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Jennifer E. Slate
Northeastern Illinois University, j-slate@neiu.edu

R Jan Stevenson
Michigan State University

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THE DIATOM FLORA OF PHOSPHORUS-ENRICHED AND UNENRICHED SITES IN AN EVERGLADES MARSH

Jennifer E. Slate[1]

Department of Biology,

Northeastern Illinois University,

Chicago, IL 60625-4699, U. S. A.

R. Jan Stevenson[2]

Department of Zoology,

Michigan State University,

East Lansing, MI 48824-1115, U. S. A.

[1] e-mail: J-Slate@neiu.edu; [2] e-mail: rjstev@msu.edu

Running Head: EVERGLADES DIATOM FLORA

ABSTRACT

Diatoms are used as environmental indicators in the Florida Everglades, a large subtropical wetland highly impacted by phosphorus pollution. However, the taxonomy of the diatom flora, a mix of temperate and tropical diatoms, is understudied. Therefore, we analyzed the taxonomy of 71 diatom taxa collected in Water Conservation Area 2A (WCA-2A). Diatoms were analyzed from sediment cores and from floating algal mats collected in phosphorus-enriched northern WCA-2A and in relatively unenriched southern WCA-2A. In addition, diatoms were analyzed from experimental mesocosms in southern WCA-2A dosed with 0-126 μgL^{-1} $P\text{-}PO_4$. Total phosphorus optima were calculated for dominant taxa. Average percent abundances in phosphorus-enriched and unenriched conditions are given for all taxa. Eleven taxa were dominant (>5% abundance in at least one sample) in unenriched conditions, 17 taxa were observed only in phosphorus-enriched conditions, and 9 taxa were observed only below 2 cm in sediment cores. We compared the flora to taxonomical accounts of diatoms from temperate and tropical regions, with a special focus on nearby Antillean islands (Cuba, Jamaica, and Puerto Rico). Light microscope images of each taxon and SEM images of selected taxa are presented. Taxonomical measurements are given for each taxon, and differences from descriptions in other taxonomical accounts are discussed. A new combination, Achnanthes caledonica Lange-Bertalot = Achnanthidium caledonicum (Lange-Bertalot) comb nov. is proposed.

INTRODUCTION

As one of the largest subtropical wetlands in the world, the Florida Everglades provides an opportunity to study a unique diatom flora that is a mix of temperate and tropical taxa. The Everglades is only 5000 years old (Gleason and Stone 1994), so taxa are immigrants from other regions. The most important sources of vascular plants are continental North America and the tropics, especially nearby Antillean islands such as Cuba, Jamaica, and Puerto Rico (Long 1974). The Antilles and other tropical regions do not appear to have been connected to Florida by a land bridge, so tropical plants and diatoms probably arrived via wind, water, and animals (Long 1974).

Phosphorus (P) enrichment is increasing in the northern Everglades due to input of P-enriched agricultural drainage (Childers et al. 2003). Because the Everglades was historically a P-limited ecosystem, the native flora is adapted to low P concentrations. For example, the dominant Everglades plant, sawgrass (Cladium jamaicense), is replaced by cattail (Typha domingensis) in areas with high P-enrichment (Davis 1994, Richardson et al. 1999). Replacement of native diatom species by pollution-tolerant cosmopolitan species has been observed in other parts of the world (Kociolek & Spaulding 2000), so continued P pollution could potentially cause the loss of Everglades diatoms adapted to low P concentrations.

The effect of P enrichment on Everglades diatoms has been studied by numerous authors (e.g. Swift & Nicholas 1987, Raschke 1993, Vymazal et al. 1994, McCormick et al. 1996, Cooper et al. 1999, Pan et al. 2000, Gaiser et al. 2006). Diatoms and other members of the periphyton community are useful biomonitors of ecological conditions in the Everglades (McCormick & Stevenson 1998). However, research is hampered by inconsistent taxonomical identifications among different research groups, in large part due to the paucity of taxonomical references from subtropical and tropical regions. Kociolek & Spaulding (2000) argue that the practice of using diatom floras from one geographical region to identify diatoms from other regions causes misidentifications due to the misconception that most diatom species have cosmopolitan distributions.

Therefore, we conducted a taxonomical study of diatoms at P-enriched and unenriched sites in an Everglades marsh (Water Conservation Area 2A), using references from temperate as well as tropical regions, including the Antilles (e.g. Hagelstein 1938, Foged 1984, and Podzorski 1985). For each taxon, we present at least one image (including SEM images for some taxa), measurements of taxonomical features, and a taxonomical discussion if the taxon differed from published descriptions. To compare P preferences, we present relative total phosphorus (TP) optima for dominant taxa and average % abundances (absences discounted) in P-enriched vs. unenriched conditions.

MATERIAL AND METHODS

Water historically flowed unimpeded through the Everglades, south from Lake Okeechobee into Florida Bay (Fig. 1). Today, much of the northern Everglades has been drained for agricultural use and the remaining Everglades is impounded by levees into Water Conservation Areas. Water Conservation Area 2A (WCA-2A) borders the Everglades Agricultural Area and receives P-enriched agricultural drainage from gates in the Hillsboro Canal. Therefore, P concentrations are high in northern WCA-2A, but decrease as water flows south and P is taken up by sediments and biota (DeBusk et al. 2001, Gaiser et al. 2006).

Two sediment cores from highly enriched northern WCA-2A and two sediment cores from relatively unenriched southern WCA-2A were collected in February 1995 (Slate & Stevenson 2000) (Fig. 1). A piston corer with a 4-cm diameter tube was used. The cores were collected in deeper-water sloughs surrounded by stands of emergent vegetation (cattail in northern WCA-2A and sawgrass in southern WCA-2A). The sediment was watery and flocculent from 0-8 cm but contained peat, rootlets, and other plant material below 8 cm. The cores were sectioned horizontally in 0.5-cm increments for the first 10 cm (except for one northern WCA-2A core, sectioned in 0.5-cm increments for the first 20 cm) and in 1-cm increments thereafter. Diatoms were analyzed in 3 core sections between 0-2 cm in both the northern and southern WCA-2A cores (1503 and 1502 diatom valves, respectively). Between 2-25 cm, 19 core sections (6568 valves) were analyzed in the southern WCA-2A cores and 20 core sections (7904 valves)

were analyzed in the northern WCA-2A cores. Although the cores were between 29 and 50 cm in depth, diatoms were not analyzed below 25 cm due to poor preservation.

Because calcareous floating algal mats disappear with high P enrichment (McCormick & Stevenson 1998, Daoust & Childers 2004), we could not collect floating algal mats from highly enriched northern WCA-2A. Calcareous floating algal mats were collected from a moderately enriched slough (surrounded by stands of cattail) in the interior of WCA-2A and a relatively unenriched slough (surrounded by stands of sawgrass) in southern WCA-2A (Fig. 1). Three samples (2258 diatom valves) were analyzed from the moderately enriched slough and 5 samples (2806 valves) were analyzed from the relatively unenriched slough.

Diatoms were also analyzed from two sets of experimental mesocosms, placed 100 m apart in relatively unenriched southern WCA-2A, in which $P\text{-}PO_4$ was added (Fig. 1). Each set consisted of 6 flow-through channels, 2 x 8 m in size. Two channels in each set served as controls and 4 were dosed with 20, 39, 57, or 126 μgL^{-1} $P\text{-}PO_4$ at one end (Pan et al. 2000). Diatoms were collected from glass slides, surface sediments, floating algal mats, and Eleocharis stems within the channels at various distances (0.5, 1, 1.5, 2, 3, 4, or 6 m) from the end dosed with $P\text{-}PO_4$ in December 1993 and June 1994. As each diatom sample was collected, a water sample (for TP measurement) was collected from the same place within the channel. A total of 23 samples (11,500 diatom valves analyzed) were collected from the control mesocosms and a total of 61 samples (30,500 valves analyzed) were collected from the mesocosms dosed with $P\text{-}PO_4$.

Water TP optima and tolerances were calculated for epiphytic diatoms collected from Eleocharis stems in the experimental channels in June 1994 (a total of 27 samples) for diatom taxa that were $\geq$1% abundance in at least one of those samples. Averages (not transformed) of water TP concentrations measured about monthly (14 times) for the 15 months prior to diatom collection were used to calculate optima and tolerances, using the computer program CALIBRATE (Juggins & ter Braak 1992). Fragilaria cf. tenera had the lowest optimum (14 μgL^{-1}) and optima for other taxa ranged from 21-77 μgL^{-1}. The relatively high values are probably a result of the time it takes for water $P\text{-}PO_4$ to be taken up by biota and

sediments. In other words, the "ecosystem" within the experimental channels had not been established long enough for the P content of the water to be in equilibrium with biota and sediments. Optima are designated as low (<30 μgL^{-1}), moderate (30-50 μgL^{-1}), or high (>50 μgL^{-1}).

Phosphorus preferences of taxa can also be evaluated from average % abundances (absences discounted) in unenriched vs. P-enriched conditions (Table 1). "Unenriched" conditions include samples from sediment cores and floating algal mats collected in relatively unenriched southern WCA-2A and from experimental mesocosms not dosed with $P\text{-}PO_4$ (controls). "P-enriched" conditions include samples from sediment cores collected in highly enriched northern WCA-2A, from floating algal mats collected in the moderately enriched interior, and from experimental mesocosms dosed with $P\text{-}PO_4$.

Diatom samples were processed by heating in concentrated nitric or sulfuric acid, with potassium dichromate or potassium permanganate. After several rinses with deionized water, diatoms were mounted onto glass slides with Naphrax. Diatoms that were $\geq$1% relative abundance in at least two samples were identified to the lowest taxonomical level at 1000x magnification. Images were obtained with a Spot RT Monochrome digital camera attached to a Leica DMR light microscope (numerical aperture = 1.4) or with a 35-mm film camera attached to a research-quality Nikon light microscope (numerical aperture = 1.35). Measurements including length, width, and striae density were determined visually through microscopic inspection and on digital images using NIH Image software (Stoermer 1996). For select taxa, photos were also obtained with a Leo model 435 VP scanning electron microscope. The references used to identify each taxon are specified, and differences between our specimens and descriptions in references are discussed.

RESULTS AND DISCUSSION

Seventy-one taxa are presented (Table 1). Eleven of the taxa (Amphora sulcata, Brachysira neoexilis morphotype I, Brachysira neoexilis morphotype II, Encyonema evergladianum, Encyonema neomesianum, Fragilaria cf. tenera, Fragilaria synegrotesca, Mastogloia lanceolata, Mastogloia smithii morphotype I, Navicula podzorskii, and Nitzschia gandersheimiensis) were dominant (>5% abundance in

at least one sample) in unenriched conditions. Seventeen of the taxa (Achnanthidium exiguum var. heterovalvum, Amphora veneta, Caloneis bacillum, Craticula molestiformis, Diadesmis confervacea, Epithemia adnata var. proboscidea, Lemnicola hungarica, Navicella pusilla, Navicula brasiliana, Navicula exigua var. capitata, Navicula oblonga, Navicula subrhynchocephala, Nitzschia frustulum, Nitzschia nana, Sellaphora minima, Synedra acus, and Synedra ulna) were only observed in P-enriched conditions. Nine of the taxa (Aulacoseira spore, Craticula cuspidata, Eunotia arcus, Eunotia camelus, Eunotia formica, Eunotia glacialis, Luticola stigma, Nitzschia terrestris, and Pinnularia maior) were only observed in sediment cores below 2 cm.

Achnanthidium caledonicum (Lange-Bertalot) comb. nov. (Figs 2, 73)

Basionym: Achnanthes caledonica Lange-Bertalot in Lange-Bertalot & Moser (1994, p. 95), holotype for this species is A. microcephala f. scotica Carter in Carter & Bailey-Watts (1981), p. 534, pl. 1: 31.

Other synonyms: A. minutissima Kützing sensu Podzorski (1985), p. 27, pl. 5: 6 (not pl. 5: 3-5 or pl. 35: 1); A. microcephala (Kützing) Grunow sensu Maldonado González (1987), p. 14, figs 1a-b; A. minutissima var. scotica (Carter) Lange-Bertalot in Lange-Bertalot & Krammer (1989), p. 106, pl. 55: 4-12, pl. 67: 35-36, pl. 57: 11 and in Krammer & Lange-Bertalot (1991b), p. 60, pl. 34: 1-6.

