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A checklist of marine phytoplankton species of Northeast Brazil

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ABSTRACT

The oceanic zone of Northeast Brazil in the southwestern tropical Atlantic Ocean is characterised by the presence of a variety of current systems. Thus, it has the potential to host a large diversity of phytoplankton species. In this context, we propose a comprehensive checklist of documented marine phytoplankton species in this region. To this end, we have compiled all the published material and supplemented it with original data from two comprehensive surveys, the ABRAÇOS surveys, covering the shelf, slope, and offshore areas of Northeast Brazil. Even if few articles were atrieved from our review research, a total of 719 phytoplankton taxa are reported, including 98 new records plus 45 potential new records from the ABRACOS data. Most taxa are accompanied by a comprehensive library of illustrations. The two major phytoplankton groups, dinoflagellates and diatoms, contributed similarly to the total checklist richness, which is consistent with the global phytoplankton diversity. The contribution of nano- and microphytoplankton varies between areas. The shelf displays a greater diversity of pennate and small/medium-sized diatoms. This may be attributed to the inputs from estuarine rivers as well as the resuspension of benthic diatoms. Conversely, dinoflagellates are more prevalent offshore, demonstrating their adaptability to changing nutritional conditions, by employing numerous metabolic and growth strategies to survive. This checklist, which reveals an remarkable diversity of nano- and microphytoplankton in Northeast Brazil, provides a valuable reference for scientists and managers to monitor community evolution under global change.

1. Introduction

Phytoplankton plays a fundamental role in marine ecosystems, influencing various biogeochemical cycles through significant contributions to oxygen production and carbon fixation. Responsible for 45 % of global photosynthesis, they are likened to the 'second global lung' (Field et al., 1998; Naselli-Flores and Padisák, 2023). Moreover, these microorganisms are vital components of marine food webs, producing organic biomass via primary production to sustain higher trophic levels. This biomass constitutes crucial environmental and economic resources in marine systems (Pierella Karlusich et al., 2020; Clementson et al., 2022). Furthermore, phytoplankton species serve as sensitive indicators of environmental changes, highlighting the need for comprehensive checklists and distribution descriptions to study their ecology and contributions to ecosystem functioning (D'Elbée, 2016).

Assessing and accurately estimating phytoplankton diversity is challenging, primarily due to their diminutive size (D'Elbée, 2016) and the high level of taxonomic expertise required to identify species (McQuatters-Gollop et al., 2017). Approximately, 5000 marine species have been described to date using traditional methods (Sournia et al., 1991; Not et al., 2012; D'Elbée, 2016; Pierella Karlusich et al., 2020). However, the true number is likely to have been significantly underestimated (de Vargas et al., 2015; Righetti et al., 2020; Guiry, 2024). Within the realm of eukaryotes, Bacillariophyceae and Dinophyceae exhibit the highest diversity, each reaching about 1800 species, followed by Haptophyceae (~500 species) and Prasinophyceae (~300 species). In

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contrast, Cryptophyceae and Euglenophyceae display markedly less diversity, with ~80 species each (D'Elbée, 2016; Pierella Karlusich et al., 2020). Another major component of marine phytoplankton originates from the Cyanobacteria phylum, encompassing about 600 species (Pierella Karlusich et al., 2020; Guiry and Guiry, 2023; Editorial Board, 2023), including both benthic and planktonic lifestyles. The taxonomic diversity of the free-living Cyanobacteria is very low with few major genera, including *Prochlorococcus*, *Synechococcus* and *Crocosphaera* (three picoplanktonic size-class taxa, 0.22–3 μm), and *Trichodesmium* (a microplanktonic size-class, over 20 μm). Notably both *Crocosphaera* and *Trichodesmium* are diazotrophic cyanobacteria (Pierella Karlusich et al., 2020).

The oceanic zone of Northeast Brazil in the southwestern tropical Atlantic is characterised by a diversity of current systems (Stramma and England, 1999; Costa da Silva et al., 2021; Dossa et al., 2021). It thus has the potential to host a wide diversity of phytoplankton species. In this context, the objective of this study is to propose a comprehensive checklist of all documented phytoplankton species in this region. To do this, we have collated all the published material and supplemented it with original data from two comprehensive surveys, ABRAÇOS 1 and 2, spanning the shelf, slope, and offshore areas of Northeast Brazil (Bertrand, 2015, 2017). Moreover, we evaluate new records observed during the ABRACOS surveys, thereby extending the diversity previously observed. Encompassing a size spectrum ranging from a few microns to over a millimetre, this checklist focuses on the nano- and micrometre fractions, typically ranging between about 10 and 200 μm, within the phytoplankton communities of Northeast Brazil.

2. Material and methods

2.1. Study area

Northeast Brazil (Figs. 1a and 1b) comprises 9 Brazilian states: Alagoas, Bahia, Ceará, Maranhão, Paraíba, Piauí, Pernambuco, Rio Grande do Norte and Sergipe. Their coasts are characterized by a narrow continental shelf (~35 km) with a shelf break between 40 and 80 m depth and a steep slope down to ~3600 m depth (Knoppers et al., 1999). Offshore lies the Fernando de Noronha Ridge, which comprises a chain of seamounts along 4°S, stretching almost 500 km and including Rocas Atoll and the Fernando de Noronha Archipelago (Mabesoone and Coutinho, 1970; Kikuchi et al., 2002). Furthermore, historically, the São Pedro and São Paulo archipelagos have been part of the special "state district" of Fernando de Noronha in the state of Pernambuco, despite the very large distance between the two island groups and the even greater distance to the state mainland.

2.2. Data review

The aim of this study was twofold: first, to provide a comprehensive floristic checklist of the southwestern tropical Atlantic Ocean, off Northeast Brazil, including the Rocas Atoll and the Fernando de Noronha and São Pedro and São Paulo archipelagos and second, to document new records from the ABRACOS surveys. To this end, we conducted a comprehensive review of all published articles and theses, as well as reports and repositories describing phytoplankton communities. These were sourced from online resources (e.g., Google Scholar, ResearchGate) as well as exchanges within our networks of co-authors (Table 1). Online searches wer conducted using combinations of the following descriptors: diversity, checklist, species, taxonomy, phytoplankton, dinoflagellastes, diatoms, marine, coastal, shelf, slope, islands, archipelagos, Northeast Brazil; results were sorted by the most relevant. This published information was supplemented with new data from the ABRAÇOS observations. Studies describing very coastal ecosystems such as estuaries, mangroves or ports, were excluded from the analysis. The checklist also provides information on some functional traits, such as the trophic mode of Dinophyceae and the shape and size of diatoms (Table 2, Table S1).

2.3. ABRACOS surveys

The "Acoustics along the BRAzilian COaSt (ABRACOS)" surveys were carried out aboard the French R/V ANTEA in Austral spring (30 August - 20 September 2015 - ABRACOS 1; Bertrand, 2015) and fall (9 April - 9 May 2017 - ABRACOS 2; Bertrand, 2017). A total of 72 stations were studied off the Northeast Brazil region (Fig. 1c). Phytoplankton was collected using Niskin bottles moundt in a rosette in the mixed-layer (~40 m, 25–53 m, depending on the station), at the deep chlorophyll maximum (DCM, ~100 m, 50–123 m) and at 200 m (where fluorescence was no longer measured) at stations with a bottom depth greater than 200 m or near the bottom (between 10 and 63 m) at stations located over the shelf. In total, 20, 48, 68 and 24 samples were collected

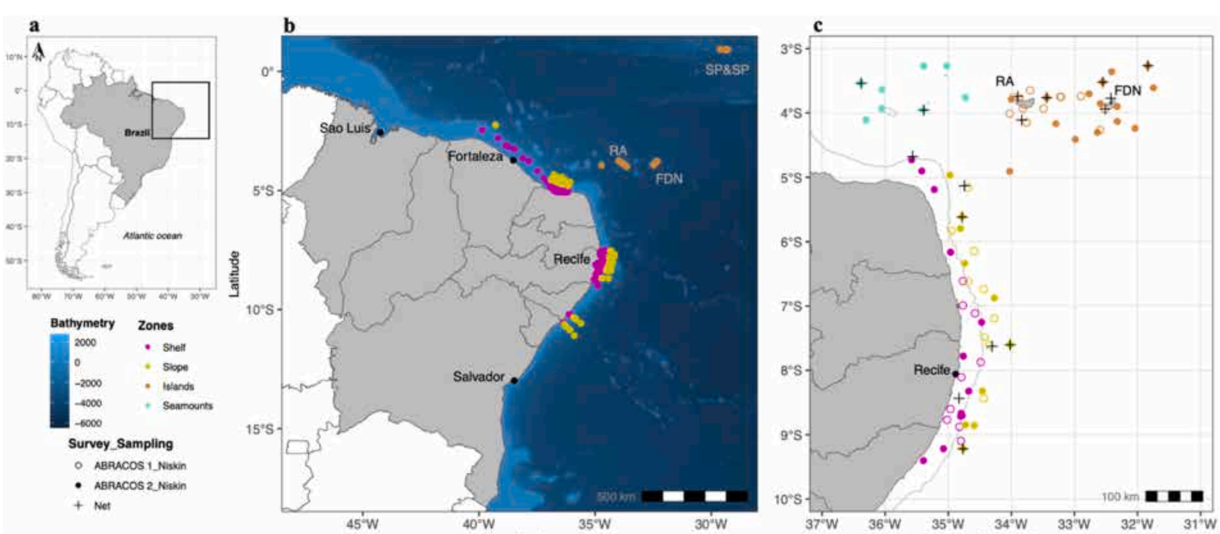

Fig. 1. Study area of the position of (a-b) the published references stations in the Northeast Brazil region and (c) the position of Abraços 1 (coloured outline) and Abraços 2 (full coloured) Niskin (circles) and phytoplankton net (stars) sampling stations. The shelf limit is represented by the isobath of 200 m (solid line). RA stands for Rocas Atoll, FNA for Fernando de Noronha archipelago, SP&SP for São Pedro and São Paulo archipelagos. Stations have been organized into four ecological areas (shelf in magenta, slope in yellow-green, oceanic islands in brown and seamounts in cyan).

Table 1
Review of phytoplankton communities' studies in Northeast Brazil. DCM= deep chlorophyll maximum.

Source number	Source	Period and Project	Sampling area and design	Sampling tool	Taxonomic scope	Taxa richness
1	Eskinazi-Leça and Passavante (1972)	1965 monthly sampling	Shelf station in Pernambuco	Horizontal "Kitahara" quantitative net (65 µm mesh size) in sub-surface	Total flora	74
2	Passavante (1979)	1965 monthly sampling and June 1965 (R/V Canopus, England)	Pernambuco shelf: 1 fixed station sampled each month and 9 stations	Horizontal "Kitahara" quantitative net (65 µm mesh size) in sub-surface	Dinophyceae	41
3	Passavante et al. (1982)	June 1965 (R/V Canopus, England)	Ceará shelf (11 stations)	Horizontal "Kitahara" quantitative net (65 µm mesh size) in sub-surface	Dinophyceae	24
4	Eskinazi-Leça et al. (1989)	Brasilian ALGAS Project, 1978 (SUDENE/CIRM)	Pernambuco shelf (15 stations)	Van Dorn bottle and horizontal qualitative 65 µm mesh size net in sub-surface	Total flora	68
5	Silva-Cunha and Eskinazi-Leça (1990)	Between June 1965 and February 1967 (R/V Canopus, England)	Pernambuco shelf (9 stations), south Paraiba (1 station), north Alagoas (1 station)	Horizontal qualitative 65 µm mesh size net in sub-surface	Diatoms	119
6	Koening and Macêdo (1999)	JOPS II−5 cruise, 1–2/03/1995 (R/V Victor Hensen, Germany)	Itamaracá-Pernambuco (10 stations along 2 profiles)	Van Dorn bottle in sub-surface and oblique qualitative 64 µm mesh size net (14–0 m in shelf stations, 160–0 m in slope stations)	Total flora	101
7	Koening and Lira (2005)	JOPS II−5 cruise, 25/02 – 3/03/1995 (R/V Victor Hensen, Germany)	Pernambuco shelf and slope (34 stations along 7 profiles)	Oblique qualitative 64 µm mesh size net (14–0 m in shelf stations, 160–0 m in slope stations)	*Ceratium* spp.	57
8	Koening et al. (2009)	JOPS II−5 cruise, 25/02–3/03/1995 (R/V Victor Hensen, Germany)	Pernambuco shelf and slope (34 stations along 7 profiles)	Oblique qualitative 64 µm mesh size net (14–0 m in shelf stations, 160–0 m in slope stations)	Total flora	173
9	Santos et al. (2010)	Servemar-X (May-July 2005) and Servemar-I (November and December 2005, January 2006) projects	Pernambuco shelf Servemar-X and Servemar-I shipwrecks as artificial reefs (12 dives - 6 for each shipwreck)	Vertical qualitative 20 µm mesh size net	Total flora	76
10	Tiburcio et al. (2011)	CNPq project, 12–16/05/2008	São Pedro and São Paulo archipelagos (2 stations: Cabeço da Tartaruga and Enseada)	Horizontal quantitative 45 µm mesh size net in sub-surface	Total flora	129
11	Queiroz et al. (2014)	March 2008	São Pedro and São Paulo archipelagos (16 stations along 4 profiles)	Horizontal quantitative 45 µm mesh size net in sub-surface	Total flora	110
12	Queiroz et al. (2015)	21–23/07/2010 and 29/09–01/10/2011 (R/V Cruzeiro do Sul, Brazil)	São Pedro and São Paulo archipelagos (6 stations along 2 profiles)	Niskin bottle (surface, 25, 50 m, DCM+10, DCM, DCM−10 m, 100 m) and vertical qualitative 20 µm mesh size net (75–105–0 m)	Total flora/ Cyanophyceae	129
13	Jales et al. (2015)	July 2010 (R/V NH 38, Brazil)	Rocas Atoll (6 stations along 2 profiles)	Niskin bottle (surface, 25, 50 m, DCM+10, DCM, DCM−10 m, 100 m) and vertical qualitative 20 µm mesh size net (DCM-10m up to the surface)	Total flora	150
14	Aquino (2016)	08/2010 and 10/2012 (R/V Cruzeiro do Sul, Brazil)	Fernando de Noronha archipelago (6 stations along 2 profiles)	Niskin bottle (surface, 25, 50 m, DCM+10, DCM, DCM−10 m, 100 m) and vertical qualitative 20 µm mesh size net (130–0 m)	Total flora	115
15	Silva-Cunha, Leça, et al. (2019)	Brazilian-Petrobras Marseal project, AGUA 1 and 2 cruises, June 2014 and December 2014 (R/V Seward Johnson, Panama)	Bacia de Sergipe-Alagoas: shelf and slope/ocean (14 stations along 2 profiles)	Niskin bottle (surface, about 50 m, DCM) and oblique qualitative 20 µm mesh size net (near bottom or 200–0 m)	Total flora	331
16	Silva-Cunha, Koening, et al., (2019)	Petrobras monitoring during 3 periods in 2002–2004, 2009–2011 and 2014: (i) Piracicaba, Pegasus I and R/V Astro Garouba, (ii) Corenav II, Marimar XII, Titanic IX, R/V Seward Johnson, Panama and R/V Luke Thomas, USA, and (iii) R/V Seward Johnson, Panama and R/V Luke Thomas, USA	Bacia Potiguar shelf and slope, Rio Grande do Norte and Ceará (i) 70 stations, (ii) 23 stations, and (iii) 20 stations	Niskin bottle in sub-surface and oblique vertical 20 µm mesh size net (near bottom or 200–0 m)	Diatoms/ Dinophyceae	93
17	Jales et al. (2022)	03–15/12/2012 and 26/08–3/09/13	Five natural pools - 3 collections per pool	20 µm mesh size filtration (200 L)	Total flora	109
18	ABRACOS observations	ABRACOS 1 and 2 cruises, October-November 2015 and April-May 2017 (R/V Antea, France)	Northeast Brazil coast: Rio Grande do Norte, Paraiba, Pernambuco, Ceara, Alagoas shelf and slope/ ocean, Rocas Atoll and Fernando de Noronha (72 stations)	Niskin bottle (about 50 m, DCM, 200 m) and oblique qualitative 20 µm mesh size net (200–0 m)	Total flora	321

Table 2
List of phytoplankton species or taxa observed in the Brazilian Northeast region at shelf, slope, around the oceanic islands and in the seamounts area since 1970. * indicates ABRACOS new records and *[?] the potential new records. We mentioned if taxa illustrations are available in the checklist sources we studied or in the Abraços pictures online database. [m] indicates mixotrophic and [h] heterotrophic taxa.

