we here present photos of the preparations serving as proof for the seemingly first documented bloom of an *Alexandrium* species worldwide.

This paper is based on a scientific contribution to the HAB2004 conference in Cape Town, South Africa. The work on Ehrenberg's types was funded by the German Federal Ministry of Education and Research, BMBF. DFG Grant JA 874/8-1 for Names Registration PhycoBank is acknowledged. We wish to thank David Lazarus for providing access to the Ehrenberg Collection at Museum für Naturkunde, Berlin. We are grateful to Michael Guiry and an anonymous referee for providing corrections and careful revision of the manuscript.

Carbonell-Moore, M.C. (2018). (2608) Proposal to conserve the name *Peridinium splendor-maris* (*Blepharocysta splendor-maris*) (Dinophyceae) with a conserved type. *Taxon* 67(3). Accepted.

Ehrenberg, C.G. (1838). *Die Infusionsthierchen als vollkommene Organismen*. Ein Blick in das tiefere organische Leben der Natur. pp. i-xviii, [1-4], 1-547, pls I-LXIV. Leipzig: Verlag von Leopold Voss.

Ehrenberg, C.G. (1860a). Einige Beobachtungen über das Meeresleuchten bei Neapel, Sorrento und Ischia. *Monatsberichte der Königlich Preussischen Akademie der Wissenschaften zu Berlin* 1859: 731-735.

Ehrenberg, C.G. (1860b). Nachtrag zu Hrn. Ehrenbergs Mittheilung vom 8. Decbr. 1859. Verzeichniss der Leuchtthierchen. *Monatsberichte der Königlich Preussischen Akademie der Wissenschaften zu Berlin* 1859: 791-793.

Ehrenberg, C.G. (1873). Die das Funkeln und Aufblitzen des Mittelmeeres bewirkenden unsichtbar kleinen Lebensformen. *Gesellschaft Naturforschender Freunde zu Berlin, Festschrift zur*

Feier des Hundertjährigen Bestehens: 1-4, pl. 1.

Gottschling, M., Tillmann, U., Kusber, W.-H., Hoppenrath, M. & Elbrächter, M. (2018). A Gordian knot: Nomenclature and taxonomy of *Heterocapsa triquetra* (*Peridiniales: Heterocapsaceae*). *Taxon* 67(1):179-185. https://doi.org/10.12705/671.11

Hallegraeff, G.M., Anderson, D.M. & Cembella, A.D. (ed.) (2003). *Manual on harmful marine microalgae*. Pp. [1]-793. Paris: UNESCO Publishing.

Jahn, R. & Kusber, W.-H. (2004). Algae of the Ehrenberg collection 1. Typification of 32 names of diatom taxa described by C.G. Ehrenberg. *Willdenowia* 34: 577-595.

Lazarus, D. & Jahn, R. (1998). Using the Ehrenberg Collection. *Diatom Research* 13: 273-291.

Montresor, M., Marino, D., Zingone, A. & Dafnis, G. (1990). Three *Alexandrium* species from coastal Tyrrhenian waters (Mediterranean Sea). In: Granéli, E., Sundström, B., Edler, L. & Anderson, D. M. (eds). *Toxic Marine Phytoplankton*. New York: Elsevier, pp. 82-87.

Steidinger, K.A. (1971). *Gonyaulax balechii* sp. nov. (Dinophyceae) with a discussion of the genera *Gonyaulax* and *Heteroaulacus*. *Phycologia* 10: 183-187.

Stein, F. (1883). *Der Organismus der Infusionsthiere* 3 (2). pp. 1-30, pls I-XXV. Leipzig: W. Engelmann.

Turland, N.J., Wiersema, J.H., Barrie, F.R., Greuter, W., Hawksworth, D.L., Herendeen, P.S., Knapp, S., Kusber, W.-H., Li, D.-Z., Marhold, K., May, T.W., McNeill, J., Monro, A.M., Prado, J., Price, M.J. & Smith, G.F. (2018, in press). *International Code of Nomenclature for algae, fungi, and plants (Shenzhen Code) adopted by the Nineteenth International Botanical Congress Shenzhen, China, July 2017*. *Regnum Vegetabile*, Vol. 159. pp. [i]-xxxviii, 1-253. Oberreifenberg: Koeltz Botanical Books.

Wyatt, T. & Zingone, A. (2005). Cape Agulhas. *Harmful Algae News* 27: 1-7.