Length: 13-39 μm; width: 3-4 μm; striae: 26-30 in 10 μm (in raphe and araphid valves). This taxon has a complicated taxonomic history. Its original name (source of the holotype) is Achnanthes microcephala f. scotica Carter in Carter & Bailey-Watts (1981). It was transferred to A. minutissima var. scotica (Carter) Lange-Bertalot in Lange-Bertalot & Krammer (1989). Lange-Bertalot (1993) proposed elevating the taxon to species rank as Achnanthes scotica, but the proposal was illegitimate due to the earlier use of the name for a different taxon (Flower & Jones 1989). A. microcephala f. scotica was legitimately elevated to species rank as Achnanthes caledonica Lange-Bertalot in Lange-Bertalot & Moser (1994). We consider it to require species rank, but it clearly belongs in Achnanthidium and thus requires transfer. Although the name scotica is now available (A. scotica was transferred to Psammothidium scoticum (Flower & Jones) Bukhtiyarova & Round), its use is not required by the International Code of Botanical

Nomenclature. Article 11.2 states that a name does not have priority outside of its rank. Therefore, we use the earliest legitimate name at species rank for this taxon (A. caledonica) as the basionym.

Although the original description of Achnanthes microcephala f. scotica states that it has parallel sides (Carter & Bailey-Watts 1981), photographs of Carter's original material show slightly swollen valve middles (Lange-Bertalot & Krammer 1989, Krammer & Lange-Bertalot 1991b). Krammer & Lange-Bertalot (1991b) state that although valve edges become more parallel in larger valves, valve middles are still slightly swollen. They also note that smaller specimens are difficult to distinguish from varieties of A. minutissima, but that larger specimens have strongly capitate ends. Valve middles of our specimens are swollen and ends are capitate, becoming more strongly capitate in larger specimens.

We observed the taxon in 70% of samples. Although Cooper et al. (1999) and Gaiser et al. (2006) reported the taxon to be common at low P concentrations in the Everglades, we found the taxon to have a moderate TP optimum (31 ± 13 μgL^{-1}) and to be common in P-enriched mesocosms and in floating algal mats collected from the moderately enriched interior of WCA-2A. We did not observe the taxon in highly enriched surface sediments in northern WCA-2A (Table 1).

Achnanthidium exiguum var. heterovalvum (Krasske) Czarnecki (Figs 3a-b)

As Achnanthes exigua var. heterovalva Krasske in Patrick & Reimer (1966), p. 258, pl. 16: 25, 26; in Germain (1981), p. 114, pl. 42: 20-26; and in Podzorski (1985), p. 25, pl. 4: 6, pl. 33: 4, 5.

Length: 10-14 μm; width: 4.5-6 μm; striae: 28 in 10 μm in raphe valve and 24 in 10 μm in araphid valve. This taxon had a high TP optimum (65 ± 24 μgL^{-1}) and we observed it only in P-enriched conditions. It was especially common in highly enriched surface sediments in northern WCA-2A (Table 1).

Amphora sulcata Schmidt (Figs 4a-b, 74a-b)

Schmidt (1874-1959), pl. 26: 46, 47; Hagelstein (1938), p. 329, pl. 3: 13; as A. arcus var. sulcata (Schmidt) Cleve in Cleve (1894-1896), p. 127; in Cleve-Euler (1953), p. 101, figs 694a, 695 b, c; and in Peragallo (1897-1908), p. 225, pl. 50: 5; as A. rhombica var. intermedia Cleve in John (1983), p. 156, pl.

64: 5; as A. veneta Kützing in Podzorski (1985), p. 52, pl. 19: 9, 10, pl. 40: 3; as A. rhombica Kitton in Foged (1986), p. 10, pl. 12: 1; as Amphora sp. in Metzeltin & Lange-Bertalot (1998), pl. 145: 8, 9. Length: 36-57 μm; width: 7-10 μm; striae: 17-19 in 10 μm; areolae on valve: 20 in 10 μm; areolae on intercalary bands: 24 in 10 μm. Although this taxon has been called a variety of names (see citations above), our specimens and images in those citations have a biarcuate raphe, an oval to rectangular-shaped frustule in girdle view, and numerous intercalary bands, resembling original illustrations of A. sulcata Schmidt (1874-1959). Areolae on the valve form undulate, longitudinal lines, as stated in the description of the synonym A. arcus var. sulcata (Schmidt) Cleve (1894-1896). (Cleve (1894-1896) also discusses A. sulcata (Brébisson) Cleve, a different taxon that should not be confused with A. sulcata Schmidt.) A. rhombica and A. rhombica var. intermedia in Cleve (1894-1896) and in Schmidt (1874-1959) have raphes that follow closely along the ventral margin, creating narrower ventral areas. A. veneta in Patrick & Reimer (1975) and in Krammer & Lange-Bertalot (1997a) lacks a biarcuate raphe. Our specimens also differ from A. lineolata in Krammer & Lange-Bertalot (1997a). A. lineolata has a slightly convex ventral margin and round to slightly pointed valve ends, while our specimens have a straight ventral margin and rostrate to capitate valve ends that curve ventrally. In girdle view, A. lineolata frustules are elliptical and valves are obscured by intercalary bands, while our frustules are almost rectangular-shaped in girdle view, with clearly visible valves. Finally, distal raphe ends are deflected ventrally in A. lineolata, but deflected dorsally in our specimens (Fig. 74a).

Although the description of the synonym A. arcus var. sulcata (Schmidt) Cleve (1894-1896) does not give a size range, images in above citations suggest that the range is greater than we observed. Podzorski (1985) provides photos of smaller specimens (lengths of 29-38 μm and width of 7 μm). Hagelstein (1938), John (1983) and Foged (1986) provide photos of larger specimens (65 x 10 μm, 80 x 14 μm, and 80 x 12.5 μm, respectively). We observed A. sulcata in 82% of samples. It was especially abundant in unenriched conditions and had a low TP optimum (22 $\pm$ 19 μgL^{-1}) (Table 1). Cooper et al.

(1999) also found that the taxon (identified as A. lineolata by S. Cooper, personal communication) indicated low P concentrations in the Everglades.

Amphora veneta Kützing (Fig. 5)

Hagelstein (1938), p. 329; Patrick & Reimer (1975), p. 72, pl. 14: 2, 3; Germain (1981), p. 295, pl. 108: 6-13; Foged (1984), p. 20, pl. 12: 4; Toledo Iser (1992b), p. 3; Krammer & Lange-Bertalot (1997a), p. 348, pl. 151: 7-17.

Length: 16-26 μm; width: 4-5 μm; striae: 18-20 in 10 μm at valve centre and 24-26 in 10 μm at valve ends; areolae on intercalary bands: 28 in 10 μm. This taxon was especially common in sediment cores from highly-enriched northern WCA-2A, both in surface sediments and below 2 cm. We did not observe the taxon in any other samples. Cooper et al. (1999) and Gaiser et al. (2006) found that the taxon indicated high P concentrations in the Everglades.

Aulacoseira spore (Fig. 6)

As Melosira turgida in Ehrlich (1973), p. 9, pl. 1: 3-6, pl. 5: 6-11.

Mantle height: 12-13 μm; diameter: 5-8 μm; striae: 28 in 10 μm; areolae: 18 in 10 μm. Spores were heavily silicified and striae were of irregular length, extending along only half of the mantle. Because vegetative cells were not observed, we did not assign a species identity. However, our specimens resemble the description and figures of spores of Melosira turgida Ehrlich (1973), which also have striae of irregular length on the valve mantle. We observed the Aulacoseira spore only in the sediment core collected closest to gate S10-C (Fig. 1), and only below 8.5 cm. However, it was a dominant taxon in those samples, with an average abundance (absences discounted) of 11%.

Brachysira neoexilis Lange-Bertalot (Morphotype I: Figs 7, 75; Morphotype II: Fig. 8)

Lange-Bertalot & Moser (1994), p. 51, pl. 5: 1-35, pl. 6: 1-6, pl. 7: 1-7, pl. 17: 7-11, pl. 32: 27-30, pl. 46: 19-27; Lange-Bertalot & Metzeltin (1996), pl. 36: 24-28; as Anomoeoneis exilis (Kützing) Cleve in Foged (1984), p. 20, pl. 7: 13; as A. exilis f. lanceolata A. Mayer in Foged (1984), p. 21, pl. 7: 12; as Anomoeoneis vitrea in Podzorski (1985), p. 31, pl. 8: 4-6, pl. 36: 4, 5 (not pl. 36: 6).

Morphotype I: Length: 17-41 μm; width 4-6 μm; striae: 32 in 10 μm.

Morphotype II: Length: 20-29 μm; width 5-6 μm; striae: 28-32 in 10 μm.

Like Lange-Bertalot & Metzeltin (1996), we separated our specimens of B. neoexilis into the following morphotypes. Morphotype I is lanceolate in shape, becoming gradually constricted toward the apices, with rostrate ends. Morphotype II is almost elliptical in shape, more abruptly constricted at the apices, with capitate ends. Although our morphotype II specimens correspond to the broad definition of Anomoeoneis vitrea (Grunow) Ross in Krammer & Lange-Bertalot (1997a) - see pl. 94: 21, a narrower definition is provided by Lange-Bertalot & Moser (1994). They argue that previous authors lumped Anomoeoneis exilis into A. vitrea and that A. vitrea sensu stricto has a narrow central area that widens little or not at all (unlike the lanceolate to round central area of our specimens). B. neoexilis replaces the invalid name A. exilis. We observed morphotype I in 79% of samples; it had a moderate TP optimum (32 $\pm$ 20 μgL^{-1}) (Table 1). We observed morphotype II in only 42% of samples; it had a low TP optimum (23 $\pm$ 26 μgL^{-1}). Gaiser et al. (2006) reported two B. neoexilis taxa in the Everglades, "var. 01" and "forma 02," both with low TP optima.

Caloneis bacillum (Grunow) Cleve (Fig. 9)

Patrick & Reimer (1966), p. 586, pl. 54: 8; Podzorski (1985), p. 44, pl. 12: 14-18; Toledo Iser (1989), p. 2, fig. 5a, (1992b), p. 4; Krammer & Lange-Bertalot (1997a), p. 390, pl. 173: 9-20; as C. bacillum (Gregory) Mereschkowsky in Foged (1984), p. 24, pl. 5: 11, 12, pl. 6: 5, 6.

Length: 16-43μm; width: 4-8μm; striae: 20-22 in 10 μm. Valve centres are bulbous in larger specimens but almost parallel in smaller specimens. The axial area sometimes widens toward the valve centre, as in

the figure in Patrick & Reimer (1966) and pl. 173: 13-16 in Krammer & Lange-Bertalot (1997a). We observed the taxon only in P-enriched conditions and it had a high TP optimum (53 ± 15 μgL^{-1}) (Table 1).

Cocconeis placentula var. lineata (Ehrenberg) Van Heurck (Figs 10a-b)

Hagelstein (1938), p. 343; Patrick & Reimer (1966), p. 242, pl. 15: 5, 6; Krammer & Lange-Bertalot (1991b), p. 87, pl. 52: 1-13; Toledo Iser (1989), p. 3, fig. 1b, (1992a), p. 4, (1992b), p. 5, fig. 9f; as C. placentula var. lineata (Ehrenberg) Cleve in Foged (1984), p. 30, pl. 2: 12, 15.

Length: 16-36 μm; width: 10-19 μm; striae: 19-21 in 10 μm in raphe and araphid valves. This taxon was more common in P-enriched conditions and had a moderate TP optimum (41 ± 22 μgL^{-1}) (Table 1).

Craticula cuspidata (Kützing) Mann (Figs 64a-b)

Metzeltin & Lange-Bertalot (1998), pl. 96: 3; as Navicula cuspidata Kützing in Hagelstein (1938), p. 383; in Patrick & Reimer (1966), p. 464, pl. 43: 9, 10; in Germain (1981), p. 167, pl. 63: 1; in Podzorski (1985), p. 34, pl. 10: 2; in Toledo Iser (1992a), p. 10, fig. 7d, (1992b), p. 8, fig. 5a; and in Krammer & Lange-Bertalot (1997a), p. 126, pl. 43: 1-8.