	Sources	Illustration availability (picture, draw)	Shelf	Slope	Oceanic islands	Seamounts
MYZOZOA						
Dinophyceae						
Spiniferites sp. G.A. Mantell, 1850	10				X	
Alexandrium minutum Halim, 1960 *	18	X		X	X	
Alexandrium sp1 Halim, 1960 *	18	X			X	
Alexandrium sp2 Halim, 1960 *	18	X	X	X	X	
Amphidinium sp. Claperède & Lachmann, 1859	15		X			
Amphidoma nucula Stein, 1883 *	18	X			X	
Amphisolenia bidentata Schröder, 1900	2, 3, 6, 8, 12, 13, 15, 16	X (16)	X	X	X	
Amphisolenia bifurcata Murray & Whitting, 1899	2, 3, 15		X	X		
Amphisolenia globifera Stein, 1883[m]	16, 18	X (16, 18)		X		X
Amphisolenia schauinslandii Lemmermann, 1899[m]	15		X	X		
Amphisolenia schroederi Kofoid, 1907[m]*	18			X		
Amphisolenia sp. Stein, 1883[m]	15	X		X		
Archaeperidinium minutum (Kofoid) Jørgensen, 1912 *	18	X			X	
Azadinium caudatum (Halldal) Nézan & Chomérat, 2012 *	18	X			X	
Azadinium sp. Elbrächter & Tillmann, 2009 *	18	X		X		
Blepharocysta sp. Ehrenberg, 1873[h]*	18	X	X	X	X	
Ceratium carriense var. carriense Gourret, 1883	15			X		
Ceratium contortum var. robustum (Karsten) Sournia, 1966	7					
Ceratium gibberum var. dispar (Pouchet) Sournia, 1966	8			X		
Ceratium macroceros var. gallicum (Kofoid) Sournia, 1966	1, 7, 8		X	X		
Ceratium pentagonum var. longisetum (Ostenfeld & J. Schmidt) Jörgensen, 1911	10, 11, 15		X		X	
Ceratium pentagonum var. tenerum Jorgensen, 1920	7, 8, 10, 11		X	X	X	
Ceratium platycorne Daday, 1888	7, 18			X		
Ceratium porrectum Karsten, 1907	9, 16	X (16)	X	X		
Ceratium sp. F. Schrank, 1793	10, 15		X		X	
Ceratium symmetricum var. coarctatum (Pavillard) Graham & Bronikovsky, 1944	7					
Ceratium symmetricum var. orthoceras (Jorgensen) Graham & Bronikovsky, 1944 *	18	X				X
Ceratium symmetricum var. symmetricum Pavillard, 1905	7, 10				X	
Ceratium tenue Ostenfeld & Schmidt, 1901	7, 15, 16, 18	X (16)	X	X		
Ceratium tenue var. buceros Balech, (1988) *	18			X		
Ceratium tenue var. tenissimum (Kofoid) Graham & Bronikovsky, 1944	7, 8			X		
Ceratium tripos f. ponticum (Jorgensen) Schiller, 1937	3		X			
Ceratium tripos var. atlanticum (Ostenfeld) Paulsen, 1908	8, 18	X		X	X	
Ceratium vultur f. japonicum (Schröder) Wood, 1954	2, 3, 7		X			
Ceratocorys armata (Schütt) Kofoid, 1910	6, 8, 12, 13, 15, 16	X (16)	X	X	X	
Ceratocorys gourretii Paulsen, 1937	6			X		
Ceratocorys horrida Stein, 1883	2, 3, 6, 8, 10, 11, 12, 13, 14, 15, 16, 17, 18	X (16, 18)	X	X	X	X
Ceratocorys sp. Stein, 1883	6, 10, 15		X	X	X	
Cladopyxis brachiolata Stein, 1883	6, 8, 15, 18		X	X		X
Cladopyxis hemibrachiata Balech, 1964	6, 15, 18			X		X
Cochlodinium sp. Schütt, 1896	15		X			
Corythodinium belgicae (Meunier) F.J.R. Taylor, (1976)	10				X	
Corythodinium constrictum (F. Stein) F.J.R. Taylor, (1976)	6, 10, 12, 13, 14, 15, 18		X	X	X	X
Corythodinium curvicaudatum (Kofoid) F.J.R. Taylor, (1976) *	18			X	X	
Corythodinium diploconus (F. Stein) F.J.R. Taylor, (1976)	12, 15, 18	X	X	X	X	X
Corythodinium elegans (Pavillard) F.J.R. Taylor	10, 12, 13, 18			X	X	X
Corythodinium frenguellii (Rampi) F.J.R. Taylor, (1976) *	18			X	X	
Corythodinium milneri (G. Murray & Whitting) F. Gómez, 2017	10, 14, 15, 18	X		X	X	X
Corythodinium sp. Loeblich Jr. & Loeblich III, 1966	10, 15, 18	X (15)	X	X	X	X
Corythodinium tesselatum (F. Stein) Loeblich Jr. & Loeblich III, 1966	10, 12, 13, 18	X	X	X	X	
Dinophyceae 1 (cf Gymnodiniales) Lemmermann, 1910 *[?]	18	X			X	
Dinophyceae 2 (cf Peridiniales) Haeckel, 1894 *[?]	18	X			X	
Dinophyceae 3 Fritsch, 1927 *[?]	18	X	X	X	X	
Dinophyceae 4 (cf Dinophysiales) Lindemann 1928 *[?]	18	X	X	X	X	
Dinophyceae 5 (cf Thoracosphaerales) Tangen in Tangen, Brand, Blackwelder & Guillard, 1982 *[?]	18	X			X	
Dinophyceae 6 Fritsch, 1927 *[?]	18	X			X	
Dinophyceae 7 (cf Gonyaulacales) Taylor, 1980 *[?]	18	X			X	
Dinophyceae 8 (cf Peridiniales) Haeckel, 1894 *[?]	18	X		X		
Dinophyceae 9 Fritsch, 1927 *[?]	18	X		X		
Dinophyceae 10 Fritsch, 1927 *[?]	18	X		X		
Dinophysis argus (Stein) Abé[m]	10, 12, 13, 15, 18		X	X	X	
Dinophysis bibulba Balech, 1971[m]*	18	X			X	
Dinophysis caudata Saville-Kent, 1881[m]	1, 2, 9, 15, 16, 17	X (15, 16)	X	X	X	

(continued on next page)

Table 2 (*continued*)

	Sources	Illustration availability (picture, draw)	Shelf	Slope	Oceanic islands	Seamounts
Dinophysis dubia Balech, 1978[m]	14				X	
Dinophysis exigua Kofoid & Skogsberg, 1928[m]	13, 14, 15, 18	X	X	X	X	
Dinophysis hastata F. Stein, 1883[m]	6, 10, 12, 13, 14, 18			X	X	
Dinophysis minuta (Cleve) Balech[m]	13				X	
Dinophysis ovata Claparéde & Lachmann, 1859[m]	14, 15		X	X	X	
Dinophysis parvula (Schütt) Balech, 1967[m]	15, 18	X	X	X	X	
Dinophysis pusilla Jørgensen, 1923[m]	14				X	
Dinophysis schuettii Murray & Whitting, 1899[m]	10, 12, 13, 14, 15, 18	X	X	X	X	X
Dinophysis sp1 Ehrenberg, 1839[m*?]	18	X		X		X
Dinophysis spp. Ehrenberg, 1839[m]	10, 13, 14, 15, 17		X	X	X	
Dinophysis uracantha Stein, 1883[m]	12, 18	X			X	
Diplopsalid 1 [h*]	18	X		X		
Diplopsalid 2 [h*]	18	X	X			X
Diplopsalid 3 [h*]	18	X		X	X	
Diplopsalid 4 [h*]	18	X				X
Diplopsalid 5 [h*]	18	X		X	X	
Dissodinium pseudolunula Swift ex Elbrächter & Drebes, 1978	12				X	
Gonyaulax birostris Stein, 1883	10, 12, 13, 15, 17, 18	X	X	X	X	X
Gonyaulax digitalis (C.H.G. Pouchet) Kofoid, 1911	12, 13				X	
Gonyaulax fusiformis H.W. Graham, 1942 *	18			X		
Gonyaulax gracilis Schiller, 1935	14				X	
Gonyaulax minuta Kofoid & Michener 1911	17				X	
Gonyaulax pacifica Kofoid, 1907	10				X	
Gonyaulax polygramma F. Stein, 1883[m*]	10, 11, 12, 13, 15, 17, 18	X	X	X	X	X
Gonyaulax sp1 Diesing, 1866 *	18	X			X	
Gonyaulax sp2 Diesing, 1866 *	18	X		X	X	
Gonyaulax sp3 Diesing, 1866 *	18	X			X	
Gonyaulax sp4 Diesing, 1866 *	18	X			X	
Gonyaulax spinifera (Claparède & Lachmann) Diesing, 1866[m]	10, 12, 13, 14, 17, 18	X (15, 18)	X	X	X	
Gonyaulax spp. Diesing, 1866	6, 10, 14, 15	X (15)	X	X	X	
Gymnodinium catenatum H.W. Graham 1943[m]	17				X	
Gymnodinium sp1 F. Stein, 1878 *[?]	18	X			X	
Gymnodinium sp2 F. Stein, 1878 *[?]	18	X			X	
Gymnodinium sp3 F. Stein, 1878 *[?]	18	X			X	
Gymnodinium sp4 F. Stein, 1878 *[?]	18	X			X	
Gymnodinium spp. F. Stein, 1878	12, 13, 14, 15, 17, 18	X	X	X	X	
Gyrodinium biconicum Kofoid & Swezy, 1921[h]	15		X			
Gyrodinium spirale (Bergh) Kofoid & Swezy, 1921[h]	15		X			
Gyrodinium spp. Kofoid & Swezy, 1921[h]	12, 15, 18	X	X	X	X	X
Heterocapsa minima A.J. Pomroy, 1989 *	18	X	X	X	X	X
Heterocapsa niei (Loeblich III) Morrill & Loeblich III, 1981 *	18	X	X	X	X	
Heterocapsa sp. Stein, 1883 *	18	X			X	
Heterodinium minutum Kofoid & Michener, 1911	13				X	
Histioneis crateriformis Stein, 1883	10, 13, 14				X	
Histioneis cymbalaria Stein, 1883[h*]	18			X		
Histioneis elongata Kofoid & Michener, 1911[h]	15		X			
Histioneis hyalina Kofoid & Michener, 1911[h]	12, 14, 15, 18	X	X	X	X	
Histioneis megalocopa Stein, 1883[h]	12, 13, 14, 15		X	X	X	
Histioneis milneri Murray & Whitting, 1899[h]	10, 11, 12, 15, 18	X		X	X	X
Histioneis mitchellana Murray & Whitting, 1899[h]	12, 14				X	
Histioneis panaria Kofoid & Skogsberg, 1928[h]	13				X	
Histioneis rotundata Kofoid & Michener, 1911[h]	13				X	
Histioneis sp. Stein, 1883[h]	12, 13, 14, 15	X		X	X	
Histioneis sp1 Stein, 1883[h*?]	18	X			X	
Histioneis sp2 Stein, 1883[h*?]	18	X			X	
Histioneis striata Kofoid & Michener, 1911[h]	13				X	
Karenia papilionacea A.J. Haywood & K.A. Steidinger, 2004 *	18	X				X
Kryptoperidinium triquetrum (Ehrenberg) U. Tillmann, M. Gottschling, M. Elbrächter, W.-H. Kusber & M. Hoppenrath, 2019[m*]	18	X		X	X	X
Lessardia elongata Saldarriaga & F.J.R. Taylor, 2003[h*]	18	X	X	X	X	X
Lingulodinium polyedra (F. Stein) J.D. Dodge, 1989[m]	10, 12, 13, 14, 15, 17, 18	X	X	X	X	
Metaphalacroma skogsbergii L.-S. Tai, 1934 *	18	X			X	
Noctiluca scintillans (Macartney) Kofoid & Swezy, 1921	12, 18	X		X	X	X
Noctiluca sp. Suriray, 1836	15		X			
Ornithocercus heteroporus Kofoid, 1907[h]	15, 18	X		X		X
Ornithocercus magnificus Stein, 1883[h]	3, 6, 8, 10, 11, 12, 13, 14, 15, 16, 17, 18	X (16, 18)	X	X	X	X
Ornithocercus quadratus Schütt, 1900[h]	2, 6, 10, 11, 12, 13, 14, 15, 17, 18	X	X	X	X	
Ornithocercus sp. Stein, 1883[h]	12, 13, 15, 17		X		X	
Ornithocercus splendidus Schütt, 1895[h]	6, 8, 12, 15, 18	X	X	X	X	
Ornithocercus steinii Schütt, 1900[h]	2, 6, 8, 10, 12, 13, 15, 18	X	X	X	X	X
Ornithocercus thumii (Schmidt) Kofoid & Skogsberg, 1928[h]	8, 10, 12, 13, 14			X	X	
Ostreopsis ovata Fukuyo, 1981[m]	17				X	
Oxytoxum caudatum Schiller, 1937 *	18	X	X	X	X	X

(*continued on next page*)

Table 2 (*continued*)

	Sources	Illustration availability (picture, draw)	Shelf	Slope	Oceanic islands	Seamounts
Oxytoxum cf. *challengeroides* Stein, 1883 *	18	X		X	X	
Oxytoxum crassum J. Schiller, 1937	10, 13, 18	X		X	X	X
Oxytoxum curvatum (Kofoid) Kofoid & J.R. Michener, 1911	14, 18		X	X	X	X
Oxytoxum elegans Pavillard, 1916	6, 18	X	X		X	
Oxytoxum globosum Schiller *	18		X		X	
Oxytoxum gracile Schiller, 1937	12, 13, 14, 15		X	X	X	
Oxytoxum laticeps Schiller, 1937	13, 14, 15, 18	X	X	X	X	X
Oxytoxum longiceps Schiller	12, 18				X	
Oxytoxum mediterraneum Schiller	13, 15, 18		X	X	X	X
Oxytoxum obliquum Schiller, 1937	12, 13, 14, 15, 18		X	X	X	X
Oxytoxum parvum Schiller, 1937 *	18	X	X	X	X	X
Oxytoxum sceptrum (F. Stein) Schröder, 1906	14, 15, 17			X	X	
Oxytoxum scolopax Stein, 1883	10, 12, 13, 14, 15, 16, 17, 18	X (15, 16, 18)	X	X	X	X
Oxytoxum sphaeroideum Stein, 1883 *	18				X	
Oxytoxum spp. Stein, 1883	13, 15		X	X	X	
Oxytoxum subulatum Kofoid, 1907	13, 18	X		X	X	
Oxytoxum tesselatum (F. Stein) Schütt, 1895	14, 15, 18		X	X	X	X
Oxytoxum turbo Kofoid, 1907 *	18	X		X	X	X
Oxytoxum variabile Schiller, 1937 *	18	X	X	X	X	X
Oxytoxum viride Schiller, 1937	13				X	
Phalacroma circumcinctum Kofoid & Michener, 1911[h]	6, 14			X	X	
Phalacroma cuneus F. Schütt, 1895[h]	6, 8, 10, 12, 13, 14		X	X	X	
Phalacroma doryphorum Stein, 1883[h]	10, 11, 12, 13, 15, 18	X	X	X	X	
Phalacroma favus Kofoid & Michener, 1911[h]	12, 13				X	
Phalacroma mitra F. Schütt, 1895[h]	12, 14, 18	X		X	X	
Phalacroma porodictyum Stein, 1883[h]*	18	X				X
Phalacroma rapa Jorgensen, 1923[h]	6, 10, 12, 13, 14, 15, 18	X		X	X	
Phalacroma rotundatum (Claparéde & Lachmann) Kofoid & J.R. Michener, 1911[h]	10, 12, 13, 14, 15, 17, 18	X	X	X	X	X
Phalacroma scrobiculatum (Balech) Díaz-Ramos & G.J. Estrella 2000[h]	14				X	
Phalacroma sp. Stein, 1883[h]	6, 15		X	X		
Podolampas bipes Stein, 1883[h]	10, 12, 13, 15		X	X	X	
Podolampas bipes var. reticulata (Kofoid) Taylor[h]	13				X	
Podolampas elegans Schütt, 1895[h]	6, 10, 13, 15, 16, 18	X (15, 16)	X	X	X	
Podolampas palmipes Stein, 1883[h]	10, 12, 13, 14, 15, 16, 17, 18	X (16, 18)	X	X	X	X
Podolampas sp. Stein, 1883[h]	15		X			
Podolampas spinifera Okamura, 1912[h]	10, 13, 15, 17, 18	X	X	X	X	X
Polykrikos kofoidii Chatton, 1914[h]	12				X	
Preperidinium meunieri (Pavillard) Elbrächter, 1993[h]	12				X	
Pronoctiluca rostrata F.J.R. Taylor, (1976)[h]*	18	X			X	
Pronoctiluca spinifera (Lohmann) Schiller, 1932[h]*	18	X		X	X	
Prorocentrum balticum (Lohmann) Loeblich III, 1970[m]	10, 12, 13, 14, 17, 18	X	X	X	X	
Prorocentrum compressum (Bailey) T.H. Abé ex J.D. Dodge, 1980	5, 10, 12, 13, 14, 15, 17		X	X	X	
Prorocentrum cordatum (Ostenfeld) J.D. Dodge, 1975[m]	12, 18	X	X	X	X	X
Prorocentrum dactylus (Stein) Dodge, 1975 *	18	X	X	X	X	X
Prorocentrum emarginatum Fukuyo 1981	17, 18				X	
Prorocentrum gracile F. Schütt, 1895	10, 12, 13, 14, 15, 16, 17, 18	X (16, 18)	X	X	X	X
Prorocentrum hoffmannianum M.A. Faust, 1990[m]	13, 14, 17				X	
Prorocentrum lenticulatum (Matzenauer) F.J.R. Taylor, (1976) *	18	X			X	
Prorocentrum lima (Ehrenberg) F. Stein 1878	17, 18	X			X	
Prorocentrum mexicanum Osorio-Tafall 1942	17, 18	X	X	X	X	
Prorocentrum micans Ehrenberg, 1834[m]	6, 10, 12, 13, 15, 16, 17, 18	X (16, 18)	X	X	X	
Prorocentrum rostratum F. Stein, 1883	12, 14, 18	X	X		X	X
Prorocentrum shikokuense Hada, 1975 *	18	X	X	X	X	
Prorocentrum sp1 Ehrenberg, 1834 *[?]	18	X	X	X	X	X
Prorocentrum sp2 Ehrenberg, 1834 *[?]	18	X			X	
Prorocentrum spp. Ehrenberg, 1834	10, 13, 14, 15		X	X		
Prorocentrum triestinum J. Schiller, 1918[m]*	18	X		X	X	
Prorocentrum vaginula (F. Stein) J.D. Dodge, 1975	12, 13, 18	X	X	X	X	X
Protoceratium reticulatum (Claparède & Lachmann) Bütschli, 1885[h]	13, 18	X	X	X	X	X
Protoceratium spinulosum (Murray & Whitting) Schiller, 1937[h]*	18	X	X	X	X	
Protoperidinium acutipes (P.-A. Dangeard, 1927) Balech, 1974[h]*	18	X			X	
Protoperidinium brevipes (Paulsen, 1908) Balech, 1974[h]	6, 18	X	X	X	X	
Protoperidinium brochii (Kofoid & Swezy, 1921) Balech, 1974[h]	14				X	
Protoperidinium cassum (Balech, 1971) Balech, 1974[h]	14, 15, 18	X	X	X	X	
Protoperidinium cerasus (Paulsen, 1907) Balech, 1973[h]	10, 12				X	
Protoperidinium conicum (Gran) Balech, 1974[h]	13				X	
Protoperidinium crassipes (Kofoid, 1907) Balech, 1974[h]	12				X	
Protoperidinium curvipes (Ostenfeld) Balech, 1974[h]*	18	X			X	
Protoperidinium deficiens (Meunier, 1919) Balech, 1974[h]*	18	X		X	X	
Protoperidinium depressum (Bailey, 1854) Balech, 1974[h]	10, 11, 12, 13, 15		X	X	X	
Protoperidinium divergens (Ehrenberg) Balech, 1974[h]	10, 14, 18	X	X	X	X	