Length: 58-186 μm; width: 15-38 μm; striae: 13-17 in 10 μm. Most valves are elliptical in shape with capitate ends, although some larger valves are lanceolate with acute ends. Patrick & Reimer (1966) and Krammer & Lange-Bertalot (1997a) also show a range of elliptical to lanceolate valves. This taxon was most common below 8 cm in sediment cores.

Craticula molestiformis (Hustedt) Lange-Bertalot (Fig. 11)

As Navicula molestiformis Hustedt in Hustedt (1949), p. 86, pl. 5: 9; in Simonsen (1987), p. 342, pl. 523: 26-29; and in Krammer & Lange-Bertalot (1997a), p. 130, pl. 45: 1-9.

Length: 10-15 μm; width: 4-5 μm; striae: 27-28 in 10 μm at valve centre and 36 in 10 μm at valve ends. We observed the taxon only in P-enriched mesocosms and in sediment cores from highly enriched northern WCA-2A. The TP optimum was high (74 ± 3 μgL^{-1}) (Table 1).

Cyclotella meneghiniana Kützing (Fig. 12)

Hagelstein (1938), p. 346, pl. 4: 10; Germain (1981), p. 32, pl. 7: 1-9; Foged (1984), p. 31, pl. 1: 6, 7; Podzorski (1985), p. 67, pl. 27: 5, 6, pl. 28: 1, 2, pl. 44: 6, 7; Maldonado González (1986), p. 50, fig. 11; (1987), p. 14, fig. 4; Krammer & Lange-Bertalot (1991a), p. 44, pl. 44: 1-10; Toledo Iser (1989), p. 3, fig. 1d, (1992a), p. 4, fig. 1f, (1992b), p. 5, figs 1d, 10a.

Diameter: 13-16 μm; striae: 7-8 in 10 μm. This taxon had low % abundances (Table 1). Gaiser et al. (2006) reported a moderate TP optimum in the Everglades.

Diadesmis confervacea Kützing (Fig. 13)

As Navicula confervacea (Kützing) Grunow in Hagelstein (1938), p. 382; in Foged (1984), p. 61, pl. 9: 11; in Podzorski (1985), p. 36, pl. 11: 10; in Toledo Iser (1989), p. 5, fig. 3d, (1992a), p. 10. fig. 6f, (1992b), p. 8, fig. 4e; and in Krammer & Lange-Bertalot (1997a), p. 221, pl. 75: 29-31; as Anomoeoneis vitrea in Podzorski (1985), pl. 36: 6.

Length: 14-16 μm; width: 6-7 μm; striae: 17-22 in 10 μm. This taxon had a high TP optimum (58 ± 25 μgL^{-1}) (Table 1). Swift & Nicholas (1987) and Cooper et al. (1999) also found that the taxon indicated high P concentrations in the Everglades.

Diploneis oblongella (Naegeli) Cleve-Euler (Figs 14a-b, 76)

Toledo Iser (1992a), p. 6, fig. 3b; Krammer & Lange-Bertalot (1997a), p. 287, pl. 108: 7-10; as D. oblongella (Naegeli ex Kützing) Ross in Patrick & Reimer (1966), p. 413, pl. 38: 8; and in Podzorski

(1985), p. 32, pl. 8: 2, 3, pl. 36: 7, 8; as D. ovalis var. oblongella (Naegeli) Cleve in Hagelstein (1938), p. 353.

Length: 19-26 µm; width: 7-8 µm; striae: 19 in 10 µm. This taxon had a low TP optimum (27 ± 9 μgL^{-1}) (Table 1), as Gaiser et al. (2006) also reported.

Diploneis cf. ovalis (Hilse) Cleve (Figs 15a-b, 77)

Length: 22-38 µm; width: 13-18 µm; striae: 13-14 in 10 µm; alveoli: 20 in 10 µm.

Our specimens fall within the range of measurements for D. ovalis given by Krammer & Lange-Bertalot (1997a) and have a similar linear-elliptical valve shape. However, they state that alveoli are irregular, forming wavy, longitudinal lines (unlike our specimens). Their pictured specimens also have larger central areas. We observed D. cf. ovalis in 82% of our samples. The taxon was more common in P-enriched conditions and had a moderate TP optimum (40 ± 19 μgL^{-1}) (Table 1).

Encyonema evergladianum Krammer (Figs 16a-c)

Krammer (1997), p. 73, pl. 142: 1-7; as Cymbella scotica A. Schmidt in Podzorski (1985), p. 48, pl. 18: 8, 9.

Length: 15-33 µm; width: 4-5 µm; striae: 19-22 in 10 µm.

Our specimens closely resemble specimens from Jamaica identified as C. scotica in measurements, shape, and ventrally deflected raphe ends (Podzorski 1985). However, Smith (1856) gives a length of 30-68 µm and 13 striae in 10 µm in the original description of C. scotica, and it is illustrated with dorsally deflected raphe ends (Schmidt 1874-1959). Valve shape of our specimens is variable. Ventral edges can be straight (Fig. 16a) or have a slight bulge in the centre that is more pronounced in larger valves (Fig. 16b), which can cause larger valves to be almost lanceolate in shape (Fig. 16c). The ventral edge is indented at the ends, so that valve ends appear to be ventrally deflected. Although we observed the taxon in 82% of samples, we did not find it in highly enriched surface sediments of northern WCA-2A. The TP optimum

was low (26 ± 16 μgL^{-1}) (Table 1). Cooper et al. (1999), Pan et al. (2000), and Gaiser et al. (2006) also reported that the taxon (identified as Cymbella sp. A by S. Cooper and C. scotica by Y. Pan, personal communication) indicated low P concentrations in the Everglades.

Encyonema neomesianum Krammer (Figs 17a-b)

Krammer (1997), p. 5, pl. 191: 7-9; as Cymbella turgida (Gregory) Cleve in Foged (1984), p. 33, pl. 12: 14, 15; as Cymbella minuta var. pseudogracilis (Cholnoky) Reimer in Patrick & Reimer (1975), p. 50, pl. 9: 1a-2b; as Cymbella mülleri in Podzorski (1985), pl. 18: 7.

Length: 35-78 μm; width: 9-15 μm; striae: 8-10 in 10 μm at valve centre and 12-14 in 10 μm at valve ends; areolae: 18-25 in 10 μm. The bulge in the centre of the ventral edge of the valve was more pronounced in larger specimens (Fig. 17b). We observed the taxon in 84% of samples; the TP optimum was low (26 ± 13 μgL^{-1}) (Table 1).

Encyonopsis microcephala (Grunow) Krammer (Fig. 18)

Krammer (1997), p. 91, pl. 143: 1, 4, 5, 8-26, pl. 146: 1-5, pl. 147: 1-3, pl. 149: 1-8, pl. 150: 22, pl. 203: 13-18; as Cymbella microcephala Grunow in Patrick & Reimer (1975), p. 33, pl. 4: 12a-13b; in Foged (1984), p. 33, pl. 12: 12; in Germain (1981), p. 274, pl. 99: 27-30; in Podzorski (1985), p. 48, pl. 18: 4, pl. 39: 4, 5; in Toledo Iser (1992a), p. 5, (1992b), p. 5; and in Krammer & Lange-Bertalot (1997a), p. 327, pl. 134: 23-32.

Length: 18-21 μm; width: 4 μm; striae: 22-24 in 10 μm at valve centre and 28 in 10 μm at valve ends. Valve ends are capitate. While this taxon occurred in unenriched conditions, it was more common in P-enriched conditions and had a moderate TP optimum (33 ± 11 μgL^{-1}) (Table 1). Everglades references reported variability in P preference. Gaiser et al. (2006) reported a low TP optimum, while Raschke (1993) and Pan et al. (2000) found the taxon to be common at P-enriched sites. Cooper et al. (1999) found that the taxon indicated moderate P but high nitrogen concentrations.

Epithemia adnata var. proboscidea (Kützing) Patrick (Fig. 19)

Patrick & Reimer (1975), p. 181, pl. 24: 5.

Length: 35-101 μm; width: 9-15 μm; striae: 13-16 in 10 μm; areolae: 11-12 in 10 μm; costae: 4-5 in 10 μm. We observed this taxon only in P-enriched conditions; it was especially common in highly enriched surface sediments of northern WCA-2A. The TP optimum was moderate (43 ± 13 μgL^{-1}) (Table 1).

Eunotia arcus Ehrenberg (Fig. 20)

Hagelstein (1938), p. 356; Patrick & Reimer (1966), p. 212, pl. 13: 11; Germain (1981), p. 90, pl. 31: 27; Krammer & Lange-Bertalot (1991a), p. 184, pl. 147: 1-17; Maldonado González (1987), p. 15, fig. 6.

Length: 47-108 μm; width: 9-10 μm; striae: 8-11 in 10 μm at valve centre and 12-16 in 10 μm at valve ends. The dorsal margin of our specimens is only slightly indented at the ends, as in pl. 147: 1, 6, 7, and 15 in Krammer & Lange-Bertalot (1991a). We observed the taxon only in northern WCA-2A sediment cores and only below 5 cm.

Eunotia camelus Ehrenberg (Figs 21a-b)

Krammer & Lange-Bertalot (1991a), pl. 160: 10, 11; Toledo Iser (1992a), p. 6, fig. 2g.

Length: 17-55 μm; width: 5-6 μm; striae: 10-11 in 10 μm at valve centre and 16 in 10 μm at valve ends. Valves contain 2-4 ridges. Some larger specimens have a slight swelling between pairs of ridges (Fig. 21b), as was also observed by Toledo Iser (1992a). We observed the taxon only in sediment cores and only below 5 cm.

Eunotia flexuosa Brébisson ex Kützing (Fig. 22)

Patrick & Reimer (1966), p. 187, pl. 10: 1; Germain (1981), p. 94, pl. 32: 11, 11b; Podzorski (1985), p. 22, pl. 3: 2-4, pl. 31: 2; Maldonado González (1986), p. 51, fig. 18; Krammer & Lange-Bertalot (1991a), p. 182, pl. 140: 8-18.

Length: 67-106 μm; width: 3-4 μm; striae: 13-16 in 10 μm. Germain (1981) gives a similar width of 2.5-3 μm but a greater striae density (16-18 in 10 μm) than occurred in our specimens. We did not observe the range in width (2-5 μm, 6 μm, and 2-7 μm) or striae density (15-19, 20, and (9)11-20 in 10 μm) given by Patrick & Reimer (1966), Maldonado González (1986), and Krammer & Lange-Bertalot (1991a), respectively. Although Patrick & Reimer (1966), Germain (1981), and Maldonado González (1986) describe valve ends as capitate, Krammer & Lange-Bertalot (1991a) state that valve ends of some populations are indistinguishable from the rest of the valve (see pl. 140: 8, 9, 15), as also occurs in our specimens and in Podzorski (1985). Bifurcate (U-shaped) raphes, characteristic of E. flexuosa, are visible in our specimens. We observed the taxon only in P-enriched conditions and below 2 cm in sediment cores. The TP optimum was moderate (40 ± 15 $\mu g L^{-1}$) (Table 1), as also reported by Gaiser et al. (2006). Raschke (1993) found the taxon to be common at P-impacted sites in the Everglades.

Eunotia formica Ehrenberg (Fig. 65)

Patrick & Reimer (1966), p. 190, pl. 10: 7; Germain (1981), p. 90, pl. 31: 29-31; Krammer & Lange-Bertalot (1991a), p. 209, pl. 152: 8-12a; Metzeltin & Lange-Bertalot (1998), pl. 16: 1-8.

Length: 39-148 μm; width: 8.5-11 μm; striae: 7-11 in 10 μm. Ends of our specimens are rounded and not wedge-capitate or triangular as pictured in Patrick & Reimer (1966) and in Krammer & Lange-Bertalot (1991a). Krammer & Lange-Bertalot (1991a) state that valve ends can vary considerably and Germain (1981) states that he has never observed triangular ends on this species as described by other authors. We observed the taxon only in sediment cores and only below 9 cm.

Eunotia glacialis Meister (Fig. 66)

Patrick & Reimer (1966), p. 188, pl. 10: 3; Krammer & Lange-Bertalot (1991a), pp. 207, 594, pl. 151: 1-10a, pl. 151a: 1, 2.

Length: 80-150 μm; width: 5-6 μm; striae: 11-13 in 10 μm. This taxon was most common below 2 cm in sediment cores (Table 1).