(*continued on next page*)

Table 2 (*continued*)

	Sources	Illustration availability (picture, draw)	Shelf	Slope	Oceanic islands	Seamounts
Protoperidinium elegans (Cleve, 1900) Balech, 1974[h]	8, 15		X	X		
Protoperidinium grande (Kofoid, 1907) Balech, 1974[h]	6			X		
Protoperidinium latispinum (Mangin, 1926) Balech, 1974[h]	10				X	
Protoperidinium longipes Balech, 1974[h]	14				X	
Protoperidinium oblongum (Aurivillius) Parke & Dodge, 1976[h]	9		X			
Protoperidinium obtusum (Karsten) Parke & J.D. Dodge, 1976[h]	10, 14, 17, 18	X			X	X
Protoperidinium oceanicum (VanHöffen, 1897) Balech, 1974[h]	12				X	
Protoperidinium ovatum Pouchet, 1883[h]	12				X	
Protoperidinium ovum (Schiller, 1911) Balech, 1974[h]	11, 12, 15		X		X	
Protoperidinium parcum (Balech, 1971) Balech, 1974[h]*	18	X	X	X	X	
Protoperidinium pedunculatum (Schütt, 1895) Balech, 1974[h]	6			X		
Protoperidinium pentagonum (Gran, 1902) Balech, 1974[h]	12				X	
Protoperidinium pyriforme (Paulsen, 1905) Balech, 1974[h]	17, 18	X	X	X	X	
Protoperidinium quarnerense (B. Schröder, 1900) Balech, 1974[h]*	18	X			X	
Protoperidinium rectum (Kofoid, 1907) Balech, 1974[h]	15		X			
Protoperidinium simulum (Paulsen, 1931) Balech, 1974[h]*	18	X			X	
Protoperidinium sp1 Bergh, 1881[h]*?	18	X			X	
Protoperidinium spp. Bergh, 1881[h]	6, 10, 12, 13, 14, 15, 17	X	X	X	X	
Protoperidinium steinii (Jørgensen, 1899) Balech, 1974[h]	12, 18	X		X	X	X
Protoperidinium subpyriforme (P.-A. Dangeard, 1927) Balech, 1974[h]	10, 18	X			X	
Protoperidinium venustum (Matzenauer, 1933) Balech, 1974[h]	15, 16	X (16)	X	X		
Pyrocystis elegans Pavillard, 1931	2		X			
Pyrocystis fusiformis C.W. Thomson, 1876	1, 2, 3, 6, 8, 10, 11, 12, 13, 15, 16, 18	X (16, 18)	X	X	X	
Pyrocystis hamulus var. inaequalis Schröder, 1900	2		X			
Pyrocystis hamulus var. semicircularis Schröder, 1900	2		X			
Pyrocystis lunula (Schütt) Schütt, 1896	6, 10, 13, 18		X	X	X	X
Pyrocystis obtusa Pavillard, 1931	13				X	
Pyrocystis pseudonoctiluca Wyville-Thompson, 1876	1, 2, 3, 6, 8, 11, 12, 14, 15, 16	X (16)	X	X	X	
Pyrocystis robusta Kofoid, 1907	6, 8, 10, 13, 14, 15, 16, 18	X (16, 18)	X	X	X	X
Pyrocystis sp. J. Murray ex Haeckel, 1890	15, 18	X		X		
Pyrophacus horologium F. Stein, 1883	1, 2, 3, 6, 10, 16	X (16)	X	X	X	
Pyrophacus sp. Stein, 1883	13, 17, 18				X	X
Pyrophacus steinii (Schiller) Wall & Dale, 1971	10, 15, 16	X (16)	X		X	
Schuettiella mitra (Schütt) Balech, (1988)	14, 18				X	X
Scrippsiella acuminata (Ehrenberg) Kretschmann, Elbrächter, Zinssmeister, S. Soehner, Kirsch, Kusber & Gottschling, 2015[m]	12, 18	X	X	X	X	
Scrippsiella sp. Balech ex A.R. Loeblich III, 1965	15, 18	X	X	X	X	X
Scrippsiella spinifera G. Honsell & M. Cabrini, 1991 *	18	X		X		
Spatulodinium pseudonoctiluca (Pouchet) J. Cachon & M. Cachon, 1968 *	18	X		X	X	
Spiraulax kofoidii H.W. Graham, 1942	11, 12, 18	X			X	
Triadinium polyedricum (Pouchet) Dodge, 1981	8, 10, 11, 12, 13, 14, 18	X	X	X	X	X
Tripos angustocornis (N. Peters) F. Gómez, 2013[m]	10, 15			X	X	
Tripos arietinus (Cleve) F. Gómez, 2013[m]	3, 7, 10, 12, 13, 15, 18	X	X	X	X	X
Tripos arietinus f. gracilentus (Jörgensen) F. Gómez, 2013[m]	7					
Tripos azoricus (Cleve) F. Gómez, 2013[m]	13, 15, 18		X	X	X	
Tripos belone (Cleve) F. Gómez, 2013[m]	11, 12, 18			X	X	
Tripos bigelowii (Kofoid) F. Gómez, 2013[m]	15			X		
Tripos brevis (Ostenfeld & Johannes Schmidt) F. Gómez, 2013[m]	1, 2, 3, 4, 7		X			
Tripos buceros (Zacharias) F. Gómez, 2013[m]	7					
Tripos candelabrum (Ehrenberg) F. Gómez, 2013[m]	1, 2, 3, 6, 7, 8, 10, 11, 12, 13, 15, 16, 18	X (16, 18)	X	X	X	X
Tripos candelabrum var. depressus (Pouchet) F. Gómez, 2013[m]	1, 2, 7		X			
Tripos carriensis (Gourret) F. Gómez, 2013[m]	1, 2, 3, 7, 8, 15, 18	X	X	X		X
Tripos cephalotus (Lemmermann) F. Gómez, 2013[m]	2, 6, 7, 8		X	X		
Tripos concilians (Jørgenen) F. Gómez, 2013[m]	7					
Tripos contortus (Gourret) F. Gómez, 2013[m]	1, 2, 3, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 18	X (16, 18)	X	X	X	
Tripos contrarius (Gourret) F. Gómez, 2013[m]	2, 8, 15		X	X		
Tripos declinatus (G. Karsten) F. Gómez, 2013[m]	9, 10, 11, 12, 13, 14, 15, 16, 17, 18	X (16, 18)	X	X	X	X
Tripos declinatus var. major (Jørgensen) F. Gómez, 2013[m]*	18	X		X		X
Tripos deflexus (Kofoid) F. Gómez, 2013[m]	7, 9		X			
Tripos dens (Ostenfeld & Johannes Schmidt) F. Gómez, 2013[m]	6		X			
Tripos digitatus (F. Schütt) F. Gómez, 2013[m]	7, 11, 12				X	
Tripos euarcuatus (Jörgenen) F. Gómez, 2013[m]	7, 8, 9, 15	X (15)	X	X		
Tripos eugrammus (Ehrenberg) F. Gómez, 2013[m]	8			X		
Tripos extensus (Gourret) F. Gómez, 2013[m]	2, 7, 9, 10, 12, 13, 14, 15, 16, 18	X (16, 18)	X	X	X	
Tripos falcatiformis (Jörgenen) F. Gómez, 2013[m]	7, 12, 14, 15			X	X	
Tripos falcatus (Kofoid) F. Gómez, 2013[m]	16, 18	X (16)	X	X	X	
Tripos furca (Ehrenberg) F. Gómez, 2013[m]	1, 2, 4, 6, 7, 9, 15, 16, 18	X (16, 18)	X	X		

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Table 2 (*continued*)

	Sources	Illustration availability (picture, draw)	Shelf	Slope	Oceanic islands	Seamounts
Tripos fusus (Ehrenberg) F. Gómez, 2013[m]	1, 2, 3, 4, 6, 7, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18	X (16, 18)	X	X	X	
Tripos geniculatus (Lemmermann) F. Gómez, 2013[m]	6, 7, 10, 18			X	X	
Tripos gibberus (Gourret) F. Gómez, 2013[m]	2, 3, 6, 7, 10, 11, 12, 13, 14, 15, 18	X	X	X	X	
Tripos gravidus (Gourret) F. Gómez, 2013[m]	2, 3, 6		X	X		
Tripos hexacanthus (Gourret) F. Gómez, 2013[m]	2, 3, 6, 7, 8, 10, 15, 18	X	X	X	X	X
Tripos hexacanthus f. spiralis (Kofoid) F. Gómez, 2013[m]	2		X			
Tripos horridus (Cleve) F. Gómez, 2013[m]	6, 7, 10, 13, 15, 16, 17, 18	X (16, 18)	X	X	X	X
Tripos incisus (Karsten) F. Gómez, 2013[m]	7, 10, 18				X	X
Tripos karstenii (Pavillard) F. Gómez, 2013[m]	7, 8, 12, 16	X (16)	X	X	X	
Tripos kofoidii (Jörgenen) F. Gómez, 2013[m]	7, 15, 18	X	X	X		X
Tripos limulus (Pouchet) F. Gómez, 2013[m]	6, 7, 12, 15, 18			X	X	X
Tripos lineatus (Ehrenberg) F. Gómez, 2013[m]	6, 7, 10, 11, 12, 13, 15, 17, 18		X	X	X	
Tripos longirostrus (Gourret) F. Gómez, 2013[m]	1, 2, 7, 10, 12, 13, 14, 15, 16	X (16)	X	X	X	
Tripos lunula (Schimper ex Karsten) F. Gómez, 2013[m]	3, 7, 10		X		X	
Tripos macroceros (Ehrenberg) F. Gómez, 2013[m]	1, 2, 3, 6, 7, 8, 10, 11, 12, 13, 14, 15, 16, 17, 18	X (16, 18)	X	X	X	X
Tripos massiliensis (Gourret) F. Gómez, 2013[m]	1, 2, 3, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 18	X (16, 18)	X	X	X	X
Tripos massiliensis f. armatus (Karsten) F. Gómez, 2013[m]	1, 2, 7, 10, 15		X	X	X	
Tripos minutus (Jörgensen) F. Gómez, 2013[m]	15		X			
Tripos mollis (Kofoid) F. Gómez, 2013[m]	10				X	
Tripos muelleri Bory de Saint-Vincent, 1827[m]	1, 2, 3, 4, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18	X (15, 16, 18)	X	X	X	X
Tripos muelleri f. parallelus (Schmidt) F. Gómez, 2013[m]	7					
Tripos paradoxides (Cleve) F. Gómez, 2013[m]	7, 10				X	
Tripos pavillardii (Jørgensen) F. Gomez, 2013[m]	7, 15		X			
Tripos pentagonus (Gourret) F. Gómez, 2013[m]	1, 2, 6, 7, 12, 13, 14, 15, 16, 17, 18	X (16, 18)	X	X	X	X
Tripos praelongus (Lemmermann) F. Gómez, 2013[m]	7					
Tripos pulchellus (Schröder) F. Gómez, 2013[m]	6, 7, 10, 15, 18		X	X	X	X
Tripos ranipes (Cleve) F. Gómez, 2013[m]	7, 15		X			
Tripos recurvus (Jørgesen) F. Gómez[m]	7, 8			X		
Tripos reflexus (Cleve) F. Gómez, 2013[m]	2, 6, 7, 10, 12, 14		X	X	X	
Tripos seta (Ehrenberg) F. Gómez, 2013[m]	7, 10, 15, 18		X	X	X	
Tripos setaceus (Jørgesen) F. Gómez, 2013[m]	15, 14		X	X	X	
Tripos strictus (Okamura & Nishikawa) F. Gómez, 2013[m]	10				X	
Tripos subrobustus (Jørgesen) F. Gómez, 2013[m]	7					
Tripos sumatranus (Karsten) F. Gómez, 2013[m]	3, 7, 8		X	X		
Tripos teres (Kofoid) F. Gómez, 2013[m]	2, 7, 8, 10, 11, 12, 13, 14, 15, 16, 17, 18	X (16, 18)	X	X	X	X
Tripos trichoceros (Ehrenberg) F. Gómez, 2013[m]	1, 2, 3, 7, 8, 9, 11, 15, 16, 18	X (16, 18)	X	X	X	X
Tripos tripodioides (Jørgesen) F. Gómez, 2013[m]	7, 8, 15		X	X		
Tripos volans (Cleve) F. Gómez, 2013[m]	2		X			
Tripos vultur (Cleve) F. Gómez, 2013[m]	2, 6, 7, 10, 11, 12, 13, 14, 15, 16	X (16)	X	X	X	
Triposolenia depressa Kofoid, 1906 *	18			X		
OCHROPHYTA						
Bacillariophyceae						
Centric form						
> 50 µm size						
Actinocyclus kützingii (A. Schmidt) Simonsen	14, 15			X	X	
Actinocyclus senarius Ehrenberg, 1838	5	X (5)	X			
Actinoptychus sp. C.G. Ehrenberg, 1843	10, 13, 18				X	X
Actinoptychus splendens (Shadbolt) Ralfs ex Pritchard, 1861	5, 15	X (5)	X			
Amphitetras antediluviana Ehrenberg, 1840	17				X	
Arachnoidiscus ehrenbergii J.W. Bailey ex Ehrenberg	15		X			
Asterolampra marylandica Ehrenberg, 1844	15, 17			X	X	
Asteromphalus heptactis (Brébisson) Ralfs, 1861	15, 16	X (16)	X	X		
Auliscus pruinosus Bailey	5	X (5)	X			
Auliscus sculptus (W. Smith) Brightwell, 1860	5, 16	X (5, 16)	X			
Bacteriastrum delicatulum Cleve, 1897	1, 4, 5, 15	X (5)	X	X		
Bacteriastrum furcatum Shadbolt, 1854	15, 18	X		X		
Bacteriastrum hyalinum Lauder, 1864	1, 4, 5, 12, 15, 16, 18	X (5, 16, 18)	X	X	X	
Bacteriastrum sp. G. Shadbolt, 1854	15		X	X		
Bacteriastrum sp1 G. Shadbolt, 1854 *[?]	18	X		X	X	X
Bellerochea malleus (Brightwell) Van Heurck, 1885	1, 4, 5, 13, 16, 17	X (5, 16)	X		X	
Biddulphia antediluviana (Ehrenberg) Van Heurck, 1885	4, 5, 10, 17	X (5)	X		X	
Biddulphia biddulphiana (J.E. Smith) Boyer, 1900	1, 4, 5, 10, 12, 15, 16, 17	X (5, 16)	X	X	X	
Biddulphia sp. S.F. Gray, 1821	15		X			
Biddulphia surirella (Ehrenberg) Rabenhorst, 1864	5		X			

(*continued on next page*)

Table 2 (*continued*)

	Sources	Illustration availability (picture, draw)	Shelf	Slope	Oceanic islands	Seamounts
Biddulphia titiana Grunow in Van Heurck, 1883	1, 4, 5	X (5)	X			
Biddulphia tridens (Ehrenberg) Ehrenberg, 1841	5, 15, 16	X (5, 16)	X			
Biddulphia tuomeyi (J.W. Bailey) Roper, 1859	1, 4, 15		X			
Centrics spp. Round & Crawford, 1990	18	X	X	X	X	X
Cerataulina bergonii Ostenfeld, 1903	1, 4, 5, 15, 18	X (5, 18)	X	X	X	
Cerataulina sp1H. Peragallo ex F. Schütt in Engler & Prantl, 1896 *	18	X				X
Chaetoceros affinis Lauder, 1864	1, 5, 9, 12, 15, 18	X (5, 18)	X	X	X	
Chaetoceros anglicus Grunow in Van Heurck, 1882	1, 5	X (5)	X			
Chaetoceros atlanticus Cleve, 1873	5, 10, 15	X (5)	X	X	X	
Chaetoceros borealis Bailey, 1854	15		X	X		
Chaetoceros brevis F. Schütt, 1895	5, 9, 15	X (5)	X			
Chaetoceros coarctatus Lauder, 1864	1, 5, 6, 8, 9, 10, 14, 15, 16, 18	X (5, 15, 16, 18)	X	X	X	X
Chaetoceros compressus Lauder, 1864	1, 5, 15	X (5)	X			
Chaetoceros concavicornis Mangin, 1917	15		X			
Chaetoceros curvisetus Cleve, 1889	1, 4, 5, 15, 16	X (5, 16)	X	X		
Chaetoceros decipiens Cleve, 1873	15, 18	X		X	X	
Chaetoceros densus (Cleve) Cleve, 1899	15		X			
Chaetoceros didymus Ehrenberg, 1845	1, 5, 9, 15	X (5)	X	X		
Chaetoceros difficilis Cleve, 1900	15		X			
Chaetoceros distans Cleve, 1873	15		X			
Chaetoceros diversus Cleve, 1873	1, 4, 5, 12, 15	X (5)	X	X	X	
Chaetoceros holsaticus F. Schütt, 1895	4, 18	X	X		X	
Chaetoceros laciniosus F. Schütt, 1895	15, 18	X	X	X	X	
Chaetoceros levis Schutt, 1896	4		X			
Chaetoceros lorenzianus Grunow, 1863	4, 5, 6, 10, 12, 13, 15, 16	X (5, 16)	X	X	X	
Chaetoceros mitra (Bailey) Cleve, 1896	5	X (5)	X			
Chaetoceros pelagicus Cleve *	18	X			X	
Chaetoceros perpusillus Cleve, 1897	15		X			
Chaetoceros peruvianus Brightwell, 1856	5, 10, 12, 13, 14, 15, 16, 18	X (5, 16, 18)	X	X	X	
Chaetoceros pseudocurvisetus Mangin, 1910	5, 12	X (5)	X		X	
Chaetoceros saltans Cleve, 1897	15		X			
Chaetoceros septentrionalis Cleve, 1896	15			X		
Chaetoceros simplex Ostenfeld, 1902 *	18	X			X	
Chaetoceros sp1C.G. Ehrenberg, 1844 *[?]	18	X			X	
Chaetoceros sp2C.G. Ehrenberg, 1844 *[?]	18	X			X	
Chaetoceros sp3C.G. Ehrenberg, 1844 *[?]	18	X			X	X
Chaetoceros spp. C.G. Ehrenberg, 1844	9, 10, 13, 15, 17, 18	X	X	X	X	
Chaetoceros teres Cleve, 1896	1, 5, 15	X (5)	X			
Chaetoceros tetrastichon Cleve, 1897	1, 5, 6, 15	X (5)	X	X		
Chrysanthemodiscus floriatus A. Mann, 1925	15, 16	X (15, 16)	X	X		
Climacodium frauenfeldianum Grunow, 1868	5, 6, 8, 15	X (5)	X	X		
Corethron criophilum Castracane, 1886	15		X			
Corethron hystrix Hensen, 1887	5, 6, 15	X (5)	X	X		
Coscinodiscus asteromphalus Ehrenberg, 1844	4		X			
Coscinodiscus centralis Ehrenberg, 1844	10	X (5, 16)	X	X	X	
Coscinodiscus concavus Ehrenberg, 1854	15		X			
Coscinodiscus curvatulus Grunow ex A. Schmidt, 1878	4		X			
Coscinodiscus granii Gough, 1905	1, 5, 14	X (5)	X		X	
Coscinodiscus lineatus Ehrenberg, 1841	5, 18	X (5)	X		X	
Coscinodiscus marginatus Ehrenberg, 1844	15			X		
Coscinodiscus oculus-iridis (Ehrenberg) Ehrenberg, 1840	5, 6, 10	X (5)	X	X	X	
Coscinodiscus radiatus Ehrenberg, 1840	15		X			
Coscinodiscus radiolatus Ehrenberg, 1854	15			X		
Coscinodiscus spp. C.G. Ehrenberg, 1839	6, 10, 13, 15, 18	X	X	X	X	X
Ditylum brightwellii (T. West) Grunow, 1885	4, 5, 6, 15, 16	X (5, 16)	X	X		
Ethmodiscus gazellae (C. Janisch ex Grunow) Hustedt, 1928	5, 6	X (5)	X	X		
Gossleriella tropica Schütt, 1892	15, 16, 18	X (16, 18)	X	X	X	
Guinardia flaccida (Castracane) H. Peragallo, 1892 *	18	X				X
Guinardia spp. H. Peragallo, 1892	9, 15		X	X		
Guinardia striata (Stolterfoth) Hasle, 1996	15, 16	X (15, 16)	X	X		
Haslea wawrikae (Hustedt) Simonsen, 1974 *	18	X			X	X
Helicotheca tamesis (Shrubsole) M. Ricard, 1987	1, 4, 5, 9, 15, 17, 18	X	X	X	X	X
Hemiaulus hauckii Grunow ex Van Heurck, 1882	12, 15, 18	X	X	X	X	
Hemiaulus indicus Karsten, 1907	5, 18	X (5, 18)	X		X	
Hemiaulus membranaceus Cleve	1, 4, 5, 8, 9, 10, 11, 12, 15, 16, 18	X (5, 15, 16, 18)	X	X	X	X
Hemiaulus sinensis Greville, 1865	5, 6, 11, 12, 16	X (5, 16)	X	X	X	
Hemiaulus sp. P.A.C. Heiberg, 1863	9, 13, 15		X		X	
Hemidiscus sp. G.C. Wallich, 1860	13				X	
Hobaniella longicruris (Greville) P.A. Sims & D.M. Williams in Sims et al., 2018	4, 5	X (5)	X			
Isthmia enervis Ehrenberg, 1838	1, 4, 5, 6, 8, 9, 13, 15, 16, 17, 18	X (5, 16, 18)	X	X	X	X
Isthmia sp. C.A. Agardh, 1832	13				X	

(*continued on next page*)

Table 2 (*continued*)

	Sources	**Illustration availability (picture, draw)**	**Shelf**	**Slope**	**Oceanic islands**	**Seamounts**
Lampriscus orbiculatum (Shadbolt) Peragallo & Peragallo, 1902	13,14		X		X	
Lampriscus shadboldtianum (Greville) H.Peragallo & M.Peragallo, 1902	10,18		X	X	X	
Lampriscus sp. A. Schmidt 1882	17				X	
Lauderia borealis Gran, 1900	5	X (5)	X			
Lioloma pacificum (Cupp) Hasle, 1996 *	18	X		X	X	X
Lithodesmium sp. C.G. Ehrenberg, 1839	9, 15		X	X		
Lithodesmium undulatum Ehrenberg, 1839	1, 4, 5, 6, 15, 17	X (5)	X	X	X	
Melchersiela hexagonalis Teixeira, 1958	4, 5, 6, 8, 9, 13, 14, 17, 18	X (5)	X	X	X	X
Melosira borreri Greville, 1833	15		X	X		
Melosira spp. C.A. Agardh, 1824	15, 18		X	X	X	
Melosira sulcata (Ehrenberg) Kützing, 1844	5		X			
Odontella aurita (Lyngbye) C. Agardh, 1832	4, 5, 9, 13	X (5)	X		X	
Odontella regia (Schultze) Simonsen, 1974	16	X (16)	X			
Odontella sp. C.A. Agardh, 1832	9		X			
Odontella turgida (Ehrenberg) Kützing, 1844	4, 5, 16	X (5, 16)	X			
Palmeria hardmanniana Greville, 1865	5, 6	X (5)	X	X		
Paralia sp. P.A.C. Heiberg, 1863	15		X			
Paralia sulcata (Ehrenberg) Cleve, 1873	6, 13, 15, 16, 17, 18	X (5, 15, 16, 18)	X	X	X	
Planktoniella sol (C.G. Wallich) Schütt, 1892	6, 8, 12, 13, 14, 15, 18	X	X	X	X	X
Pleurosira laevis (Ehrenberg) Compère, 1982	10				X	
Proboscia alata (Brightwell) Sundström, 1986	1, 5, 9, 14, 15, 16, 18	X (5, 16, 18)	X	X	X	X
Proboscia indica (H. Peragallo) Hernández-Becerril, 1995	16	X (5, 16)	X	X		
Rhizosolenia acuminata (H. Peragallo) H. Peragallo, 1907	5, 6, 15, 16	X (5, 16)	X	X		
Rhizosolenia alata var. corpulenta Cleve, 1897	15		X			
Rhizosolenia bergonii H. Peragallo, 1892	5, 6, 8, 14, 15	X (5)	X	X	X	
Rhizosolenia calcar-avis Schultze, 1858	1, 4, 5, 14, 15	X (5)	X		X	
Rhizosolenia castracanei H. Peragallo, 1888	5, 6, 8, 15, 18	X (5, 18)	X	X		X
Rhizosolenia clevei Ostenfeld, 1902	12				X	
Rhizosolenia cylindrus Cleve, 1897	1, 5, 16, 18	X (5, 16, 18)	X	X		X
Rhizosolenia delicatula Cleve, 1900	12, 15		X	X	X	
Rhizosolenia flaccida Castracane, 1886	15		X	X		
Rhizosolenia formosa H. Peragallo, 1888	5, 6	X (5)	X			
Rhizosolenia fragilissima f. fragilissima Bergon, 1903	15		X	X		
Rhizosolenia hebetata Bailey, 1856	9, 14, 18	X	X		X	
Rhizosolenia imbricata Brightwell, 1858	4, 5, 6, 12, 14, 15, 16, 17, 18	X (5, 16, 18)	X	X	X	
Rhizosolenia indica H. Peragallo, 1892	5		X			
Rhizosolenia robusta G. Norman ex Ralfs, 1861	1, 5, 15	X (5, 15)	X	X		
Rhizosolenia semispina Hensen, 1887	1, 5, 15	X (5)	X	X		
Rhizosolenia setigera Brightwell, 1858	1, 4, 5, 9, 13, 15, 16	X (5, 16)	X	X	X	
Rhizosolenia shrubsolei Cleve, 1881	1, 5	X (5)	X			
Rhizosolenia spp. T. Brightwell, 1858	9, 12, 15	X	X	X	X	
Rhizosolenia stolterfothii H. Peragallo, 1888	1, 4, 5, 6, 15	X (5)	X	X		
Rhizosolenia styliformis T. Brightwell, 1858	1, 5, 6, 8, 9, 10, 14, 15, 16, 17, 18	X (5, 15, 16, 18)	X	X	X	X
Skeletonema costatum (Greville) Cleve, 1873	1, 4, 5, 9, 13, 15, 18	X (5, 18)	X	X	X	
Spatangidium arachne Brébisson, 1857	14, 15, 18	X	X	X	X	X
Thalassiosira eccentrica (Ehrenberg) Cleve, 1904	5, 15, 16	X (5, 16)	X	X		
Triceratium alternans f. alternans J.W. Bailey, 1851	5, 10	X (5)	X		X	
Triceratium contortum Shadbolt, 1854	4, 5	X (5)	X			
Triceratium elongatum Grunow, 1867	1, 4, 10		X		X	
Triceratium favus Ehrenberg, 1839	5, 12, 16	X (5, 16)	X		X	
Triceratium formosum f. formosum Brightwell, 1856	4		X			
Triceratium orbiculatum Schibkova in Krotov & Schibkova, 1959	1, 10		X		X	
Triceratium pentacrinus (Ehrenberg) Wallich, 1858	1, 4, 5, 13, 16, 17, 18	X (5, 16)	X		X	X
Triceratium repletum Greville	13, 15			X	X	
Triceratium sp. C.G. Ehrenberg, 1839	12				X	
Triceratium sp1C.G. Ehrenberg, 1839 *[?]	18	X			X	X
Trieres mobiliensis (J.W. Bailey) Ashworth & E.C. Theriot in Ashworth, Nakov & E.C. Theiriot, 2013	1, 4, 5, 6, 16, 18	X (5, 16, 18)	X	X		
Trieres regia (M. Schultze) M.P. Ashworth & E.C. Theriot, 2013	1, 4, 5, 15, 17	X (5)	X		X	
< 50 µm size						
Asteromphalus flabellatus (Brébisson) Greville, 1859	15, 18		X	X	X	
Auricula sp. A.F. Castracane, 1873	1, 17		X		X	
Chaetoceros cinctus Gran, 1897	15			X		
Chaetoceros danicus Cleve, 1889	15		X	X		
Chaetoceros rostratus Ralfs, 1864	1, 5	X (5)	X			
Chaetoceros socialis H.S. Lauder, 1864	4, 12		X		X	
Chaetoceros subtilis Cleve, 1896	15		X	X		
Coscinodiscus nitidus Schmidt in Schmidt et al., 1878	15		X	X		
Coscinodiscus scintillans Greville, 1863	15		X	X		
Cyclotella sp1 (F.T. Kützing) A. de Brébisson, 1838 *	18	X		X	X	
Lauderia confervacea Cleve, 1896	15		X	X		
Lauderia pumila Castracane, 1886	15		X	X		

(*continued on next page*)

Table 2 (*continued*)