Fragilaria capucina var. gracilis (Oestrup) Hustedt (Fig. 23)

Krammer & Lange-Bertalot (1991a), p. 123, pl. 110: 8-13, pl. 111: 1-3, pl. 113: 22-26.

Length: 28-39 μm; width: 1.5-2 μm; striae: 20-22 in 10 μm. This taxon had a moderate TP optimum (40 ± 30 μgL^{-1}) (Table 1).

Fragilaria synegrotesca Lange-Bertalot (Fig. 24)

Lange-Bertalot (1993), p. 49, pl. 12: 1-11; as Fragilaria vaucherii (Kützing) Peters in Podzorski (1985), p. 20, pl. 1: 13, pl. 30: 1-3; as S. minuscula Grunow in Podzorski (1985), pl. 30: 7 (not pl. 1: 19, 20).

Length: 17-88 μm; width: 3 μm; striae: 13-15 in 10 μm. Lange-Bertalot (1993) described the species from a population collected in the Everglades with a length range of 30-170 μm. However, we found specimens as small as 17 μm in length. Our specimens closely resemble photographs of specimens from Jamaica identified as F. vaucherii and S. minuscula (Podzorski 1985). F. vaucheriae in Patrick & Reimer (1966) has a smaller length:width ratio and rostrate rather than capitate ends. S. minuscula in Patrick & Reimer (1966) has striae on both sides of the central area (rather than "ghost" striae on one side as occurs in F. synegrotesca), a smaller length:width ratio, and rostrate rather than capitate ends. Although we observed F. synegrotesca in 86% of samples, we did not find it in highly enriched surface sediments of northern WCA-2A. It was especially common in unenriched conditions and had a low TP optimum (22 ± 18 μgL^{-1}) (Table 1). Cooper et al. (1999), Pan et al. (2000), and Gaiser et al. (2006) also reported that the taxon (identified as Fragilaria sp. A by S. Cooper, personal communication) indicated low P concentrations in the Everglades.

Fragilaria cf. tenera (W. Smith) Lange-Bertalot (Figs 25, 78)

As Synedra minuscula Grunow in Podzorski (1985), p. 21, pl. 1: 19, 20 (not pl. 30: 7); as Fragilaria famelica (Kützing) Lange-Bertalot in Lange-Bertalot (1993), pl. 12: 12-14.

Length: 59-84 μm; width: 2-3 μm; striae: 16-20 in 10 μm. Our specimens resemble Synedra tenera W. Smith lectotypes in the linear-lanceolate shape, rostrate to capitate apices, and striae density (Krammer & Lange-Bertalot 1991a, pl. 115: 1, 2). However, the shorter striae of S. tenera create a wider, more easily visible pseudoraphe than occurs in our specimens. The pseudoraphe of our specimens is so narrow that it is usually not visible in the light microscope. It is sometimes visible in larger specimens, especially toward valve middles. SEM reveals that striae are areolate and that the pseudoraphe results from a slight gap between median areolae (Fig. 78). There is no central area. Lange-Bertalot (1993) also collected this taxon in the Everglades but identified it as Fragilaria famelica. However, Synedra famelica Kützing in Patrick & Reimer (1966) and F. famelica (Kützing) Lange-Bertalot in Krammer & Lange-Bertalot (1991a) have central areas and smaller length:width ratios. Podzorski (1985) collected specimens from Jamaica, identified as Synedra minuscula, that closely resemble Everglades specimens in measurements, shape of valve and apices, very narrow pseudoraphe, and lack of central area. However, S. minuscula in Patrick & Reimer (1966) has a smaller length:width ratio and a wider pseudoraphe. The similarities between our specimens, other specimens collected in the Everglades (Lange-Bertalot 1993), and specimens from Jamaica (Podzorski 1985) cause us to suspect that they are a distinct subtropical or tropical taxon. Lange-Bertalot (1993) reports that the taxon is found in oligotrophic to mesotrophic waters in Florida, Jamaica, Mexico, and Central America. We observed F. cf. tenera in 53% of samples. It was especially common in unenriched conditions and had a low TP optimum (14 ± 13 $\mu g L^{-1}$) (Table 1).

Gomphonema affine Kützing (Fig. 26)

Patrick & Reimer (1975), p. 133, pl. 17: 5; Podzorski (1985), p. 53, pl. 20: 2, 3; Maldonado González (1986), p. 52, fig. 23; Toledo Iser (1989), p. 4, fig. 2d, (1992a), p. 8, (1992b), p. 6; Krammer & Lange-Bertalot (1997a), p. 366, pl. 161: 1-3.

Length: 51-69 μm; width: 9-12 μm; striae: 9-12 in 10 μm; areolae: 17 in 10 μm. Tobias & Gaiser (2006) analyze the taxonomy of Everglades specimens in detail. We observed this taxon only in P-enriched conditions; the TP optimum was moderate (43 $\pm$ 16 μgL^{-1}) (Table 1). Gaiser et al. (2006) reported a low TP optimum for this taxon in the Everglades.

Gomphonema gracile Ehrenberg (Fig. 27)

Hagelstein (1938), p. 361; Patrick & Reimer (1975), p. 131, pl. 17: 1-3; Germain (1981), p. 310, pl. 115: 1-14, pl. 168: 12; Foged (1984), p. 43, pl. 13: 3, 4, 8, 12; Krammer & Lange-Bertalot (1991b), p. 406, pl. 79: 1-7; Toledo Iser (1989), p. 4, figs 2f, 3a, (1992a), p. 9, fig. 4d, (1992b), p. 7; Krammer & Lange-Bertalot (1997a), p. 361, pl. 154: 26, 27, pl. 156: 1-11; as G. gracile Ehrenberg, "aurita" series in Podzorski (1985), p. 53, pl. 20: 10, 11; pl. 41: 1, 2.

Length: 20-69 μm; width: 5-9 μm; striae: 11-16 in 10 μm. Valves are lanceolate in shape with acute apices. Tobias & Gaiser (2006) analyzed the taxonomy of Everglades specimens in detail. We observed the taxon in 50% of samples. It was more common in P-enriched conditions and had a moderate TP optimum (39 $\pm$ 16 μgL^{-1}) (Table 1). Cooper et al. (1999) and Pan et al. (2000) also found that the taxon indicated moderate P concentrations in the Everglades.

Gomphonema parvulum (Kützing) Grunow (Fig. 28)

Hagelstein (1938), p. 362; Germain (1981), p. 308, pl. 144: 23-27; Foged (1984), p. 44, pl. 13: 13; as G. parvulum (Kützing) Kützing in Patrick & Reimer (1975), p. 122, pl. 17: 7-12; in Podzorski (1985), p. 54, pl. 21: 1, 2; in Maldonado González (1986), p. 52, figs 24, 25, (1987), p. 15, fig. 11; in Toledo Iser

(1989), p. 5, fig. 3b, (1992a), p. 9, fig. 4f, (1992b), p. 7; in Krammer & Lange-Bertalot (1991b), p. 400, pl. 76: 1-7; and in Krammer & Lange-Bertalot (1997a), p. 358, pl. 154: 1-25.

Length: 13-23 μm; width: 5-6 μm; striae: 12-15 in 10 μm. Tobias & Gaiser (2006) analyzed the taxonomy of Everglades specimens in detail. We found the taxon to have a high TP optimum (52 ± 20 μgL^{-1}) (Table 1). Other authors (Swift & Nicholas 1987, Raschke 1993, McCormick et al. 1996, Cooper et al. 1999, Pan et al. 2000, Gaiser et al. 2006) also found that the taxon indicated high P concentrations in the Everglades.

Gomphonema tenellum Kützing (Fig. 29)

Patrick & Reimer (1975), p. 124, pl. 17: 16a-b; as G. parvulum Kützing, "micropus" series, in Podzorski (1985), p. 54, pl. 21: 3.

Length: 18-30 μm; width: 4-5 μm; striae: 12-14 in 10 μm. This taxon was more common in P-enriched conditions and had a high TP optimum (55 ± 19 μgL^{-1}) (Table 1).

Gomphonema cf. vibrioides Reichardt & Lange-Bertalot (Fig. 30)

Length: 75-92 μm; width: 9-11 μm; striae: 9 in 10 μm. Our specimens resemble G. vibrioides in Metzeltin & Lange-Bertalot (1998), except that head poles of our specimens are more broadly rounded and wider than foot poles. Tobias & Gaiser (2006) analyze the taxonomy of Everglades specimens in detail, comparing them to the closely related G. intricatum var. vibrio. We observed the taxon in 69% of samples. The TP optimum was low (28 ± 16 μgL^{-1}) (Table 1).

Hantzschia amphioxys (Ehrenberg) Grunow (Fig. 31)

Hagelstein (1938), p. 368; Germain (1981), p. 326, pl. 122: 5-10; Podzorski (1985), p. 55, pl. 22: 1; Maldonado González (1986), p. 53, fig. 27, (1987), p. 15, fig. 12; Toledo Iser (1989), p. 5, fig. 5e, (1992a), p. 9, fig. 6b, (1992b), p. 7; Krammer & Lange-Bertalot (1997b), p. 128, pl. 88: 1-7.

Length: 75-112 μm; width: 8-12 μm; striae: 15-18 in 10 μm; fibulae: 7 in 10 μm. This taxon was most common below 2 cm in sediment cores (Table 1).

Kobayasiella subtilissima (Cleve) Lange-Bertalot (Fig. 32)

As Navicula subtilissima Cleve in Patrick & Reimer (1966), p. 483, pl. 46: 4; in Germain (1981), p. 233, pl. 85: 48, pl. 169: 1-3; in Podzorski (1985), p. 40, pl. 12: 4, pl. 37: 5; and in Krammer & Lange-Bertalot (1997a), p. 182, pl. 79: 22-26.

Length: 15-26 μm; width: 3-4 μm. Striae are too fine to be resolved with a light microscope. Ends of our specimens are narrowly rostrate to slightly capitate, resembling Krammer & Lange-Bertalot (1997a), pl. 79: 22 more than other cited figures. The TP optimum was moderate (35 ± 17 μgL^{-1}) (Table 1).

Lemnicola hungarica (Grunow) Round & Basson (Figs 33a-b)

As Achnanthes hungarica (Grunow) Grunow in Patrick & Reimer (1966), p. 259, pl. 16: 27, 28; in Germain (1981), p. 112, pl. 41: 38-45; in Lange-Bertalot & Krammer (1989), p. 66, pl. 35: 11-27, pl. 34: 8; in Krammer & Lange-Bertalot (1991b), p. 33, pl. 19: 1-15; and in Metzeltin & Lange-Bertalot (1998), pl. 67: 23-32.

Length: 10-30 μm; width: 4.5-6.5 μm; striae: 18-23 in 10 μm in both raphe and araphid valves. This taxon was common in sediment cores from highly enriched northern WCA-2A, both in surface sediments and below 2 cm (Table 1).

Luticola stigma (Patrick) Johansen (Fig. 34)

As Navicula mutica var. stigma Patrick in Patrick & Reimer (1966), p. 455, pl. 42: 5; as Navicula terminata Hustedt in Foged (1984), p. 71, pl. 8: 4.

Length: 13-35 μm; width: 6-8 μm; striae: 19-21 in 10 μm. We observed this taxon only below 4 cm in sediment cores.

Mastogloia lanceolata Thwaites ex W. Smith (Figs 35a-b)

Smith (1856), p. 64, pl. 54: 340; Hagelstein (1938), p. 375; Podzorski (1985), p. 29, pl. 5: 19, 20.

Length: 37-69 μm; width: 16-20 μm; striae: 16-20 in 10 μm; areolae: 14-16 in 10 μm; partecta: 9-10 in 10 μm. We observed this taxon in 64% of samples (Table 1). The TP optimum was low (22 ± 14 μgL^{-1}), as Gaiser et al. (2006) also reported.

Mastogloia smithii Thwaites ex W. Smith (Morphotype I: Figs 36a-e, 79; Morphotype II: Figs 37a-c)

Smith (1856), p. 65, pl. 54: 341; Hagelstein (1938), p. 376; Patrick & Reimer (1966), p. 299, pl. 20: 10-11; Foged (1984), p. 57, pl. 4: 6; Podzorski (1985), p. 29, pl. 5: 18, 21-23; Maldonado González (1986), p. 53, fig. 28; Toledo Iser (1992a), p.10, fig. 7a; Krammer & Lange-Bertalot (1997a), p. 434, pl. 201: 1-9.