	Sources	Illustration availability (picture, draw)	Shelf	Slope	Oceanic islands	Seamounts
Endictya oceanica Ehrenberg, 1845	4		X			
Eupodiscus radiatus var. antiqua Cox in Kain & Schultze, 1889	4, 5	X (5)	X			
Leptocylindrus danicus Cleve, 1889	4, 5, 6, 8, 9, 10, 15	X (5)	X	X	X	
Leptocylindrus sp. P.T. Cleve in C.G.J. Petersen, 1889	15		X	X		
Thalassiosira leptopus (Grunow ex Van Heurck) Hasle & G. Fryxell, 1977	6, 15		X	X		
Thalassiosira sp. P.T. Cleve, 1873 emend. Hasle, 1973	12, 13, 14, 15, 17, 18		X	X	X	
Thalassiosira subtilis (Ostenfeld) Gran, 1900	15, 16	X (16)	X	X		
Pennate form						
> 50 µm size						
Achnanthes brevipes C. Agardh, 1824	5, 6	X (5)	X			
Achnanthes longipes C. Agardh, 1824	5	X (5)	X			
Achnanthes sp. Bory, 1822	14				X	
Amphiprora complexa Gregory, 1857	9		X			
Amphiprora sp. C.G. Ehrenberg, 1843	1, 15, 17, 18		X		X	
Ardissonea formosa (Hantzsch) Grunow	13, 17				X	
Asterionella bleakeleyi var. notata Grunow, 1867	1, 4, 5, 6, 6, 9, 15, 18	X (5, 18)	X	X	X	
Asterionella glacialis Castracane, 1886	6, 9, 13, 14, 15, 16, 17, 18	X (15, 16, 18)	X	X	X	X
Asterionella japonica Cleve, 1882	1, 4, 5, 15	X (5)	X	X		
Asterionella sp. A.H. Hassall, 1850	15			X		
Asterionella sp1 A.H. Hassall, 1850 *[?]	18	X		X	X	
Bacillaria paxillifera (O.F. Müller) T. Marsson, 1901	4, 5, 6, 9, 15, 16, 17, 18	X (5, 16, 18)	X	X	X	
Bacillaria ulna Nitzsch, 1817	5	X (5)	X			
Campylodiscus clypeus (Ehrenberg) Ehrenberg ex Kützing, 1844	1, 5, 6, 13, 15, 17	X (5)	X	X	X	
Campylodiscus ecclesianus Greville	5	X (5)	X			
Campylodiscus fastuosus Ehrenberg, 1845	5	X (5)	X			
Campylodiscus grevillii Leuduger-Fortmorel, 1879	5		X			
Campylodiscus sp. C.G. Ehrenberg ex F.T. Kützing, 1844	4, 14		X		X	
Campyloneis grevillei (W. Smith) Grunow & Eulenstein in Grunow 1868	17	X (5)			X	
Climaconeis mirifica (W. Smith) Kuntze, 1898	1		X			
Climacosphenia elongata J.W. Bailey, 1854	10, 13, 17				X	
Climacosphenia moniligera Ehrenberg, 1843	1, 4, 5, 6, 10	X (5)	X		X	
Cylindrotheca closterium (Ehrenberg) Reimann & J.C. Lewin, 1964	4, 5, 6, 9, 10, 15, 17, 18	X (5, 15, 18)	X	X	X	X
Diploneis bombus (Ehrenberg) Ehrenberg, 1853	6, 9, 15, 17		X	X	X	
Diploneis spp. (C. G. Ehrenberg) P.T. Cleve, 1894	12, 13, 15, 17, 18		X	X	X	
Epithemia sp. F.T. Kützing, 1844	15		X			
Frustulia rhomboides (Ehrenberg) De Toni, 1891	5, 14	X (5)	X		X	
Gyrosigma balticum (Ehrenberg) Rabenhorst, 1853	4, 5, 6, 9, 16	X (5, 16)	X	X		
Gyrosigma sp. A.H. Hassall, 1845	15		X			
Licmophora abbreviata C. Agardh, 1831	6, 10, 15		X	X	X	
Licmophora ehrenbergii (Kützing) Grunow, 1867	10				X	
Licmophora gracilis (Ehrenberg) Grunow, 1867	10, 15		X		X	
Licmophora lyngbyei (Kützing) Grunow ex Van Heurck, 1867	13				X	
Licmophora remulus Grunow, 1867	13, 14, 15		X		X	
Licmophora sp. C.A. Agardh, 1827	9, 10, 12, 13, 15, 17		X		X	
Lyrella lyra (Ehrenberg) Karajeva, 1978	5, 6, 9, 13, 15, 16, 17, 18	X (5, 16, 18)	X	X	X	
Navicula humerosa f. humerosa Brébisson ex W. Smith, 1856	5, 14	X (5)	X		X	
Nitzschia longissima (Brébisson) Ralfs, 1861	6, 9, 10, 12, 13, 15, 17, 18	X	X	X	X	X
Nitzschia longissima var. reversa Grunow, 1880	15		X	X		
Nitzschia lorenziana Grunow, 1879	15, 18	X	X	X	X	
Nitzschia lorenziana var. incerta Grunow in Cleve & Grunow, 1880	13				X	
Nitzschia pungens Grunow ex Cleve, 1897	15		X			
Nitzschia pungens var. atlantica Cleve, 1897	4, 5	X (5)	X			
Nitzschia sigma (Kützing) W. Smith, 1853	4, 6, 9, 13, 15, 17, 18	X	X		X	
Nitzschia sigma var. intercedens Grunow, 1878	15		X			
Nitzschia spathulata W. Smith, 1853	17, 18	X			X	
Pennate 1 Mann, 1990 *[?]	18	X	X			
Pinnularia crabro Ehrenberg, 1844	15		X			
Pinnularia sp. C.G. Ehrenberg, 1843 *	18	X			X	
Plagiotropis lepidoptera (Gregory) Kuntze, 1898	15, 18	X	X		X	
Plagiotropis sp1 E. Pfitzer, 1871 *	18	X	X	X	X	X
Pleuro/Gyrosigma sp. Haeckel, 1878	9, 17		X		X	
Pleurosigma affine Grunow, 1880	15		X	X		
Pleurosigma angulatum (Queckett) W. Smith, 1852	15		X			
Pleurosigma scalprum var. gallicum Grunow in Van Heurck, 1880–1885	15		X			
Pleurosigma spp. W. Smith, 1852	9, 12, 14, 15		X	X	X	
Pleurosigma virginiacum H.L. Smith, 1877 *	18	X	X			
Podocystis adriatica (Kützing) Ralfs, 1861	4, 5, 9, 13, 14, 16, 17, 18	X (5, 16, 18)	X	X	X	
Podocystis americana Bailey, 1854	10				X	
Podocystis sp. J.W. Bailey, 1854	14				X	
Podosphenia ovata W. Smith, 1853	10				X	
Pseudo-nitzschia delicatissima (Cleve) Heiden, 1928	9		X			
Pseudo-nitzschia pungens (Grunow ex Cleve) G.R. Hasle, 1993	9, 15, 18		X		X	

(*continued on next page*)

Table 2 (*continued*)

	Sources	Illustration availability (picture, draw)	Shelf	Slope	Oceanic islands	Seamounts
Pseudo-nitzschia seriata complex H. Peragallo in H. Peragallo & M. Peragallo, 1900 *	18	X	X	X		
Pseudo-nitzschia sp. H. Peragallo in H. Peragallo & M. Peragallo, 1900	10, 15	X	X	X	X	
Pseudo-nitzschia sp1H. Peragallo in H. Peragallo & M. Peragallo, 1900 *	18	X		X	X	
Pseudosolenia calcar-avis (Schultze) B.G. Sundström, 1986	6, 12, 16, 18	X (16, 18)	X	X	X	X
Rhabdonema adriaticum Kützing, 1844	1, 4, 5, 9, 10, 13, 14, 15, 16, 17, 18	X (5, 16, 18)	X	X	X	
Rhabdonema punctatum (Harvey & Bailey) Stodder, 1880	4, 5, 9, 10, 15	X (5)	X		X	
Rhabdonema sp. F.T. Kützing, 1844	9, 13		X		X	
Schizonema smithii var. smithii Agardh, 1824	15		X			
Streptotheca thamesis var. thamesis Shrubsole, 1890	6	X (5)	X	X		
Striatella interrupta (Ehrenberg) Heiberg, 1863	1, 4, 5, 13, 15, 16	X (5, 16)	X		X	
Striatella sp. C.A. Agardh, 1832	9, 18		X			
Striatella unipunctata (Lyngbye) C. Agardh, 1832	1, 5, 6, 9, 13, 16, 18	X (5, 16, 18)	X	X	X	
Surirella fastuosa (Ehrenberg) Ehrenberg, 1843	13, 14, 17	X (5)			X	
Surirella febigerii F.W. Lewis, 1861	4, 5, 16	X (5, 15, 16)	X			
Surirella gemma f. gemma Ehrenberg, 1840	4		X			
Surirella nervata (Grunow) Mereschkowsky, 1902	5	X (5)	X			
Surirella recedens var. recedens Schmidt in Schmidt et al., 1875	5	X (5)	X			
Surirella sp. P.J.F. Turpin, 1828	14				X	
Surirella sp1 P.J.F. Turpin, 1828 *[?]	18	X	X	X		
Synedra acus var. acus Kützing, 1844	18	X			X	
Synedra crystallina (C. Agardh) Kützing, 1844	18	X			X	
Synedra doliolus Wallich, 1860	14				X	
Synedra sp. C.G. Ehrenberg, 1830	10, 13, 15, 17		X	X	X	
Synedra sp1 C.G. Ehrenberg, 1830 *[?]	18	X	X	X	X	
Tabularia fasciculata (C. Agardh) D.M. Williams & Round, 1986 *	18				X	
Terpsinoë musica Ehrenberg, 1843	1, 5, 15	X (5)	X			
Thalassionema frauenfeldii (Grunow) Tempère & Peragallo, 1910	1, 5, 9, 15, 16	X (5, 16)	X			
Thalassionema nitzschioides (Grunow) Mereschkowsky, 1902	1, 4, 5, 9, 15, 16, 18	X (5, 16, 18)	X	X	X	X
Thalassiothrix longissima Cleve & Grunow, 1880 *	18	X			X	
Thalassiothrix sp. P.T. Cleve & A. Grunow, 1880	15		X			
Thalassiothrix sp1 P.T. Cleve & A. Grunow, 1880 *[?]	18	X		X		X
Toxarium undulatum Bailey, 1854	4, 5, 10, 13, 15, 17		X		X	
Trachyneis aspera (Ehrenberg) Cleve, 1894	13, 17, 18		X	X	X	
Tropidoneis seriata Cleve, 1892	5, 6, 15	X (5)	X			
Tropidoneis sp. P.T. Cleve, 1891	17				X	
Tryblionella gracilis W. Smith, 1853	15		X			
Tryblionella punctata W. Smith, 1853	17				X	
< 50 µm size						
Amphora arenaria Donkin, 1858	5, 6, 13, 17	X (5)	X		X	
Amphora egregia Ehrenberg, 1861	9		X			
Amphora fluminensis Grunow 1863	13				X	
Amphora ostrearia Brébisson, 1849	9		X			
Amphora sp. C.G. Ehrenberg ex F.T. Kützing, 1844	9, 10, 13, 14, 15, 17, 18	X	X		X	
Amphora sp1 C.G. Ehrenberg ex F.T. Kützing, 1844 *[?]	18					X
Amphora sp2 C.G. Ehrenberg ex F.T. Kützing, 1844 *[?]	18			X		
Amphora turgida var. turgida Gregory, 1857 *	18		X			
Campyloneis sp. A. Grunow, 1862	18		X			
Campylosira sp. A. Grunow ex H. Van Heurck, 1885 *	18	X		X	X	X
Cocconeis regalis Greville, 1859	4		X			
Cocconeis scutellum Ehrenberg, 1838	4, 5, 6, 13, 17, 18	X (5, 18)	X	X	X	
Cocconeis sp. C.G. Ehrenberg, 1837	13	X			X	
Dimeregramma dubium (Grunow) Grunow in Van Heurck, 1881	9		X	X		X
Dimeregramma sp. J. Ralfs in A. Pritchard, 1861	17				X	
Entomoneis alata (Ehrenberg) Ehrenberg, 1845	4, 6, 17, 18	X	X	X	X	X
Fragilaria capucina Desmazières, 1830	9, 15		X	X		
Fragilaria hyalina (Kützing) Grunow ex Van Heurck, 1880	15		X			
Fragilaria sp. H.C. Lyngbye, 1819	1, 15		X			
Fragilariopsis sp. F. Hustedt in A. Schmidt et al., 1913	12				X	
Grammatophora flexuosa Grunow, 1881	5	X (5)	X			
Grammatophora hamulifera Kützing, 1844	5	X (5)	X			
Grammatophora marina (Lyngbye) Kützing, 1844	4, 5, 15, 16	X (5, 16)	X			
Grammatophora oceanica Ehrenberg, 1840	5, 15, 16, 17	X (5, 16)	X	X	X	
Grammatophora serpentina Ehrenberg, 1844	13, 15		X		X	
Grammatophora sp. C.G. Ehrenberg, 1840	10, 15, 17, 18		X	X	X	
Mastogloia fimbriata (T. Brightwell) Grunow, 1863	5	X (5)	X			
Mastogloia sp1 G.H.K. Thwaites in W. Smith, 1856 *	18	X	X		X	
Mastogloia splendida (Gregory) H. Pergallo, 1888	16	X (5, 16)	X	X		
Navicula fastuosa Ehrenberg, 1840	5		X			
Navicula incurvata Gregory, 1856	14				X	
Navicula lewisiana Greville, 1863	4		X			
Navicula marina var. marina Ralfs in Pritchard, 1861	5, 14, 15	X (5)	X		X	

(*continued on next page*)

Table 2 (*continued*)

	Sources	Illustration availability (picture, draw)	Shelf	Slope	Oceanic islands	Seamounts
Navicula membranacea Cleve, 1897	15, 18	X	X	X		X
Navicula powellii sensu H. Peragallo, 1888	15		X			
Navicula cf *trevelyana* J.B.M. Bory de Saint-Vincent, 1822	15		X			
Navicula sp1 J.B.M. Bory de Saint-Vincent, 1822 *?	18	X	X			
Navicula sp3 J.B.M. Bory de Saint-Vincent, 1822 *?	18	X	X		X	
Navicula sp4 J.B.M. Bory de Saint-Vincent, 1822 *?	18	X		X	X	X
Navicula sp2 J.B.M. Bory de Saint-Vincent, 1822 *?	18	X	X			
Navicula sp5 J.B.M. Bory de Saint-Vincent, 1822 *?	18	X		X		
Navicula splendida var. splendida Gregory, 1856	13				X	
Navicula spp. J.B.M. Bory de Saint-Vincent, 1822	6, 9, 10, 12, 13, 14, 15, 17, 18	X	X	X	X	
Nitzschia distans sensu Brockmann, 1950	17				X	
Nitzschia granulata Grunow, 1880	5	X (5)	X			
Nitzschia pacifica Cupp, 1943	13, 15, 17			X	X	
Nitzschia panduriformis f. panduriformis Gregory, 1857	15, 17		X		X	
Nitzschia sp1 A.H. Hassall, 1845 *?	18	X			X	
Nitzschia sp2 A.H. Hassall, 1845 *?	18	X			X	X
Nitzschia sp3 A.H. Hassall, 1845 *?	18	X	X		X	
Nitzschia spp. A.H. Hassall, 1845	6, 9, 10, 13, 15, 17		X	X	X	
Nitzschia tryblionella Hantzsch, 1860	1, 5	X (5)	X			
Plagiogramma sp. R.K. Greville, 1859	15, 18		X	X		
Rhaphoneis amphiceros (Ehrenberg) Ehrenberg, 1844	5	X (5)	X			
Rhaphoneis discoides Subrahmanyan, 1946	5	X (5)	X			
Stauroneis sp. C.G. Ehrenberg, 1843 *	18	X				X
Dictyochophyceae						
Dictyocha fibula Ehrenberg 1839	12, 13, 14, 15, 17, 18	X (15, 18)	X	X	X	X
Octactis octonaria (Ehrenberg) Hovasse, 1946 *	18	X			X	
Octactis speculum (Ehrenberg) F.H. Chang, J.M. Grieve & J.E. Sutherland, 2017	13, 15, 18	X (15)	X	X	X	
CYANOBACTERIA						
Cyanophyceae						
Anabaena sp. Bory de Saint-Vincent ex Bornet & Flahault, 1886	17				X	
Anabaena sp1 *Bory de Saint-Vincent ex Bornet & Flahault, 1886* *?	18	X		X		
Aphanocapsa sp1C. Nägeli, 1849 *	18	X				X
Aphanocapsa sp2 C. Nägeli, 1849 *	18	X		X		X
Arthrospira sp1 Sitzenberger ex Gomont, 1892 *	18	X		X		
Chroococcus sp. Nägeli, 1849	15		X			
Chroococcus turgidus (Kützing) Nägeli, 1849	15			X		
Cyanophyceae spp. Schaffner, 1909	13, 17				X	
Jaaginema sp1 Anagnostidis & Komárek, 1988 *	18	X		X	X	
Katagnymene pelagica Lemmermann, 1899	11, 12				X	
Katagnymene spiralis Lemmermann, 1899	12				X	
Lyngbya anomala (C.B. Rao) Umezaki & Watanabe, 1994	9		X			
Lyngbya sp. C.Agardh ex Gomont, 1892	9, 14, 15, 17		X		X	
Lyngbya sp1C. Agardh ex Gomont, 1892 *?	18	X		X	X	X
Merismopedia sp. Meyen, 1839	15		X			
Microcystis sp. Lemmermann, 1907	15		X			
Oscillatoria perornata Skuja, 1949	9		X			
Oscillatoria princeps Vaucher ex Gomont, 1892	6, 8		X	X		
Oscillatoria cf. margaritifera Vaucher ex Gomont, 1892 *	18	X	X	X	X	
Oscillatoria sp1 Vaucher ex Gomont, 1892 *?	18	X			X	
Oscillatoria spp. Vaucher ex Gomont, 1892	6, 8, 9, 10, 13, 15, 17		X	X	X	
Phormidium retzii Kützing ex Gomont, 1892	9		X			
Phormidium sp. Kützing ex Gomont, 1892	9, 15		X	X		
Phormidium sp1 Kützing ex Gomont, 1892 *? (=Katagnymene?)	18	X			X	
Phormidium sp2 Kützing ex Gomont, 1892 *? (=Katagnymene?)	18	X	X		X	
Planktolyngbya sp. Anagnostidis & Komárek, 1988	14				X	
Planktolyngbya cf *limnetica* Anagnostidis & Komárek, 1988 *	18	X		X	X	X
Pseudanabaena sp1 Lauterborn, 191 *	18	X				
Richelia intracellularis J.A. Schmidt, 1901	1, 12, 13, 14, 18	X (12, 18)	X	X	X	X
Rivularia sp. C. Agardh ex Bornet & Flahault, 1886	15		X			
Scytonematopsis crustacea (Thuret ex Bornet & Flahault) Kovàlik & Komárek, 1988	15	X (15)	X	X		
Spirulina sp. Turpin ex Gomont, 1892	4, 9, 18		X			
Stichosiphon sansibaricus (Hieronymus) F.E. Drouet & W.A. Daily, 1956	9		X			
Trichodesmium clevei (J. Schmidt) Anagnostidis & Komárek, 1988 *	18	X			X	
Trichodesmium erythraeum Ehrenberg ex Gomont, 1892	4, 6, 8, 11, 12, 14, 15	X (12, 15)	X	X	X	
Trichodesmium hildebrandtii Gomont, 1892	12	X (12)			X	
Trichodesmium radians (Wille ex Kirchner) Golubic, 1978	12				X	
Trichodesmium sp. Ehrenberg ex Gomont, 1892	1		X			
Trichodesmium thiebautii Gomont ex Gomont, 1890	9, 10, 11, 12, 13, 14, 15, 17, 18	X	X	X	X	X
HAPTOPHYTA						
Prymnesiophyceae						