Morphotype I: Length: 25-57 μm; width: 7-9 μm; striae: 18-20 in 10 μm; areolae: 20 in 10 μm; partecta: 5-6 in 10 μm; width of frustule in girdle view: 7-10 μm.

Morphotype II: Length: 22-45 μm; width: 10-13 μm; striae: 14-15 in 10 μm; areolae: 17-18 in 10 μm; partecta: 6-8 in 10 μm; width of frustule in girdle view: 10-12 μm.

Morphotype I valves are linear-lanceolate, while morphotype II valves are almost elliptical in shape. Although morphotype I tends to have slightly larger lengths than morphotype II, the length ranges overlap. Other measurements (valve width, width of the frustule in girdle view, and number of striae, areolae, and partecta in 10 μm) have little to no overlap between morphotypes. Morphotypes I and II also appear to occur in Jamaica (Podzorski 1985). Linear-lanceolate valves in pl. 5: 21, 22 correspond to our morphotype I, with a width of 7 μm, 19 striae in 10 μm, and 5 partecta in 10 μm. The nearly elliptical valve in pl. 5: 18 corresponds to our morphotype II, with a width of 12 μm and 7 partecta in 10 μm.

In some ways, morphotype I resembles M. smithii var. lacustris. It has a linear-lanceolate shape, a characteristic of the variety in Patrick & Reimer (1966) and in Krammer & Lange-Bertalot (1997a).

Krammer & Lange-Bertalot (1997a) also show rounded ends and a greater distance between septa and valve ends, but we observed these characteristics only in our largest morphotype I specimens (Figs 36d-e). Because these large morphotype I specimens have the same measurements and other characteristics as smaller specimens, we suspect that the rounded ends and the greater distance between septa and valve ends may be characteristics of initial valves. Our morphotype I specimens have denser striae and areolae than given for M. smithii var. lacustris in citations. Patrick & Reimer (1966) give 15-16 striae and 13-15 areolae in 10 μm. Krammer & Lange-Bertalot (1997a) give 15-18 striae and 13-15 areolae in 10 μm.

Morphotype I was more common than any other taxon in this study; we observed it in 87% of samples. Although it was common in P-enriched mesocosms and in floating algal mats collected in the moderately enriched interior of WCA-2A, we did not find it in highly enriched surface sediments of northern WCA-2A (Table 1). The TP optimum was low (27 ± 15 μgL^{-1}). Morphotype II occurred in fewer samples (46%), at low % abundances, and had a moderate TP optimum (33 ± 10 μgL^{-1}) (Table 1). Numerous authors (Swift & Nicholas 1987, Raschke 1993, McCormick & O'Dell 1996, McCormick et al. 1998, Pan et al. 2000, and Gaiser et al. 2006) reported M. smithii or M. smithii var. lacustris as a dominant Everglades taxon at low P concentrations. Vymazal et al. (1994) observed M. smithii only in P-enriched mesocosms in the Everglades. Although van Dam et al. (1994) reported that M. smithii var. lacustris indicates eutrophic conditions, Lange-Bertalot & Metzeltin (1996) found the taxon in oligotrophic lakes.

Navicella pusilla (Grunow) Krammer (Fig. 38)

As Cymbella pusilla Grunow in Patrick & Reimer (1975), p. 25, pl. 3: 18; in Germain (1981), p. 286, pl. 105: 6, pl. 160: 6; and in Krammer & Lange-Bertalot (1997a), p. 340, pl. 148: 1-9.

Length: 19-21 μm; width: 4-5 μm; striae: 16 in 10 μm at valve centre and 20 in 10 μm at valve ends. We observed this taxon only in P-enriched conditions. The TP optimum was moderate (32 ± 5 μgL^{-1}) (Table 1).

Navicula brasiliana (Cleve) Cleve (Fig. 39)

Hagelstein (1938), p. 381, pl. 6: 7; Toledo Iser (1992b), p. 8, fig. 4a; Krammer & Lange-Bertalot (1997a), p. 166, pl. 52: 1, 2; Metzeltin & Lange-Bertalot (1998), p. 144, pl. 93: 5-7.

Length: 29-69 μm; width: 9-15 μm; striae: 20-22 in 10 μm. Metzeltin & Lange-Bertalot (1998) believe that further taxonomic study may reveal that this species belongs in the genus Placoneis. We observed the taxon only in sediment cores from highly enriched northern WCA-2A, both in surface sediments and below 2 cm (Table 1).

Navicula cryptocephala Kützing (Fig. 40)

Hagelstein (1938), p. 383; Patrick & Reimer (1966), p. 503, pl. 48: 3; Germain (1981), p. 188, pl. 72: 1-3; Podzorski (1985), p. 42, pl. 13: 6-7 (not pl. 38: 7); Toledo Iser (1992a), p. 10, fig. 6e, (1992b), p. 8; Cox (1995), p. 108, figs 23-27; Krammer & Lange-Bertalot (1997a), p. 102, pl. 31: 8-14.

Length: 29-57 μm; width: 5-8 μm; striae: 14-16 in 10 μm; lineolae: 40 in 10 μm. This taxon was common in sediment cores from highly enriched northern WCA-2A, both in surface sediments and below 2 cm (Table 1).

Navicula cryptotenella Lange-Bertalot (Fig. 41)

Toledo Iser (1989), p. 5, fig. 3e, (1992a), p. 10, fig. 7e, (1992b), p. 8, fig. 4d; Krammer & Lange-Bertalot (1997a), p. 106, pl. 33: 9-11, 13-17; as Navicula radiosa var. tenella (Brébisson) Van Heurck in Hagelstein (1938), p. 390; as N. radiosa var. tenella (Brébisson ex Kützing) Grunow in Patrick & Reimer (1966), p. 510, pl. 48: 17; and in Podzorski (1985), p. 43, pl. 13: 12, pl. 38: 5.

Length: 22-34 μm; width: 5-6 μm; striae: 14-16 in 10 μm. We observed this taxon in 55% of samples. It was more common in P-enriched conditions and had a moderate TP optimum (42 ± 17 $\mu g L^{-1}$) (Table 1).

Gaiser et al. (2006) also reported a moderate TP optimum and Raschke (1993) found it to be common at P-impacted sites in the Everglades.

Navicula exigua var. capitata Patrick (Fig. 42)

Patrick & Reimer (1966), p. 522, pl. 49: 24.

Length: 24-30 μm; width: 9-11 μm; striae: 11 in 10 μm at valve centre and 16 in 10 μm at valve ends.

Cox (1987) notes that the nominate variety of this species was transferred to the genus Placoneis by Mereschkowsky. We observed the taxon only in sediment cores from highly enriched northern WCA-2A, both in surface sediments and below 2 cm (Table 1).

Navicula oblonga (Kützing) Kützing (Fig. 67)

Patrick & Reimer (1966), p. 534, pl. 51: 6; Germain (1981), p. 196, pl. 76: 1; Foged (1984), p. 68, pl. 8: 3; Krammer & Lange-Bertalot (1997a), p. 121, pl. 41: 2.

Length: 118-163 μm; width: 16-20 μm; striae: 6-7 in 10 μm. We observed this taxon only in sediment cores from highly enriched northern WCA-2A. It occurred in surface sediments but was especially common in some samples below 2 cm (Table 1).

Navicula podzorskii Lange-Bertalot (Figs 43, 80)

Lange-Bertalot (1993), p. 129, pl. 59: 1-7, pl. 60: 3-6; Metzeltin & Lange-Bertalot (1998), pl. 75: 1-3; as Navicula lanceolata in Podzorski (1985), p. 42, pl. 13: 13, pl. 38: 8.

Length: 50-73 μm; width: 8-11 μm; striae: 13-15 in 10 μm; lineolae: 25-29 in 10 μm.

Although the source population for the original description of this taxon is from the Everglades (Lange-Bertalot 1993), our specimens have slightly different measurements. Lange-Bertalot (1993) gives a length of 40-60 μm, a width of 8-10 μm, 12-13 striae in 10 μm and 26-28 lineolae in 10 μm. Otherwise, our specimens closely resemble the description and images. Valves are lanceolate, gradually narrowing

toward rounded ends. Bent proximal raphe ends are clearly visible in the light microscope. The narrow axial area widens somewhat toward the centre of the valve. The central area is small and variable (round, elliptical, or lanceolate). Specimens from Jamaica identified as N. lanceolata in Podzorski (1985) also have these characteristics and closely resemble our specimens. However, N. lanceolata in Patrick & Reimer (1966) and in Krammer and Lange-Bertalot (1986) has a much larger, rectangular-shaped central area and only 10-13 striae in 10 μm. Our specimens also differ from N. radiosa, which has a width of 10-19 μm, 10-12 striae in 10 μm, and 32 areolae in 10 μm (Patrick & Reimer 1966, Krammer & Lange-Bertalot 1997a). We observed N. podzorskii in 68% of samples; the TP optimum was moderate (31 ± 16 μgL^{-1}) (Table 1).

Navicula subrhynchocephala Hustedt (Fig. 44)

Germain (1981), p. 182, pl. 69: 7; Foged (1984), p. 71, pl. 8: 12; Simonsen (1987), p. 178, pl. 281: 1-6; Toledo Iser (1992a), p. 12, fig. 8e, (1992b), p. 10, figs 6c, 12c; Krammer & Lange-Bertalot (1997a), p. 102, pl. 31: 6, 7.

Length: 35-37 μm; width: 7-8.5 μm; striae: 12-13 in 10 μm; lineolae: 26 in 10 μm. We observed this taxon only in sediment cores from highly enriched northern WCA-2A, both in surface sediments and below 2 cm (Table 1).

Nitzschia amphibia f. frauenfeldii (Grunow) Lange-Bertalot (Fig. 45)

Krammer & Lange-Bertalot (1997b), p. 109, pl. 78: 25, 26.

Length: 16-77 μm; width: 3-4 μm; striae: 16-18 in 10 μm; areolae: 24 in 10 μm; fibulae: 7-10 in 10 μm. We observed this taxon in 65% of samples. It was especially abundant in P-enriched conditions and had a moderate TP optimum (48 ± 16 μgL^{-1}) (Table 1). Cooper et al. (1999), Pan et al. (2000), and Gaiser et al. (2006) reported that the taxon (identified as N. amphibia by S. Cooper and Y. Pan, personal communication) indicated high P concentrations in the Everglades.

Nitzschia frustulum (Kützing) Grunow (Fig. 46)

Hagelstein (1938), p. 395; Podzorski (1985), p. 61, pl. 24: 8-10, pl. 43: 4; Krammer & Lange-Bertalot (1997b), p. 94, pl. 68: 1-8.

Length: 9-12 μm; width: 3 μm; striae: 24-25 in 10 μm; fibulae: 9-12 in 10 μm. This taxon had a high TP optimum (77 ± 17 μgL^{-1}) and was observed only in P-enriched mesocosms and in sediment cores from highly enriched northern WCA-2A (Table 1).

Nitzschia gandersheimiensis Krasske (Figs 47, 81)

Foged (1984), p. 76; as Nitzschia gandersheimiensis sensu stricto in Lange-Bertalot & Simonsen (1978), pp. 28-31, figs 40-42a; in Lange-Bertalot et al. (1996), p. 161, pl. 49: 6-11; and in Krammer & Lange-Bertalot (1997b), p. 90, pl. 64: 12-16.

Length: 46-71 μm; width: 3-4 μm; striae: 27-35 in 10 μm; fibulae: 9-10 in 10 μm.

Our specimens closely resemble photographs of Krasske's type specimens in Lange-Bertalot & Simonsen (1978), Lange-Bertalot et al. (1996), and Krammer & Lange-Bertalot (1997b). Valves are linear, becoming asymmetrically narrower toward valve ends (one side of the valve is slightly straighter). Ends are capitate. There is a slight gap between median fibulae, where the valve is indented, with a more pronounced indentation on the keel side of the valve. Our specimens resemble N. gandersheimiensis sensu stricto rather than the various taxa that Lange-Bertalot & Simonsen (1978) list as synonyms. Photos of type specimens of N. balcanica, N. capitellata, N. frequens, N. diserta, N. salinicola, and N. subcapitellata in Simonsen (1987) and photos of N. parvula in Krammer & Lange-Bertalot (1997b) are of wider, more symmetrical valves than our specimens. Although SEM reveals that striae of our specimens consist of areolae (Fig. 81), they are too small to be visible in the light microscope as they are in the photo of the type specimen of N. calcicola (Simonsen 1987). In the photo of the type specimen of N. paleaeformis, median fibulae are separated by a wider gap and the indentation at the valve middle is less

pronounced (Simonsen 1987). Lange-Bertalot & Simonsen (1978) state that N. gandersheimiensis is often found in heavily polluted water, with N. palea, but they include the taxa discussed above as synonyms. We found N. gandersheimiensis sensu stricto to be more common in unenriched conditions, with a low TP optimum (25 ± 13 μgL^{-1}) (Table 1). Foged (1984) also identified the taxon as oligotrophic. We observed it in 70% of samples.