(*continued on next page*)

Table 2 (*continued*)

	Sources	Illustration availability (picture, draw)	Shelf	Slope	Oceanic islands	Seamounts
Emiliania huxleyi (Lohmann) W.W. Hay & H.P. Mohler, 1967	13, 17, 18	X		X	X	X
Calciosolenia brasiliensis (Lohmann) J.R. Young, 2003	15			X		
Calciosolenia murrayi Gran, 1912	15	X (15)		X		
Coccolithophorid 1 (cf Rhabdosphaeraceae Lemmermann, 1908) *	18	X			X	
Coccolithophorid 2 *	18	X		X	X	
Coccolithophorid 3 *	18	X			X	
Coccolithophorid 4 *	18	X		X		X
Coccolithus sp1 E.H.L. Schwarz, 1894	17				X	
Coccolithus sp2 E.H.L. Schwarz, 1894	17				X	
Discosphaera tubifer (Murray & Blackman) Ostenfeld, 1900	15			X		
Papposphaera lepida Tangen, 1972	15			X		
Phaeocystis sp. Lagerheim, 1893 *	18	X		X		
Pontosphaera discopora Schiller, 1930	12				X	
Pontosphaera sp. Lohmann, 1902 *	18	X				X
Scyphosphaera apsteinii Lohmann, 1902	13, 18	X (15, 18)			X	X
Syracosphaera pulchra Lohmann, 1902 *	18	X			X	
Syracosphaera sp. Lohmann, 1902	13				X	
PLANTAE						
Charophyta						
Closterium setaceum Ehrenberg ex Ralfs, 1848	15		X	X		
Closterium sp. Nitzsch ex Ralfs, 1848	15		X			
Chlorophyta						
Ankistrodesmus sp. Corda, 1838	15		X			
Characium sp. A. Braun, 1849	15			X		
Chlorophyceae 1 Wille, 1884 *	18					X
Chlorophyceae 2 Wille, 1884 *	18				X	X
Chlorophyceae 3 Wille, 1884 *	18					X
Chlorophyceae 4 Wille, 1884 *	18		X			
Korshikoviella sp. P.C. Silva, 1959	15, 18	X (15)	X	X		X
Pterosperma marginatum Gaarder, 1954 *	18	X			X	
Pterosperma moebii (Jørgensen) Ostenfeld, 1901 *	18	X		X		
Pterosperma sp. Pouchet, 1893	15			X		
Cladophora sp. Kützing, 1843	15		X			
Echinosphaerella limnetica G.M. Smith, 1920	15		X			
Monactinus simplex (Meyen) Corda, 1839	15		X			
Scenedesmus sp. Meyen, 1829	15		X			
Rhizoclonium sp. Kützing, 1843	9		X			
Cryptophyta						
Plagioselmis prolonga Butcher ex G. Novarino, I.A.N. Lucas & S. Morrall, 1994 *	18	X			X	
EUGLENOZOA						
Euglenoidea						
Euglenophyceae sp. Cavalier-Smith, 1981	9, 18		X		X	
Eutreptia sp. Perty, 1852	15		X			
Eutreptiella sp. A. da Cunha, 1914	15		X	X		
Lepocinclis acus (O.F. Müller) B. Marin & Melkonian, 2003	6	X (15)		X		
Euglena sp. Ehrenberg, 1830	4	X (15)	X			
Phacus sp. Dujardin, 1841	15		X	X		

over the shelf, the slope, the oceanic islands and the seamounts of the region, respectively (Fig. 1c). For each sample, approximately 2 L was concentrated by filtration on 5 µm filters (47 mm diameter, PC) and resuspended in 30 mL of 0.2 µm seawater, fixed with lugol at 4 % final concentration and stored in the dark at 4°C. To complement these observations, in 15 stations representative of each area, samples were collected using an oblique plankton net with a 20 µm mesh-size (Fig. 1c). These oblique tows were achieved from 200 m to the surface at offshore stations and from the bottom to the surface at shelf stations. These net samples were concentrated in 250 mL bottles, fixed with buffered formaldehyde at 4 % final concentration and stored at room temperature in the dark until analysis.

For Niskin samples, taxonomic identification was performed from observations and pictures taken with 20X or 40X objectives using an inverted microscope (TCM 400 Labomed) equipped with an iVu 5000 Labomed camera (operating with the Jenoptik's application), using Utermöhl chambers where at least 400 cells were counted. Phytoplankton net samples were observed between slides and coverslips (about ten slides for each concentrated sample) with 20X, 40X (DIC or not) and 100X objectives using an upright microscope (AxioScope 1 Zeiss) equipped with an AxioCam MRc Zeiss camera. Formol fixation of the net samples allowed us to detect cells morphological details that might have been obscured by the lugol staining, and to verify the identifications made during the counting of lugol-stained samples. Taxa were identified at the lowest possible taxonomic level (class, genus or species) according to the literature, in particular Taylor (1976), Balech (1988), Licea et al. (1995), Tomas et al. (1997), Tenenbaum (2006), Gomez et al. (2008) and Hoppenrath et al. (2009), and verified using WoRMS « World Register of Marine Species » (http://www.marinespecies.org). Taxa identified at the genus level for which we could not identify the species were designated as ".spx". Whenever possible, photographs were taken and identifying characteristics documented. All high-quality species pictures were included in an open-access global phytoplankton recognition and identification database (Carré and Fabre, 2021 - https://data.oreme.org/plankton/plankton_gallery/index/phyto), which is linked to standard diversity databases such as WoRMS and GBIF.

2.4. New records

The identification of new records depends on the accuracy of the taxonomic identification in both the reviewed literature and the

ABRACOS data. When taxonomic identification to species level was not possible, we used the available images from publications to differentiate between taxa, and assigned a unique ".spx" to each taxon. However, when no images were available, we were unable to differentiate undetermined species from the literature, which hindered the identification of potential new records. The ABRACOS taxa that were not identified at the specific level and/or for which we had no images but the genus was already recorded in the literature, were recorded as potential new records. These taxa were grouped based on their lowest identified level and named accordingly, with the addition of ".sp" (or ".spp" when several species were differentiated for the same genus, as indicated in the checklist, Table 2).

3. Results

3.1. Review

The online bibliographic search showed that most of the articles retrieved related to research on marine phytoplankton biodiversity further south in Brazil, or described ecosystems at the interface or very close to the coast. Very few described communities of the northeastern shelf and oceanic ecosystems. This search, supplemented by the exchanges within our working group, identified 17 publications describing phytoplankton communities in Northeast Brazil, covering the period from 1972 to 2022 (publication years) (Table 1). These works were primarily authored by the phytoplankton group of the Department of Oceanography at the UFPE, and were conducted in collaboration with local fishers boats, the Brazilian Navy, and research vessels through international partnerships with England, Germany, Panama, the USA, and more recently, France through the ABRACOS surveys. Until 2010, these studies focused on the coastal regions, specifically the continental shelf and slope of the states of Pernambuco, Ceará, Paraiba and Alagoas (Eskinazi-Leça and Passavante, 1972; Passavante, 1979; Passavante et al., 1982; Eskinazi-Leça et al., 1989; Silva-Cunha and Eskinazi-Leça, 1990; Koening and Macêdo, 1999; Koening and Lira, 2005; Koening et al., 2009; Santos et al., 2010). Phytoplankton organisms were typically sampled with a 64 µm mesh size plankton net, enabling the observation of the largest species. From 2011–2016 (with the latest Jales et al.; 2022 publication), the focus shifted to the description of phytoplankton communities around oceanic archipelagos/islands (Fernando

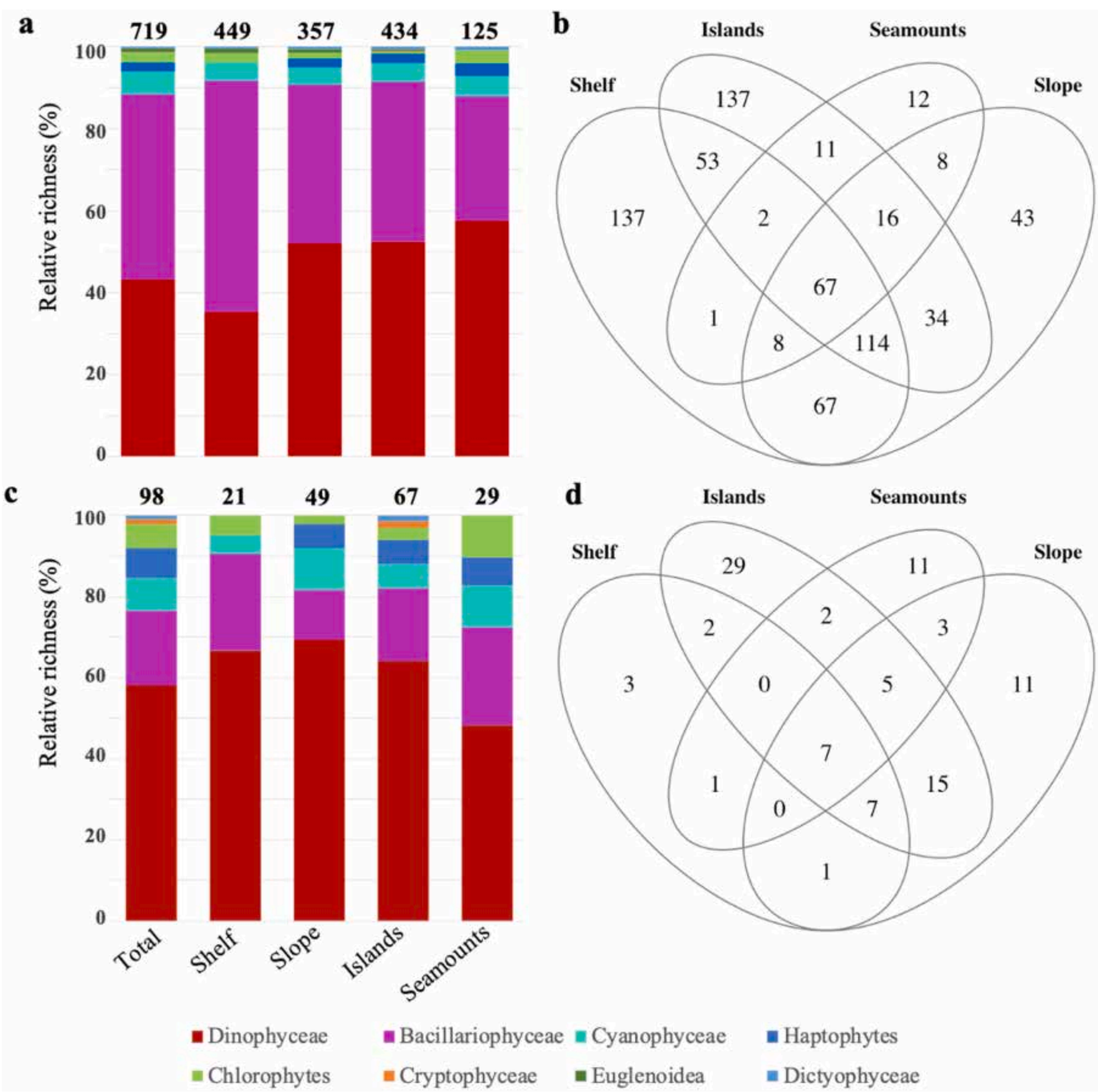


Fig. 2. Relative phytoplankton richness by group and area, for the complete checklist (a) and the ABRACOS new records (c). The bold numbers above each bar indicate the number of taxa recorded. Venn diagrams representing the number of exclusive and common taxa in the four areas for the complete checklist (b) and the ABRACOS new records (d).

de Noronha, São Pedro and São Paulo) and the Rocas Atoll (Tiburcio et al., 2011; Queiroz et al., 2014, 2015; Jales et al., 2015; Aquino, 2016). During this phase, the sampling protocols were refined by incorporating the use of nets with smaller mesh-size and Niskin bottles for sampling at different depths. This refinement enabled a greater richness of taxa to be observed at each location. Subsequently, in 2019, two comprehensive studies focused on the Brazilian Northeast coastal region (Silva-Cunha, Koening, et al., 2019; Silva-Cunha, Leça, et al., 2019). Silva-Cunha, Koening, et al. (2019) described diatoms and dinoflagellates observed in the Bacia Potiguar. Meanwhile, Silva-Cunha, Leça, et al. (2019) identified a total of 331 taxa in the total phytoplankton flora observed in the Bacia de Sergipe-Alagoas.

3.2. Checklist

A total of 719 phytoplankton taxa were observed from the literature and ABRAÇOS data (Table 2), with varying distribution patterns in different areas, including the shelf, slope, islands and seamounts areas, with 449, 357, 434 and 125 taxa documented, respectively (Fig. 2a). Bacillariophyceae (diatoms, 45.1 % of the total number of species, 325 taxa) and Dinophyceae (dinoflagellates, 43.3 %, 312 taxa) contributed most to this richness (Fig. 2a). Cyanophyceae (39 taxa), Haptophytes (Prymnesiophyceae and silicoflagellates, 17 taxa) and Chlorophytes (17 taxa) together accounted for 10.2 % of the total richness. Euglenoidea (6 taxa), Dictyophyceae (3 taxa), and Cryptophyceae (1 taxon) represented only 1.3 % of the total richness (Fig. 2a).

The shelf and islands areas exhibited higher exclusive richness, with 137 taxa each, followed by the slope with 43 taxa and the seamounts with 12 taxa (Fig. 2b). Notably, 53 taxa were common to both the shelf and islands areas. Moreover, a large number of taxa observed on the slope were common to the shelf and islands areas (114 taxa), the islands and seamounts areas (16 taxa), or exclusively with the shelf (67 taxa) or the islands areas (34 taxa). The seamounts area shared few taxa with the other areas, 11 taxa with the islands, 8 with the slope and 1 with the shelf. A total of 67 taxa were found to be common to all four areas (Fig. 2b).

The study identified 100 different genera of diatoms, including 246 identified to the species level and 2 unidentified taxa referred to as morpho-like group (one centric and one pennate, with available images) (Table 2; Carré and Fabre, 2021). The shelf had the highest number of taxa (253), followed by the islands (168) and the slope (137) (Fig. 3a). Ninety-four taxa were exclusive to the shelf, and 42 exclusive to the islands. Most of the slope taxa were shared with the shelf (45 taxa) and with both the shelf and the islands areas (49 taxa). A total of 42 taxa were shared between the islands and the shelf, and 18 taxa were shared between all four areas (Fig. 3a). The diatoms identified were predominantly centric (165) or pennate (159); 76.9 % were large cells or colonies (over 50 µm size) (Table S1). The pennate group contained the majority of the smallest diatoms (56 taxa, 17.3 % of the global diatom community) (Table S1), and they were mainly observed in the shelf area (Table 2).

Dinophyceae comprised 47 genera, with 255 taxa (81.7 % of the total richness) identified at the species level, 15 unidentified taxa, 10 were named with their family affiliation, and 5 with their morphological group affiliation, each with available pictures in the online database. While the relative richness of dinoflagellate species was higher in the seamounts area, the greatest diversity was observed around the islands, on the slope and shelf areas, with 229, 187 and 159 different taxa, respectively (Table 2, Fig. 3b). A total of 76 taxa (24.3 %) were exclusive to the islands, while 23 taxa were observed over the shelf and slope, and only 4 on the seamounts (Fig. 3b). Most of the commonly observed taxa were shared between the shelf, slope and islands areas (61 taxa), across all four areas (46 taxa), between the slope and islands areas (24 taxa) and between the shelf and slope areas (16 taxa) (Fig. 3b). Notably, 95 taxa were described in the literature as having mixotrophic behaviours, and 83 taxa were heterotrophic. The mixotrophic group consisted mainly of genera such as *Amphisolenia, Dinophysis, Gonyaulax, Gymnodinium, Prorocentrum*, *Scrippsiella* and *Tripos*, while the heterotrophic group consisted of *Gyrodinium, Histioneis, Ornithocercus, Phalacroma, Podolampas, Pronoctiluca* and *Protoperidininum* (Table 2). These functional characteristics were observed in all four areas studied.

The Cyanophyceae included 4 Chroococcales, 13 Oscillatoriales, and 2 Nostocales taxa from 19 different genera. Among them, 15 taxa were identified at the species level (Table 2). Haptophytes were represented by 9 different genera, including 8 taxa identified at the species level and 4 unidentified taxa. These coccolithophorids were primarily observed in offshore areas (Table 2). Dictyophyceae silicoflagellates were represented by 2 genera (*Dictyocha* and *Octactis*), of which 3 taxa were identified. Cryptophytes were represented by one species, the nanoflagellate *Plagioselmis prolonga*. The Plantae phylum comprised 2 taxa, the genus *Closterium* in Charophyta and Chlorophytes comprised 9 genera. Among Chlorophytes, 4 taxa were identified at the species level, while 4 taxa were not identified but differentiated by their form and organisation (colonial and isolated flagellate, colonial coccoid) (Table 2).