Nitzschia nana Grunow (Fig. 48)

Krammer & Lange-Bertalot (1997b), p. 26, pl. 17: 4-8; as N. obtusa W. Smith in Maldonado González (1986), p. 54, fig. 36.

Length: 68-123 μm; width: 3.5-4 μm; fibulae: 8-9 in 10 μm. Striae could not be resolved with a light microscope. Its sigmoid shape and length:width ratio resemble pl. 17: 8 more than other figures in Krammer & Lange-Bertalot (1997b). Our specimens resemble a specimen from Cuba with a length of 72 μm, width of 3.5 μm, and 10-11 fibulae in 10 μm, identified as N. obtusa (Maldonado González 1986). However, N. obtusa in Krammer & Lange-Bertalot (1997b) is larger (length 120-350 μm and width 7-13 μm), has 5-6 fibulae in 10 μm, and 22-30 striae in 10 μm. We found N. nana to have a moderate TP optimum (42 ± 10 μgL^{-1}) (Table 1).

Nitzschia palea var. debilis (Kützing) Grunow (Fig. 49)

Germain (1981), p. 350, pl. 132: 15-20; Krammer & Lange-Bertalot (1997b), p. 86, pl. 60: 1-7.

Length: 25-29 μm; width: 2.5-3 μm; fibulae: 11-14 in 10 μm. Striae could not be resolved with a light microscope. Although the N. palea group (all varieties combined) had a high TP optimum (57 ± 22 μgL^{-1}) (Table 1), we found N. palea var. debilis to be common in unenriched conditions. Similarly, Gaiser et al. (2006) reported a low TP optimum for N. palea var. debilis.

Nitzschia perminuta (Grunow) Peragallo (Fig. 50)

Podzorski (1985), p. 63, pl. 25: 11; Krammer & Lange-Bertalot (1997b), p. 99, pl. 72: 1-23a.

Length: 22-23 μm; width: 2.5-3 μm; striae: 30-36 in 10 μm; fibulae: 14 in 10 μm. Our specimens have capitate ends and areolate striae. The TP optimum was high (58 ± 20 μgL^{-1}) (Table 1).

Nitzschia radicula Hustedt (Fig. 51)

Simonsen (1987), p. 306, pl. 459: 21-25; Krammer & Lange-Bertalot (1997b), p. 105, pl. 77: 7-10.

Length: 23-42 μm; width: 2.5-3 μm; striae: 29-30 in 10 μm; fibulae: 10-13 in 10 μm. Shape of valves varies from linear to linear-lanceolate. Although Krammer & Lange-Bertalot (1997b) state that there is a gap between median fibulae, we found that a gap was not always evident. The taxon was more common in P-enriched conditions and had a moderate TP optimum (48 ± 18 μgL^{-1}) (Table 1).

Nitzschia scalaris (Ehrenberg) W. Smith (Fig. 52)

Hagelstein (1938), p. 402; Germain (1981), p. 330, pl. 123: 3; Foged (1984), p. 80, pl. 15: 5, 6; Podzorski (1985), p. 59, pl. 24: 4; Maldonado González (1986), p. 54, figs 37a-b; Toledo Iser (1992b), p. 11; Krammer & Lange-Bertalot (1997b), p. 34, pl. 25: 1-4; Metzeltin & Lange-Bertalot (1998), pl. 206: 15.

Length: 449-465 μm; width: 18-26 μm; striae: 9-10 in 10 μm; fibulae: 3-4 in 10 μm. The TP optimum was high (51 ± 22 μgL^{-1}) (Table 1).

Nitzschia semirobusta Lange-Bertalot (Fig. 53)

Lange-Bertalot (1993), p. 149, pl. 120: 3-21, pl. 122: 7, pl. 123: 1-7; as Nitzschia denticula Grunow in Toledo Iser (1992a), p. 13, fig. 9f, (1992b), p. 10, fig. 12h; and in Podzorski (1985), p. 60, pl. 23: 9, 10, pl. 42: 2-4; as Nitzschia kittoni H. L. Smith in Hagelstein (1938), p. 397, pl. 8: 2, 3.

Length: 19-47 μm; width: 5 μm; striae: 14-15 in 10 μm; fibulae: 5-6 in 10 μm. This taxon occurred in 54% of samples and had a moderate TP optimum (33 ± 12 μgL^{-1}) (Table 1).

Nitzschia serpentiraphe Lange-Bertalot (Figs 54a-b)

Lange-Bertalot (1993), p. 151, pl. 125: 2-6, pl. 126: 1-9, pl. 127: 1-6; as Denticula occidentalis Østrup in Hagelstein (1938), p. 348, pl. 5: 1.

Length: 48-96 μm; width: 6-7 μm; striae: 11-12 in 10 μm; fibulae: 5-6 in 10 μm. Lange-Bertalot (1993) described this taxon from a population collected in the Everglades with a length range of 40-80 μm. However, we found specimens as large as 96 μm in length, and populations as small as 10-30 μm have been found elsewhere in the Everglades and in the Yucatán peninsula of Mexico (E. Gaiser, personal communication). Hagelstein (1938) photographed a frustule 36 μm in length that he states is abundant in Puerto Rico. Although he identified the frustule as D. occidentalis, the strong indentation in the middle of the frustule in girdle view suggests N. serpentiraphe. We observed N. serpentiraphe in both unenriched and P-enriched conditions; the TP optimum was moderate (32 ± 7 μgL^{-1}) (Table 1). Gaiser et al. (2006) reported a low TP optimum.

Nitzschia terrestris (Petersen) Hustedt (Fig. 55)

Krammer & Lange-Bertalot (1997b), p. 30, pl. 22: 7-11.

Length: 36-71 μm; width: 4-7 μm; fibulae: 7-10 in 10 μm. Striae could not be resolved with a light microscope. We observed the taxon only in sediment cores and only below 14 cm.

Nupela silvahercynia (Lange-Bertalot) Lange-Bertalot (Figs 56a-b)

Lange-Bertalot & Metzeltin (1996), p. 97, pl. 22: 55, 56, pl. 118: 1; as Achnanthes silvahercynia Lange-Bertalot in Lange-Bertalot & Krammer (1989), p. 139, pl. 71: 30-37, pl. 73: 2-4; and in Krammer & Lange-Bertalot (1991b), p. 48, pl. 27: 15, pl. 28: 21-31.

Length: 12-18 μm; width: 3-4 μm; striae: 28 in 10 μm in both raphe and araphid valves. The araphid valve has striae on both sides of the central area, as in pl. 28: 30 in Krammer & Lange-Bertalot (1991b). The TP optimum was high (52 ± 24 μgL^{-1}) (Table 1).

Pinnularia acrosphaeria W. Smith (Fig. 57)

Patrick & Reimer (1966), p. 623, pl. 60: 2, 3; Podzorski (1985), p. 46, pl. 16: 1; Metzeltin & Lange-Bertalot (1998), pl. 168: 1-6; Krammer (2000), p. 54, pl. 19: 1-6, pl. 20: 5-7, pl. 21: 1-7, pl. 22: 1, 2; as P. acrosphaeria Brébisson in Hagelstein (1938), p. 405; in Germain (1981), p. 256, pl. 92: 10, 11; and in Foged (1984), p. 82, pl. 9: 20, pl. 10: 8-10; as P. acrosphaeria Rabenhorst in Toledo Iser (1989), p. 6, fig. 4b, (1992a), p. 14, fig. 10a, (1992b), p. 11, fig. 11a; and in Krammer & Lange-Bertalot (1997a), p. 409, pl. 181: 1-3.

Length: 56-116 μm; width: 8-15 μm; striae: 11-13 in 10 μm. Patrick & Reimer (1966) explain that W. Smith is the correct author of this species. This taxon was most common in northern WCA-2A sediment cores (Table 1).

Pinnularia cf. divergens W. Smith (Figs 58a-b, 82)

Length: 75-118 μm; width: 12-15 μm; striae: 8 in 10 μm. Our specimens resemble P. divergens in some characteristics (Patrick & Reimer 1966, Krammer & Lange-Bertalot 1997a, and Krammer 2000). Valve margins are weakly triundulate, widening slightly at the central area and near valve ends. The axial area varies from one-quarter to one-third of valve width and becomes wider toward the central area. Striae are strongly radiate in the valve middle but become convergent at valve ends. Large, bayonet-shaped distal raphe ends are embedded in a hyaline field. However, our specimens differ from P. divergens in size, shape, central area, and raphe. Our specimens have a larger length:width ratio and are linear in shape, with nearly parallel sides. We did not observe the range of elliptical to lanceolate valve shapes in Krammer & Lange-Bertalot (1997a) and Krammer (2000). Ends of our valves are also more strongly constricted, producing apices that are rostrate to slightly capitate, unlike the broadly rounded to slightly rostrate apices of P. divergens. The central area of P. divergens extends to valve margins, with a rounded thickening of silica at the valve margins. Although careful focusing reveals darker, thickened silica

between proximal raphe ends of our specimens, there is not thickened silica at valve margins of the central area. Instead, there are often irregular striae on one or both sides of the central area (Figs 58a-b). Proximal raphe ends of our specimens are strongly deflected to one side, with larger central nodules than occur in P. divergens. Raphes in our specimens are also more strongly sinuous, twisting twice between proximal and distal raphe ends. Pinnularia cf. divergens occurred in 50% of our samples, but at low % abundances (Table 1).

Pinnularia maior (Kützing) Rabenhorst (Fig. 68)

Patrick & Reimer (1966), p. 629, pl. 61: 4; Germain (1981), p. 260, pl. 93: 3, pl. 94: 1-3; Podzorski (1985), p. 46, pl. 16: 2, 3; Maldonado González (1986), p. 55, fig. 39; Toledo Iser (1992a), p. 14, fig. 11b, (1992b), p. 12, fig. 8b; Krammer & Lange-Bertalot (1997a), p. 429, pl. 196: 1-4, pl. 7: 3, 4, pl. 13: 7.

Length: 150-230 μm; width: 29-33 μm; striae: 6-7 in 10 μm. We observed this taxon only in sediment cores and only below 2 cm (Table 1).

Pinnularia viridiformis Krammer (Fig. 69)

As P. viridiformis morphotype 4 in Krammer (2000), p. 168, pl. 179: 1-4.

Length: 75-120 μm; width: 12-18 μm; striae: 8-10 in 10 μm. Our specimens resemble morphotype 4 in Krammer (2000), which has a length of 72-130 μm, width of 14.7-18.8 μm, and 7-9 striae in 10 μm. The axial area is one-third to one-fourth of the width of the valve and widens to an asymmetrical central area that is round on one side. The raphe is complex and twisting. Striae are slightly radiate at the valve middle, becoming convergent at ends. Our specimens have greater striae density and can be smaller than P. viridis var. minor and P. streptoraphe var. minor, which have 6-8 and 6-7 striae in 10 μm, lengths of 85-100 and 85-120 μm, and widths of 15-17 and 15-18 μm, respectively (Patrick & Reimer 1966, Krammer & Lange-Bertalot 1997a). P. viridiformis was most common below 2 cm in sediment cores (Table 1).

Rhopalodia gibba (Ehrenberg) Müller (Fig. 70)

Patrick & Reimer (1975), p. 189, pl. 28: 1; Germain (1981), p. 320, pl. 119: 1; Foged (1984), p. 92, pl. 14: 2, 3; Podzorski (1985), p. 55, pl. 21: 11; Maldonado González (1986), p. 55, fig. 43; Toledo Iser (1989), p. 6, fig. 4a, (1992a), p. 15, (1992b), p. 12, figs 8a, 11c; Krammer & Lange-Bertalot (1997b), p. 159, pl. 111: 1, 2, 4, 6, 7-13a.