3.3. ABRACOS list

A total of 321 phytoplankton taxa were identified from the ABRAÇOS data (Table 2, Fig. S1). Pictures are available for 198 taxa (Carré and Fabre, 2021), some examples are shown in Fig. 4. Within the 321 taxa observed, the richness was primarily composed of Dinophyceae (55.8 %,

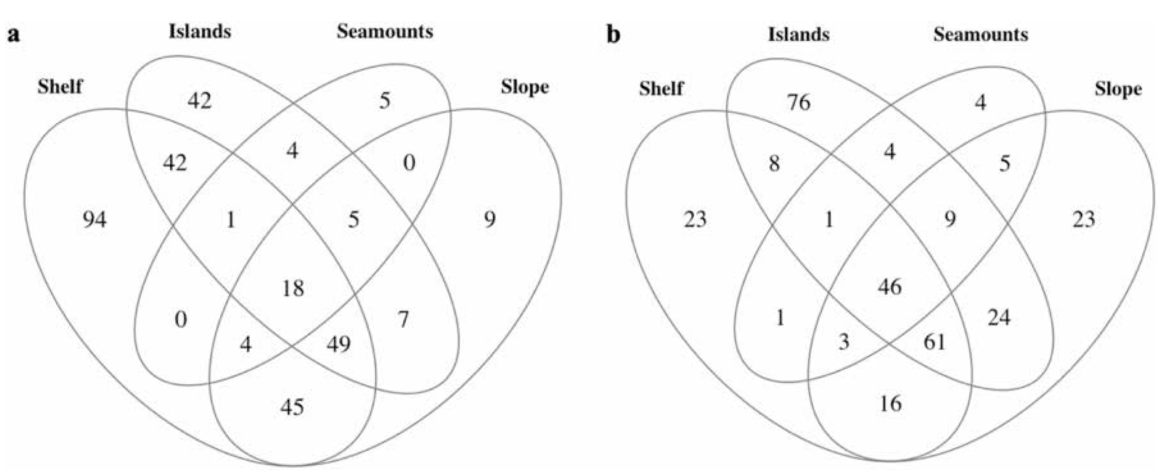


Fig. 3. Venn diagrams of Bacillariophyceae (a) and Dinophyceae (b) richness in the four areas considered in the checklist.

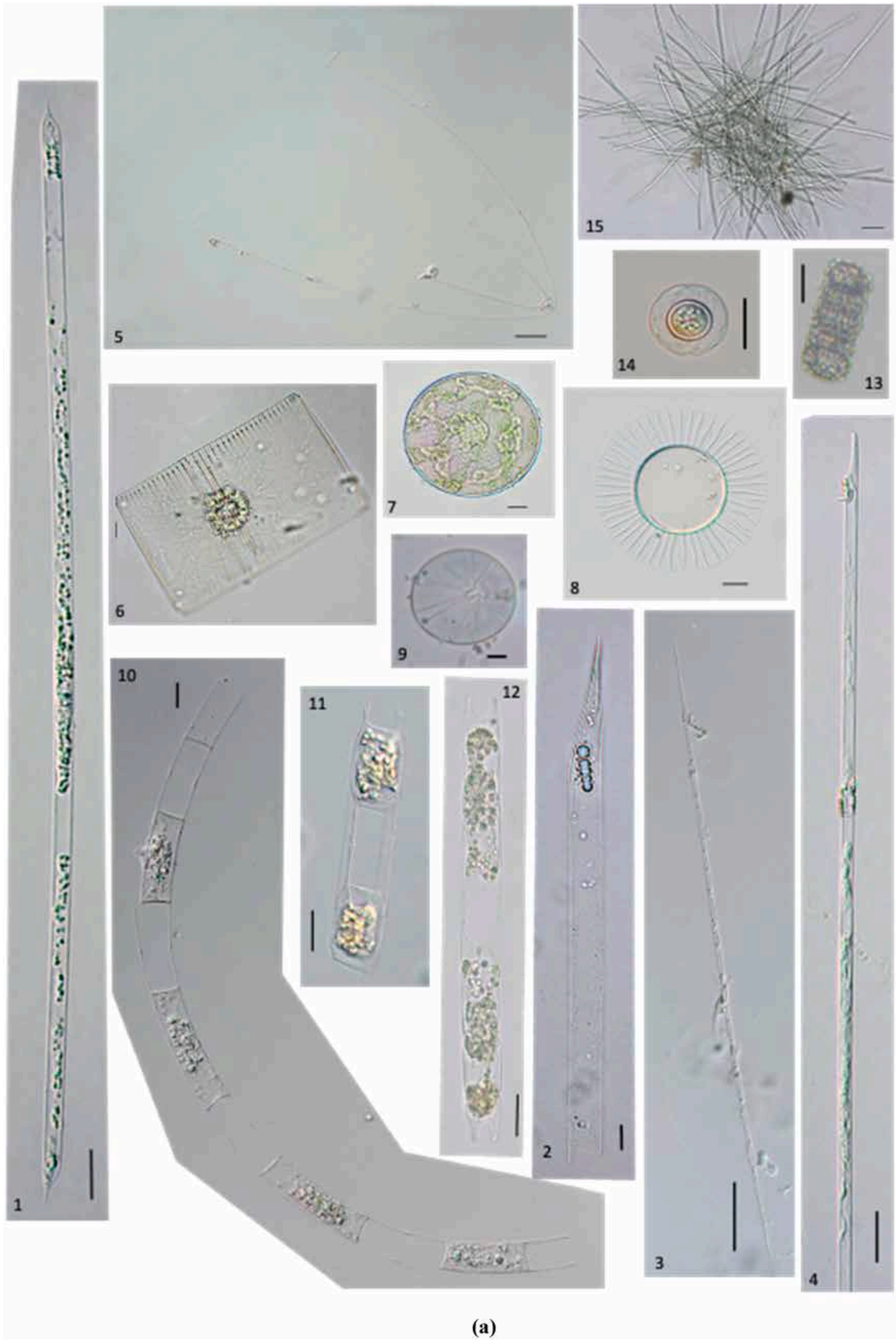


Fig. 4. Illustrations of phytoplankton richness found in nets and rosette samples collected during the Abraços (not exhaustive list): 62 species/taxa composed by 13 Diatoms (1−13), 1 Prasinophyceae (14) and 1 Cyanophyceae (15) and 48 Dinoflagellates (16−62). Scale bar = 10 µm for pictures 2, 6–9, 16–19, 21–24, 26–33, 35–38, 42, 44–49, 57; 20 µm for pictures 1, 4, 10–14, 20, 25, 34, 39–41, 43, 50–54, 56, 58 and 62; 50 µm for pictures 3,15, 55, 59–61 and 100 µm for picture 5 (a) 1. *Rhizosolenia imbricata*, 2. *Rhizosolenia styliformis*, 3. *Haslea wawrikae*, 4. *Proboscia alata*, 5. *Chaetoceros peruvianus*, 6. *Fragilaria unipunctata*, 7. *Coscinodiscus sp.*, 8. *Coscinodiscus sol*, 9. *Asteromphalus sp.*, 10. *Hemiaulus hauckii*, 11. *Hemiaulus indicus*, 12. *Hemiaulus membranaceus*, 13. *Paralia sulcata*, 14. *Pterosperma moebii*, 15.

Trichodesmium sp. (b) 16. *Protoperidinium cassum*, 17. *Protoperidinium parcum*, 18. *Protoperidinium subpyriforme*, 19. *Blepharocysta sp*., 20. *Protoperidinium quarnerense*, 21. *Protoperidinium brevipes*, 22. *Protoperidinium deficiens*, 23. *Spiraulax kofoidii*, 24. *Protoperidinium simulum*, 25. *Alexandrium minutum*, 26. *Scrippsiella spinifera*, 27. *Metaphalacroma skogsbergii*, 28 a and b. *Dinophyceae sp*., 29. *Diplopsalid,* 30. *Prorocentrum balticum*, 31. *Prorocentrum lenticulatum*, 32. *Prorocentrum mexicanum*, 33. *Prorocentrum rostratum*, 34. *Oxytoxum scolopax*, 35. *Azadinium sp*., 36. *Heterocapsa sp*., 37. *Heterocapsa minima*, 38. *Spatulodinium pseudonoctiluca*. (c) 39. *Ornithocercus heteroporus*, 40. *Ornithocercus quadratus*, 41. *Dinophysis schuettii*, 42. *Podolampas spinifera*, 43. *Podolampas palmipes*, 44. *Histioneis milneri*, 45. *Histioneis hyalina*, 46. *Phalacroma rotundatum*, 47. *Dinophysis bibulba*, 48. *Dinophysis exigua*, 49. *Amphisolenia globifera*, 50. *Tripos candelabrum*, 51. *Ornithocercus splendidus*. (d) 52. *Tripos hexacanthus*, 53. *Tripos declinatus var. major*, 54. *Tripos declinatus*, 55. *Tripos carriensis*, 56. *Tripos pentagonus*, 57. *Tripos kofoidii*, 58. *Tripos gibberus*. (e) 59. *Tripos macroceros*, 60. *Tripos massiliensis*, 61. *Tripos trichoceros*, 62. *Tripos contortus*.

179 taxa) and Bacillariophyceae (32.7 %, 105 taxa). Cyanophyceae (16 taxa), Haptophytes (Prymnesiophyceae, 9 taxa), Chlorophytes (7 taxa) collectively represented 10 % of this richness diversity. In contrast, Dictyophyceae (3 taxa) and Cryptophyceae and Euglenoidea (1 taxon each) collectively represented only 1.6 % of the richness (Fig. S1a). The spatial distribution of these taxa was as follows: 110 on the shelf, 178 on the slope, 211 around the islands and 125 in the seamounts area (Fig. S1a). Specific area richness was higher around the islands (79 taxa) than on the slope (29 taxa), the seamounts (23 taxa) and the shelf (15 taxa) (Fig. S1b), while 38 taxa were common to all areas. Although the shelf area shared 14 taxa with the slope and 21 with the islands areas, the majority of common taxa of the ABRACOS list were observed on the slope, islands, and seamounts areas (Fig. S1b).

This review identified 98 new taxa records plus 45 potential new records in the ABRACOS samples (Table 2). The majority of the new records richness belonged to Dinophyceae (57 taxa; 58.2 %) (Fig. 2c). Of these, 43 taxa were identified at the species level, 9 at the genus level and 5 were classified into morphological groups. Additionally, 18 taxa (18.4 %) belonged to Bacillariophyceae, including 9 taxa identified at the species level and the remaining 9 at the genus level (Fig. 2c). Furthermore, 8 new taxa (8.2 %) were Cyanophyceae including four new genera and one identified at the species level. Moreover, 7 taxa (7.1 %) were new records of Haptophytes, 1 identified at the species level, the others at the genus or class level. Finally, 6 taxa (6.1 %) were new records of Chlorophytes, including *Pterosperma marginatum* and *P. moebii*. The Cryptophyceae nanoflagellate, *Plagioselmis prolong*a, and one of the three Dictyophyceae taxa, *Octactis octonari,* were documented for the first time in the region, both observed in the vicinity of the oceanic islands. However, there were no new records of Euglenoidea (Fig. 2c).

Spatially, the new records were distributed as follows: 21 taxa over the shelf, 49 taxa on the slope, 67 taxa around the islands and 29 taxa in the seamounts area. The slope exhibited new records of Dinophyceae and fewer new records of Bacillariophyceae, while the shelf lacked new Haptophytes. In contrast, the seamounts area differed from other areas by having a few new records of Dinophyceae but a notable presence of Chlorophytes. Most new records were area-exclusive, with 29 around the islands, 11 over the slope and 11 in the seamounts areas. Additionally, 7 new records were common to four areas (Fig. 2d).

4. Discussion

This study examines the nano- and microphytoplankton fractions, revealing a remarkably diverse ocean in Northeast Brazil. In total, we listed 719 different taxa, accompanied by a comprehensive library of illustrations. These images can be found in this article, in the online database, or in the reviewed papers to facilitate further identification. This checklist includes almost 15 % of all known marine phytoplankton species worldwide, exceeding the Australian Ocean Data Network (AODN) database which records 541 phytoplankton taxa (286 species) (Davies et al., 2016; Eriksen et al., 2019). It also represents 42 % of the species listed in PhytoBase, the global synthesis of open ocean phytoplankton (Righetti et al., 2020).

This high richness occurs in a region characterised by low biomass, with average abundances of over 80 % of pico- and nanophytoplankton dominated by *Prochlorococcus* (Farias et al., 2022). These observations may seem contradictory, but such a feature has already been observed in other oligotrophic open-ocean tropical regions at the same low latitude with the same ecological characteristics (Bouvy et al., 2016; Ibarbalz et al., 2019; Pierella Karlusich et al., 2020; Righetti et al., 2020).

The comprehensive checklist shows that the two major phytoplankton groups, dinoflagellates and diatoms, contribute similarly to total richness, which is consistent with the global phytoplankton diversity (Pierella Karlusich et al., 2020; Vincent et al., 2022). Our study also provides comprehensive spatial coverage, including both coastal and oceanic areas, which is rare on a global scale, as most studies focus on more localised communities, particularly those near the coast. Comparable group repartition has been observed in other subtropical regions with similar ecological configurations such as the Australian coast (Davies et al., 2016), the Western Pacific Ocean (Chen et al., 2021), and around the Scattered islands in the Indian Ocean (Bouvy et al., 2016).

Locally, the richness of nano- and microphytoplankton varies between areas. The shelf area exhibited a greater diversity of pennate and small to medium-sized diatoms. This may be due to the inputs from estuarine rivers as well as the resuspension of benthic diatoms (Taffs et al., 2017). In contrast, dinoflagellates species were more prevalent offshore, demonstrating their adaptability to changing nutritional conditions, by employing multiple metabolic and growth strategies to survive (Reynolds, 2007; Cohen et al., 2021). These spatial patterns of diversity mirror the results of other studies at similar latitudes (Malviya et al., 2016; Vincent et al., 2022).

The ABRACOS surveys covered shelf, slope, and offshore areas, resulting in the recording of 319 taxa and the identification of nearly 100 new records (plus 45 potential new records), primarily dinoflagellates. These surveys provide a comprehensive view of the marine phytoplankton communities richness, which is consistent with the observations of other surveys with similar spatial coverage conducted in the Atlantic Ocean (Sal et al., 2013; Silva-Cunha, Leça, et al., 2019). It has been acknowledged that expanded regional sampling increases the likelihood of discovering new species (D'Elbée, 2016). Thus, the extensive sampling effort conducted offshore, coupled with the higher richness of dinoflagellates in this region (in contrast to the shelf area), could explain the predominance of this group in the new records documented during the ABRACOS surveys.

It is difficult to determine whether these new records are introduced, invasive, or characteristic of these ecosystem types, and therefore responsive to environmental change. The potential for misidentification or oversight by analysts over time due to changes in sampling methods, microscopes, and expertise, complicates such assessments (Zingone et al., 2015).

Moreover, identifying species-level proved to be challenging for some specimens. The taxa listed in the checklist or specifically observed during the ABRACOS surveys were often identified at the genus, family, or generic group level (e.g. combining several species or genera of similar morphology), which sometimes hindered the identification of new records. This limitation is partly due to the difficulty to identifying diatom species (both pennate and centric) using light microscopy. Detailed examination by electron microscopy is required. For example, genera such as *Amphora*, *Navicula*, *Nitzschia* and *Pseudo-nitzschia* for

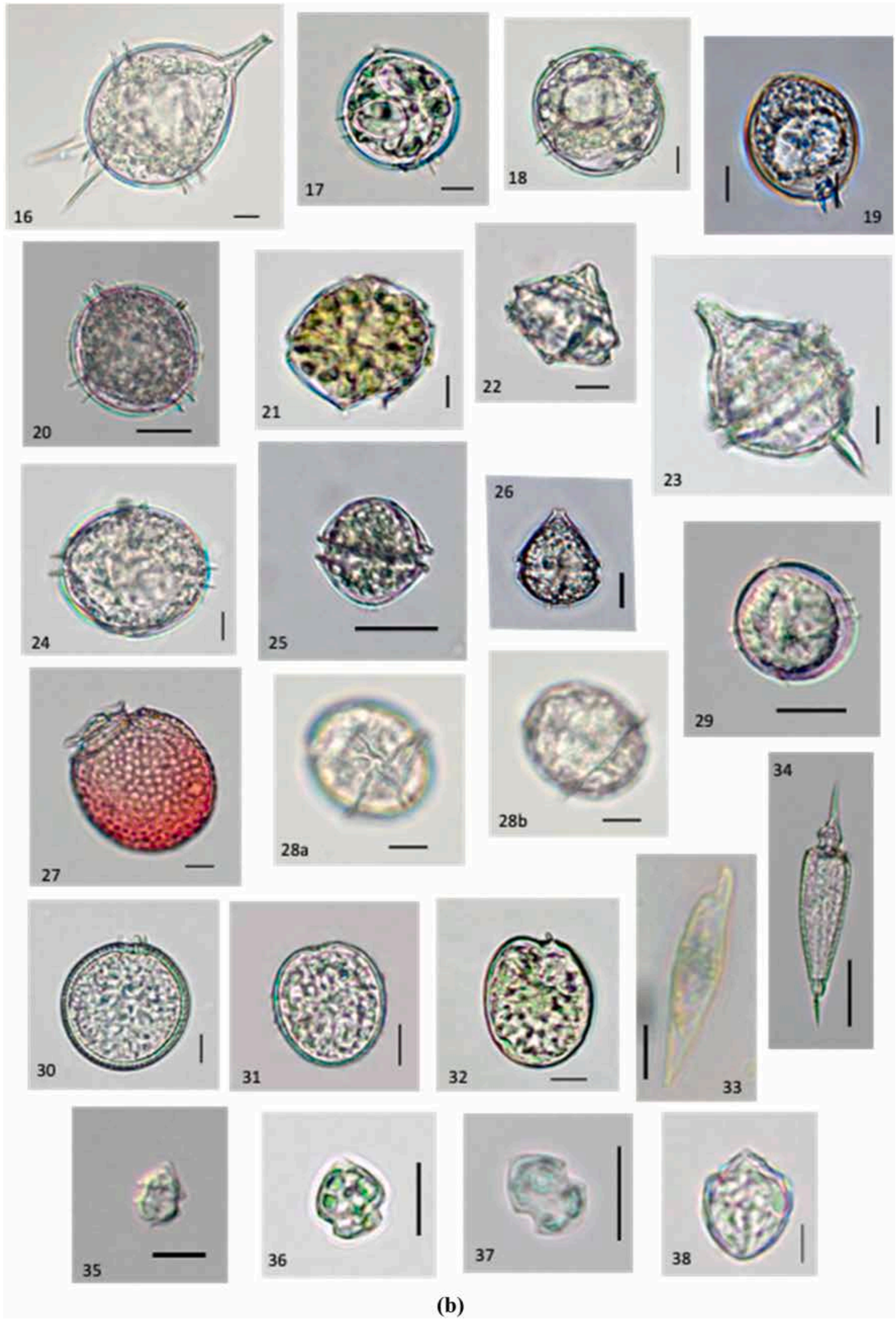


Fig. 4. (*continued*).

pennates, and *Chaetoceros*, *Coscinodiscus* and *Thalassiosira* for centric diatoms, often require higher-resolution imaging. As an example, Kraberg et al. (2010) recommend using *Pseudo-nitzschia "seriata complex"* Hasle & Syvertsen, 1997, as species of this genus with cell widths greater than 3 μm (e.g., *P. pungens* and *P. seriata*) are difficult to differentiate. Fixation with lugol iodine solution can cause dinoflagellates to lose their

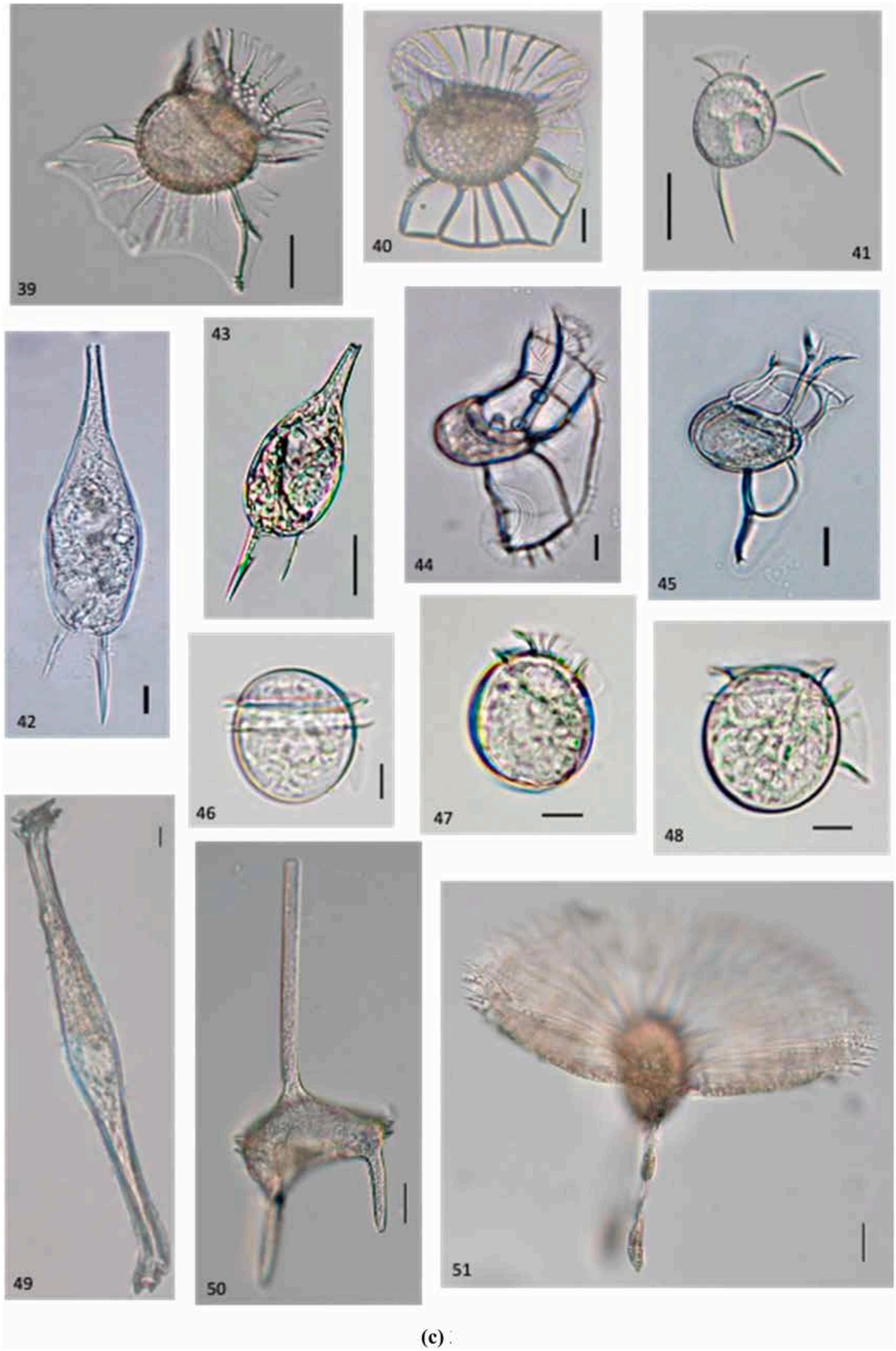
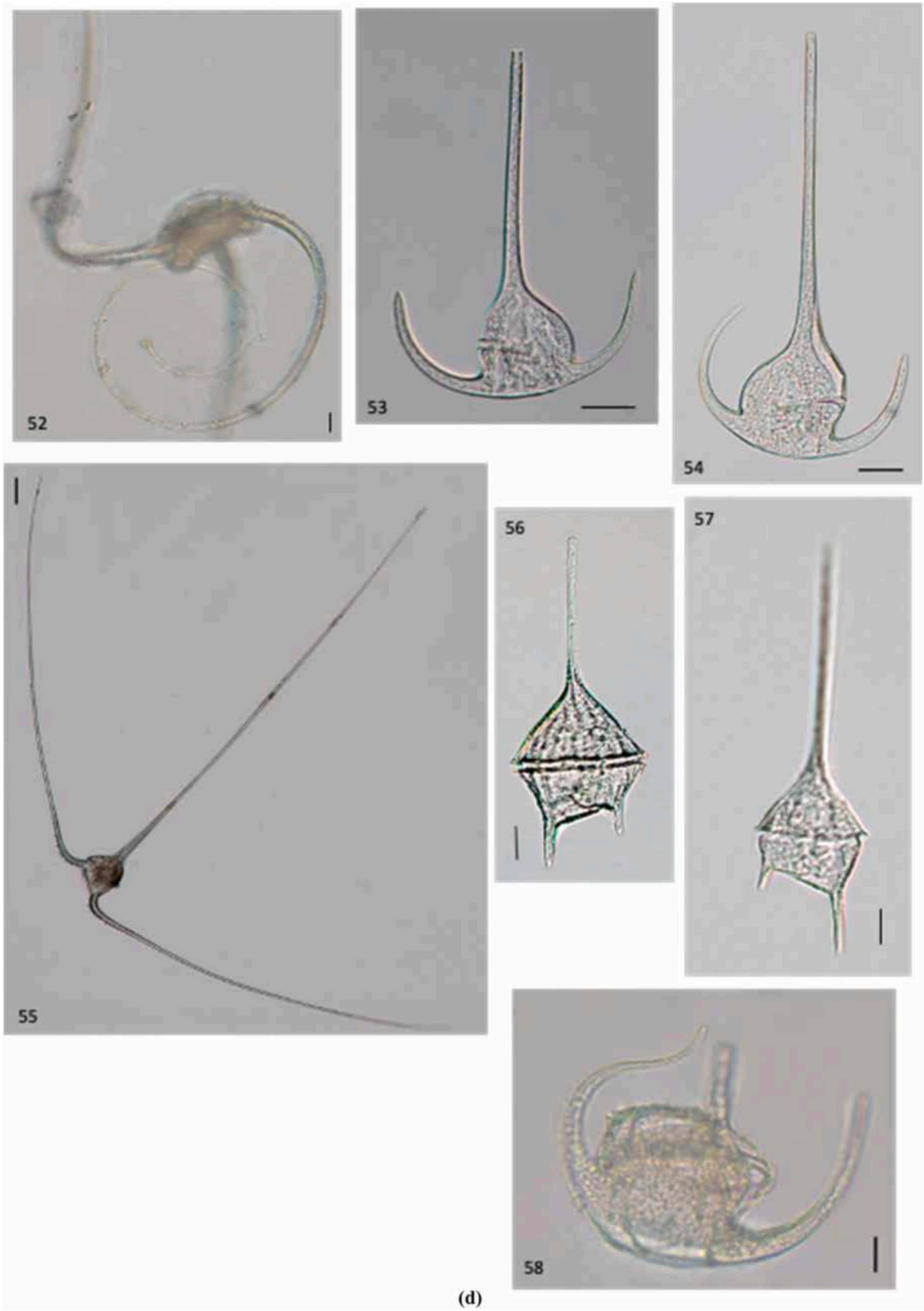


Fig. 4. (*continued*).

distinctive features, especially naked cells, making identification difficult, even at the genus level. Similarly, fixation with acidic lugol and acidic formaldehyde can damage calcified coccilithophorids. These are then often very small, and their identification may require electron microscopy for genus or species confirmation. This review includes many unidentified Cyanophyceae taxa due to the paucity of articles on



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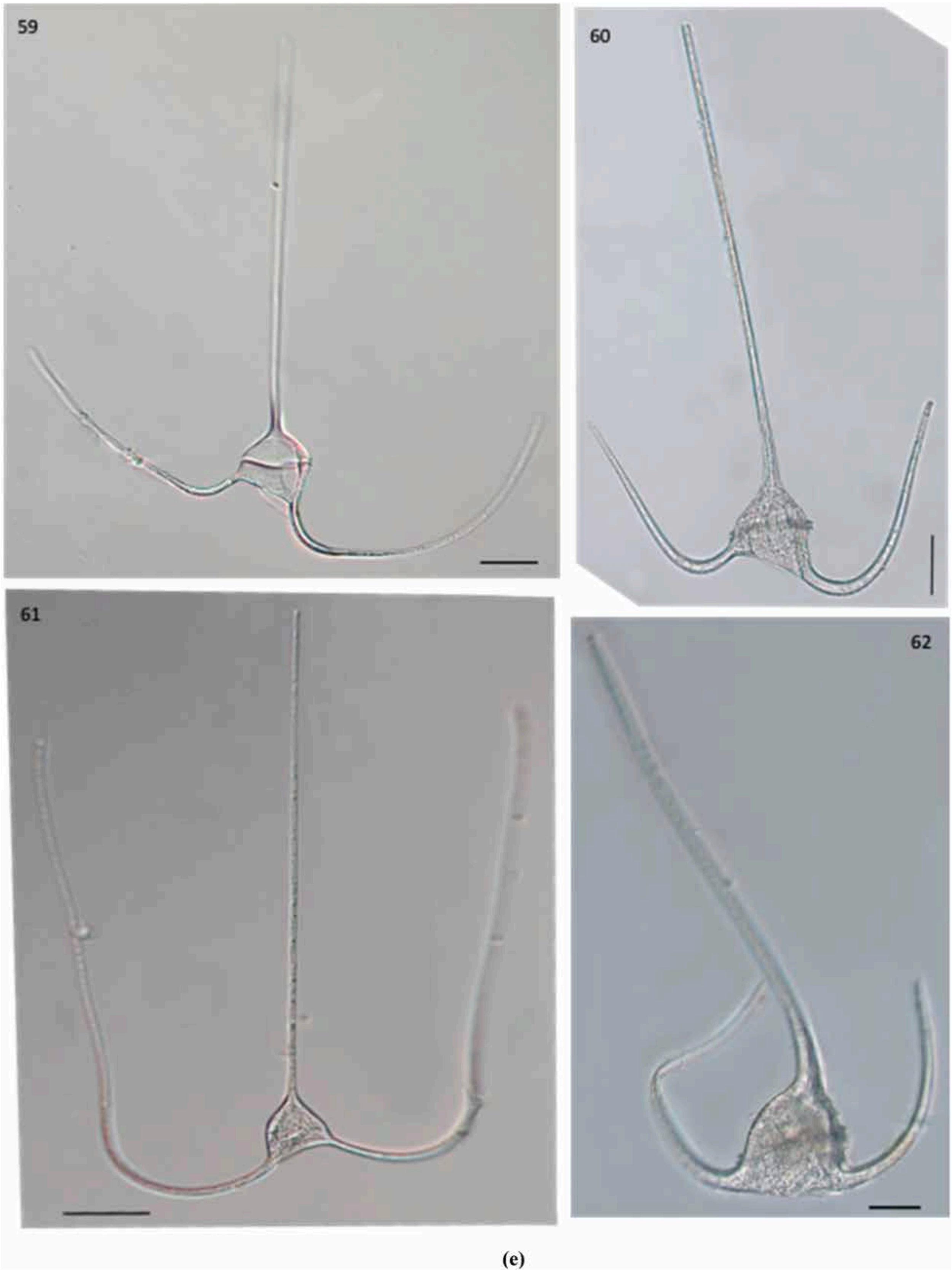

Fig. 4. (*continued*).

the taxonomy of planktonic Cyanophyceae in tropical marine coastal environments. Furthermore, traditional morphological observations are often insufficient to differentiate species within genera, necessitating the use of additional methods such as culture and genetic analysis (Komárek, 2016; Brito et al., 2017; Willis and Woodhouse, 2020). Finally, the equipment used to observe Chlorophyceae, Prasinophyceae, Euglenoideae and other nanoflagellates (about 10 μm size) was unsuitable for their identification and detection. Future taxonomic studies in this region should focus on these communities and plan specific sampling and observations. For instance, using epifluorescence microscopy with 40X and 60X objectives can improve detection, confirm identification, and differentiate their trophic mode, heterotrophic or autotrophic. These aspects are often crucial in determining species-level classification.

Despite its limitations, this checklist reveals an incredible diversity of nano- and microphytoplankton in the oceanic zone of Northeast Brazil. It provides a useful reference for scientists and managers to monitor community evolution under global change. This work emphasises the importance of ensuring data continuity, for example through programmes such as the Peld TAMS observatory in Tamandaré, Brazil (Cordeiro et al., 2022). Such programmes provide valuable opportunities to conduct time series analyses and assess the adaptation of these communities and their response to changing environmental conditions, detect unusual episodes as efflorescences potentially toxic due to rising temperatures and sewage emissions. Blooms have been known locally since 1943 (Barbosa, 1944) and also by Satô et al. (1963), but in sporadic events. However, in recent years, these events have intensified in frequency and intensity, with almost 300 people poisoned in the last event (personal communication).

Ethical approval

No animal testing was performed during this study.

Sampling and field studies

All necessary permits for sampling and observational field studies have been obtained by the authors from the competent authorities and are mentioned in the acknowledgements, if applicable. The study is compliant with CBD and Nagoya protocols.

CRediT authorship contribution statement

Marina Cavalcanti Jales: Data curation. **Sírleis Rodrigues Lacerda:** Data curation. **Isis Amália Cordeiro:** Data curation. **Gabriel Bittencourt Farias:** Writing – review & editing. **Béatrice Bec:** Writing – review & editing, Methodology, Conceptualization. **Leandro Ferreira Cabanez:** Resources, Data curation. **Arnaud Bertrand:** Writing – review & editing, Writing – original draft, Methodology, Funding acquisition, Conceptualization. **Claire Carré:** Writing – review & editing, Writing – original draft, Resources, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Pedro Augusto Mendes de Castro Melo:** Writing – review & editing, Resources. **Monique Simier:** Writing – review & editing. **Maria da Glória Gonçalves Silva-Cunha:** Writing – review & editing, Resources, Methodology, Data curation, Conceptualization. **Nayana Buarque Antao Silva:** Data curation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.rsma.2024.103887.

Data availability

Data will be made available on request.

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