Length: 41-105 μm; width: 8 μm; striae: 16 in 10 μm; areolae: 15 in 10 μm; costae: 6-7 in 10 μm; width of frustule in girdle view: 19-21 μm. Like McCormick & O'Dell (1996), McCormick et al. (1996), McCormick et al. (1998), McCormick et al. (2001), and Gaiser et al. (2006), we found that the taxon indicated high P concentrations (optimum: 54 ± 16 μgL^{-1}) (Table 1).

Sellaphora laevissima (Kützing) Mann (Fig. 59)

Mann (1989), p. 2, fig. 3; as Navicula laevissima Kützing in Patrick & Reimer (1966), p. 497, pl. 47: 13; in Germain (1981), p. 204, pl. 78: 1-3; in Toledo Iser (1992a), p. 11, fig. 7g (not fig. 7c); and in Krammer & Lange-Bertalot (1997a), p. 189, pl. 67: 6-10.

Length: 17-70 μm; width: 5-11.5 μm; striae: 12-16 in 10 μm at valve centre and 16-24 in 10 μm at valve ends. The central area is round, as in the figure in Mann (1989), unlike the rhombic to rectangular central area in figures in Patrick & Reimer (1966), Germain (1981), and Krammer & Lange-Bertalot (1997a). The taxon was most common in sediment cores from highly enriched northern WCA-2A, both in surface sediments and below 2 cm (Table 1). Gaiser et al. (2006) reported a moderate TP optimum in the Everglades.

Sellaphora minima (Grunow) Mann (Fig. 60)

As Navicula minima Grunow in Patrick & Reimer (1966), p. 488, pl. 46: 17, 18; in Germain (1981), p. 232, pl. 85: 41, pl. 158: 7; and in Krammer & Lange-Bertalot (1997a), p. 229, pl. 76: 39-47.

Length: 7-12 μm; width: 3-4.5 μm; striae: 28-32 in 10 μm. Valves are linear-elliptical in shape and the central area approaches a rectangular shape, resembling pl. 46: 17 in Patrick & Reimer (1966), pl. 76: 39-41 in Krammer & Lange-Bertalot (1997a), and figures in Germain (1981) more than other cited figures. We observed this taxon only in P-enriched mesocosms and in sediment cores from highly enriched northern WCA-2A. The TP optimum was high (68 $\pm$ 12 μgL^{-1}) (Table 1).

Sellaphora parapupula Lange-Bertalot (Fig. 61)

Lange-Bertalot & Metzeltin (1996), p. 101, pl. 82: 1-3; as Navicula pupula var. capitata Skvortzow & Meyer in Patrick & Reimer (1966), p. 496, pl. 47: 8; in Germain (1981), p. 205, pl. 78: 10-11; in Foged (1984), p. 69, pl. 8: 14; and in Maldonado González (1986), p. 54, fig. 32.

Length: 31-48 μm; width: 7-10 μm; striae: 16 in 10 μm at valve centre and 21 in 10 μm at valve ends. This taxon was more common in P-enriched conditions; the TP optimum was moderate (43 $\pm$ 12 μgL^{-1}) (Table 1).

Sellaphora seminulum (Grunow) Mann (Fig. 62)

As Navicula seminulum Grunow in Hagelstein (1938), p. 391; in Patrick & Reimer (1966), p. 489, pl. 46: 19; in Germain (1981), p. 230, pl. 85: 23-30; pl. 158: 3; in Podzorski (1985), p. 39; and in Krammer & Lange-Bertalot (1997a), p. 230, pl. 76: 30-36.

Length: 8-15 μm; width: 3-5 μm; striae: 18-22 in 10 μm. Larger valves are linear and shorter valves are more elliptical in shape, as noted in Germain (1981) and in Krammer & Lange-Bertalot (1997a). Valves are not bulbous at the centre, unlike the illustration in Patrick & Reimer (1966). The taxon was especially common in sediment cores from highly enriched northern WCA-2A, both in surface sediments and below 2 cm. The TP optimum was high (57 $\pm$ 19 μgL^{-1}) (Table 1).

Stauroneis pseudosubobtusoides Germain (Fig. 63)

Germain (1981), p. 160, pl. 60: 13-17, pl. 60b: 13-17; Krammer & Lange-Bertalot (1997a), p. 249, pl. 91: 1-7.

Length: 9-29 μm; width: 3.5-5 μm; striae: 19-21 in 10 μm. Germain (1981) and Krammer & Lange-Bertalot (1997a) state in their descriptions that valve width is 6-8 μm. However, widths of specimens in their photographs are 3.5-5 μm. This taxon was most common below 2 cm in sediment cores (Table 1).

Synedra acus Kützing (Fig. 71)

Patrick & Reimer (1966), p. 135, pl. 5: 1; Germain (1981), p. 78, pl. 27: 1-5; Podzorski (1985), p. 20, pl. 1: 14, 15, pl. 30: 4; Toledo Iser (1989), p. 6, fig. 4c, (1992b), p. 13; as Fragilaria ulna var. acus (Kützing) Lange-Bertalot in Krammer & Lange-Bertalot (1991a), p. 144, pl. 122: 11-13, pl. 119: 8.

Length: 98-262 μm; width: 3.5-5 μm; striae: 11-13 in 10 μm. Faint striae are visible in the central area, as in photographs in Germain (1981) and in Krammer & Lange-Bertalot (1991a). The TP optimum was high (56 ± 24 μgL^{-1}) (Table 1).

Synedra ulna (Nitzsch) Ehrenberg (Fig. 72)

Patrick & Reimer (1966), p. 148, pl. 7: 1, 2; Podzorski (1985), p. 22; Maldonado González (1986), p. 56, fig. 46, (1987), p. 19, fig. 14; Toledo Iser (1989), p. 6, fig. 4d, (1992a), p. 16, (1992b), p. 13; as Fragilaria ulna (Nitzsch) Lange-Bertalot in Krammer & Lange-Bertalot (1991a), p. 143, pl. 122: 1-8.

Length: 134-235 μm; width: 4.5-7 μm; striae: 9 in 10 μm. We observed this taxon only in P-enriched conditions. The TP optimum was high (57 ± 22 μgL^{-1}) (Table 1).

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Table 1. Total valves observed, number of samples, water TP optima and tolerances (μgL^{-1}), and average % abundances (absences discounted) for each taxon. Samples are from experimental mesocosms, floating algal mats, and 0-2 cm (surface sediments) or 2-25 cm in sediment cores. The first number (normal type) designates unenriched; the second number (bold type) designates P-enriched.

Diatom taxon	Valves (samples)	Opt (tol)	Mesocosm	Mats	0-2 cm, >2 cm core	
Achnanthidium caledonicum	1251 (96)	31.3 (13.2)	1, **3** %	1, **7** %	3, **0** %	1, **2** %
Achnanthidium exiguum var. heterovalvum	229 (24)	65.2 (24.0)	0, **1**	0, **0.3**	0, **5**	0, **3**
Amphora sulcata	8107 (112)	22.0 (19.3)	25, **10**	8, **0.2**	15, **0**	28, **0.3**
Amphora veneta	609 (12)		0, **0**	0, **0**	0, **15**	0, **10**
Aulacoseira spore	481 (11)		0, **0**	0, **0**	0, **0**	0, **11**
Brachysira neoexilis morph. I	2341 (108)	32.4 (19.6)	9, **4**	3, **3**	2, **0**	1, **1**
Brachysira neoexilis morph. II	340 (57)	23.1 (25.9)	2, **1**	2, **0.2**	3, **0**	2, **0**
Caloneis bacillum	329 (34)	52.8 (14.7)	0, **2**	0, **0**	0, **2**	0, **2**
Cocconeis placentula var. lineata	427 (26)	41.0 (21.7)	0.3, **3**	0, **0**	0, **7**	0, **4**
Craticula cuspidata	79 (16)		0, **0**	0, **0**	0, **0**	2, **1**
Craticula molestiformis	110 (10)	73.7 (3.0)	0, **2**	0, **0**	0, **0**	0, **0.4**
Cyclotella meneghiniana	104 (24)		0, **0**	0.2, **0**	0, **1**	1, **1**
Diadesmis confervacea	370 (17)	57.9 (25.4)	0, **5**	0, **0**	0, **0**	0, **5**
Diploneis oblongella	134 (46)	26.8 (8.8)	1, **1**	1, **1**	1, **0**	1, **0.2**
Diploneis cf. ovalis	914 (112)	39.8 (18.8)	0.3, **1**	0.3, **1**	1, **1**	2, **7**
Encyonema evergladianum	5274 (113)	26.3 (15.5)	19, **7**	12, **4**	11, **0**	6, **4**
Encyonema neomesianum	816 (115)	26.3 (12.7)	1, **1**	4, **2**	3, **1**	3, **2**
Encyonopsis microcephala	583 (47)	32.8 (10.6)	0.3, **3**	0.4, **3**	0, **0**	0, **0**
Epithemia adnata var. proboscidea	732 (35)	43.2 (12.7)	0, **4**	0, **0**	0, **10**	0, **4**
Eunotia arcus	52 (9)		0, **0**	0, **0**	0, **0**	0, **1**
Eunotia camelus	181 (15)		0, **0**	0, **0**	0, **0**	1, **4**

Eunotia flexuosa	150 (40)	40.0 (15.4)	0, **1**	0, **0**	0, **0.4**	1, **1**
Eunotia formica	72 (17)		0, **0**	0, **0**	0, **0**	2, **2**
Eunotia glacialis	72 (13)		0, **0**	0, **0**	0, **0**	3, **1**
Fragilaria capucina var. gracilis	52 (23)	39.9 (29.8)	0.4, **1**	0, **0.3**	1, **0**	0.4, **0**
Fragilaria synegrotesca	5405 (118)	22.2 (17.6)	16, **4**	42, **11**	24, **0**	9, **2**
Fragilaria cf. tenera	719 (73)	14.2 (12.6)	4, **1**	5, **0**	2, **0**	1, **0**
Gomphonema affine	250 (35)	42.6 (16.1)	0, **1**	0, **4**	0, **1**	1, **1**
Gomphonema gracile	898 (68)	38.5 (16.2)	1, **4**	1, **1**	1, **3**	2, **1**
Gomphonema parvulum	732 (59)	51.6 (19.9)	0, **2**	0, **0.2**	0, **6**	1, **5**
Gomphonema tenellum	1032 (46)	54.6 (18.9)	1, **6**	0, **0**	0, **1**	0.2, **1**
Gomphonema cf. vibrioides	865 (94)	27.8 (15.6)	1, **2**	1, **4**	1, **0**	2, **0**
Hantzschia amphioxys	61 (19)		0, **0**	0, **0**	0, **0.3**	2, **1**
Kobayasiella subtilissima	257 (55)	35.1 (17.3)	1, **1**	1, **1**	1, **0**	1, **1**
Lemnicola hungarica	157 (12)		0, **0**	0, **0**	0, **3**	0, **3**
Luticola stigma	50 (10)		0, **0**	0, **0**	0, **0**	0.4, **1**
Mastogloia lanceolata	495 (87)	21.6 (14.1)	1, **1**	0.4,**0.1**	1, **0**	3, **0**
Mastogloia smithii morph. I	11363 (119)	27.2 (14.7)	15, **19**	17, **44**	28, **0**	27, **1**
Mastogloia smithii morph. II	314 (63)	32.9 (9.7)	0.3, **1**	0, **1**	0, **0**	1, **0**
Navicella pusilla	83 (14)	32.1 (4.9)	0, **1**	0, **1**	0, **0**	0, **0**
Navicula brasiliana	115 (16)		0, **0**	0, **0**	0, **2**	0, **2**
Navicula cryptocephala	282 (25)		0, **0**	0, **0**	0, **4**	0.2, **3**
Navicula cryptotenella	843 (75)	41.8 (16.8)	0.2, **3**	0.3, **3**	0, **0.4**	0.4, **1**
Navicula exigua var. capitata	26 (7)		0, **0**	0, **0**	0, **0.4**	0, **1**
Navicula oblonga	320 (4)		0, **0**	0, **0**	0, **2**	0, **14**
Navicula podzorskii	628 (93)	31.1 (16.3)	1, **1**	1, **1**	2, **1**	3, **0.4**
Navicula subrhynchocephala	51 (8)		0, **0**	0, **0**	0, **1**	0, **1**

Nitzschia amphibia f. frauenfeldii	6109 (89)	47.7 (16.0)	0.3, **15**	0, **1**	0, **29**	0.4, **15**
Nitzschia frustulum	44 (8)	77.2 (16.8)	0, **1**	0, **0**	0, **0**	0, **2**
Nitzschia gandersheimiensis	1304 (96)	24.9 (13.0)	4, **3**	2, **1**	1, **0**	1, **1**
Nitzschia nana	67 (11)	41.6 (9.7)	0, **1**	0, **0**	0, **0**	0, **1**
Nitzschia palea varieties	924 (99)	56.7 (22.4)	2, **2**	3, **2**	0.4, **1**	1, **2**
Nitzschia perminuta	213 (40)	58.3 (19.5)	0.3, **1**	0, **0**	0, **0**	0, **0**
Nitzschia radicula	915 (49)	47.7 (17.6)	0.2, **4**	0, **0**	0, **1**	0, **1**
Nitzschia scalaris	54 (19)	50.5 (22.0)	0, **1**	0, **0**	0, **0**	0.3,**0.2**
Nitzschia semirobusta	410 (74)	33.2 (12.3)	0.4, **1**	1, **4**	0.4, **0**	1, **2**
Nitzschia serpentiraphe	143 (47)	31.7 (7.0)	1, **1**	0.4, **1**	0.3, **0**	0.4, **1**
Nitzschia terrestris	24 (7)		0, **0**	0, **0**	0, **0**	0.2, **1**
Nupela silvahercynia	70 (14)	52.0 (23.9)	0, **1**	0, **0**	0, **0**	0.4, **0**
Pinnularia acrosphaeria	61 (19)		0, **0**	0, **0**	0, **1**	0.2, **1**
Pinnularia cf. divergens	250 (68)		0.3,**0.4**	0.3, **0**	1, **0.4**	1, **2**
Pinnularia maior	3 (3)		0, **0**	0, **0**	0, **0**	0.1,**0.1**
Pinnularia viridiformis	388 (28)		0, **0**	0, **0.1**	0.2,**0.2**	6, **4**
Rhopalodia gibba	410 (50)	53.6 (16.3)	0.4, **1**	0, **0.2**	0, **3**	0, **3**
Sellaphora laevissima	61 (10)		0, **0**	0, **0**	0, **2**	0.4, **2**
Sellaphora minima	1251 (35)	67.5 (11.5)	0, **7**	0, **0**	0, **10**	0, **6**
Sellaphora parapupula	183 (31)	43.2 (12.2)	0.4, **1**	0, **0**	0, **0.2**	1, **3**
Sellaphora seminulum	496 (48)	57.3 (19.0)	0.2, **1**	0, **0**	0, **5**	0, **5**
Stauroneis pseudosubobtusoides	66 (10)		0, **0**	0, **0**	0, **0.4**	1, **2**
Synedra acus	482 (26)	55.8 (24.2)	0, **4**	0, **0**	0, **0**	0, **0.4**
Synedra ulna	154 (43)	57.4 (22.4)	0, **1**	0, **1**	0, **0.3**	0, **1**

FIGURE CAPTIONS

Fig. 1. The Everglades in southern Florida. Water Conservation Area 2A (WCA-2A) is directly southeast of the Everglades Agricultural Area. Locations of sediment cores, floating algal mat samples, and experimental mesocosms in WCA-2A are specified.

Fig. 2. Achnanthidium caledonicum. **Fig. 3.** Achnanthidium exiguum var. heterovalvum. **A.** raphe valve, **B.** araphid valve. **Fig. 4.** Amphora sulcata. **A.** frustule in girdle view, **B.** valve. **Fig. 5.** Amphora veneta. **Fig. 6.** Aulacoseira spore. **Fig. 7.** Brachysira neoexilis morphotype I. **Fig. 8.** Brachysira neoexilis morphotype II. **Fig. 9.** Caloneis bacillum. **Fig. 10.** Cocconeis placentula var. lineata. **A.** raphe valve, **B.** araphid valve. **Fig. 11.** Craticula molestiformis. **Fig. 12.** Cyclotella meneghiniana. **Fig. 13.** Diadesmis confervacea. **Fig. 14.** Diploneis oblongella. **A.** valve, **B.** same valve, higher focus. **Fig. 15.** Diploneis cf. ovalis. **A.** valve, **B.** same valve, higher focus. **Figs 16a-c.** Encyonema evergladianum.

Figs 17a-b. Encyonema neomesianum. **Fig. 18.** Encyonopsis microcephala. **Fig. 19.** Epithemia adnata var. proboscidea. **Fig. 20.** Eunotia arcus. **Figs 21a-b.** Eunotia camelus. **Fig. 22.** Eunotia flexuosa. **Fig. 23.** Fragilaria capucina var. gracilis. **Fig. 24.** Fragilaria synegrotesca. **Fig. 25.** Fragilaria cf. tenera. **Fig. 26.** Gomphonema affine. **Fig. 27.** Gomphonema gracile. **Fig. 28.** Gomphonema parvulum. **Fig. 29.** Gomphonema tenellum. **Fig. 30.** Gomphonema cf. vibrioides. **Fig. 31.** Hantzschia amphioxys.

Fig. 32. Kobayasiella subtilissima. **Fig. 33.** Lemnicola hungarica. **A.** araphid valve, **B.** raphe valve. **Fig. 34.** Luticola stigma. **Fig. 35.** Mastogloia lanceolata. **A.** valve, **B.** partecta of valvocopula of same specimen. **Fig. 36.** Mastogloia smithii morphotype I. **A.** valve, **B.** partecta of valvocopula, **C.** frustule in girdle view, **D.** valve at upper end of size range, **E.** partecta of valvocopula of same specimen as D. **Fig. 37.** Mastogloia smithii morphotype II. **A.** valve, **B.** partecta of valvocopula of same specimen, **C.** frustule in girdle view. **Fig. 38.** Navicella pusilla. **Fig. 39.** Navicula brasiliana. **Fig. 40.** Navicula cryptocephala.

Fig. 41. Navicula cryptotenella. **Fig. 42.** Navicula exigua var. capitata. **Fig. 43.** Navicula podzorskii. **Fig. 44.** Navicula subrhynchocephala.

Fig. 45. Nitzschia amphibia f. frauenfeldii. **Fig. 46.** Nitzschia frustulum. **Fig. 47.** Nitzschia gandersheimiensis. **Fig. 48.** Nitzschia nana. **Fig. 49.** Nitzschia palea var. debilis. **Fig. 50.** Nitzschia perminuta. **Fig. 51.** Nitzschia radicula. **Fig. 52.** Nitzschia scalaris, small portion of valve. **Fig. 53.** Nitzschia semirobusta. **Fig. 54.** Nitzschia serpentiraphe. **A.** valve, **B.** frustule in girdle view. **Fig. 55.** Nitzschia terrestris. **Fig. 56.** Nupela silvahercynia. **A.** araphid valve, **B.** raphe valve. **Fig. 57.** Pinnularia acrosphaeria. **Figs 58a-b.** Pinnularia cf. divergens. **Fig. 59.** Sellaphora laevissima. **Fig. 60.** Sellaphora minima. **Fig. 61.** Sellaphora parapupula. **Fig. 62.** Sellaphora seminulum. **Fig. 63.** Stauroneis pseudosubobtusoides.

Fig. 64. Craticula cuspidata. **A.** valve, **B.** inner septum. **Fig. 65.** Eunotia formica, partial valve. **Fig. 66.** Eunotia glacialis. **Fig. 67.** Navicula oblonga, partial valve. **Fig. 68.** Pinnularia maior, partial valve. **Fig. 69.** Pinnularia viridiformis. **Fig. 70.** Rhopalodia gibba. **Fig. 71.** Synedra acus. **Fig. 72.** Synedra ulna, partial valve.

Fig. 73. Achnanthidium caledonicum. **Fig. 74.** Amphora sulcata. **A.** valve, **B.** partial frustule in girdle view. **Fig. 75.** Brachysira neoexilis morphotype I. **Fig. 76.** Diploneis oblongella (scale bar not available). **Fig. 77.** Diploneis cf. ovalis. **Fig. 78.** Fragilaria cf. tenera, central portion of valve. **Fig. 79.** Mastogloia smithii morphotype I. **Fig. 80.** Navicula podzorskii. **Fig. 81.** Nitzschia gandersheimiensis. **Fig. 82.** Pinnularia cf. divergens.

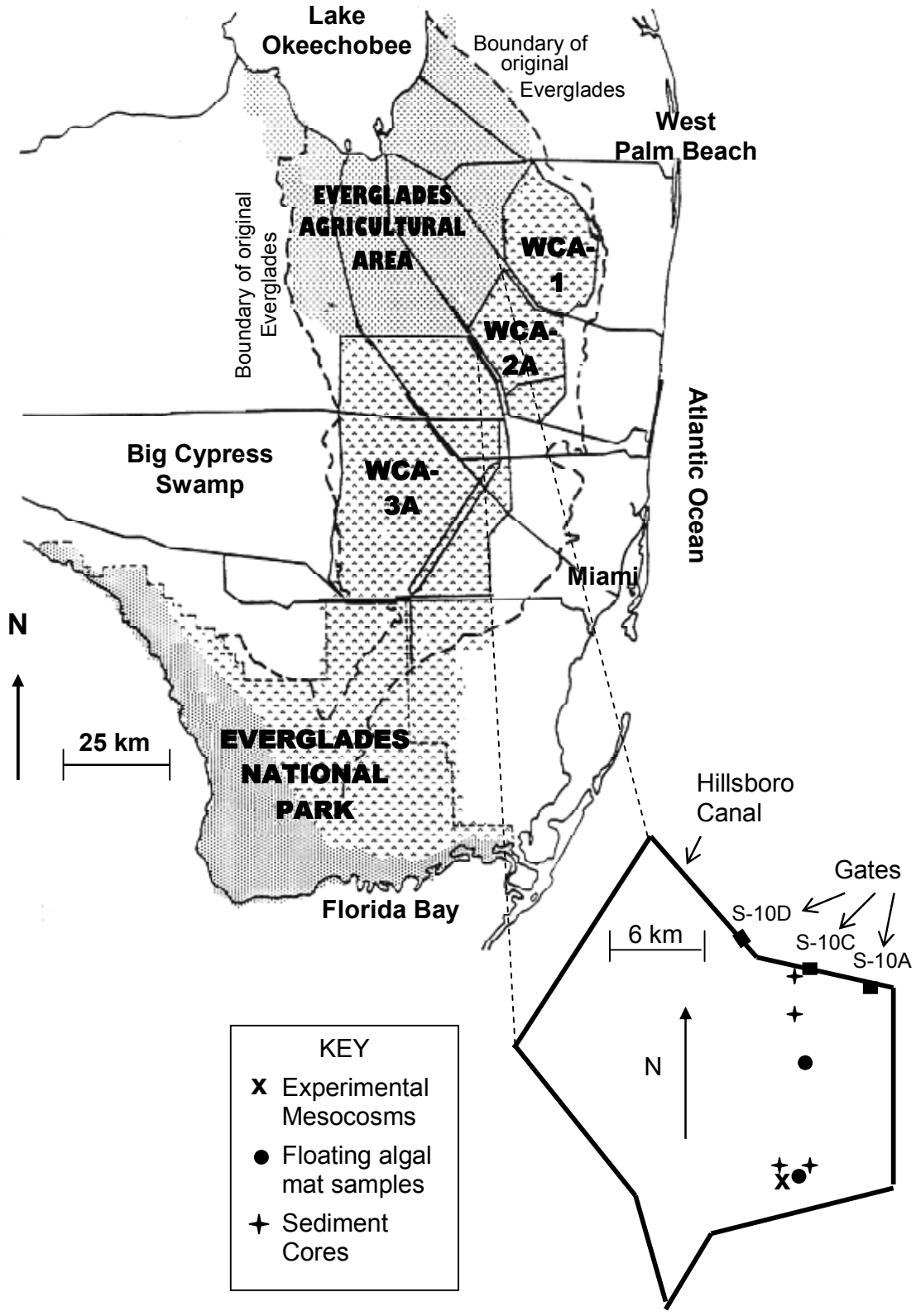
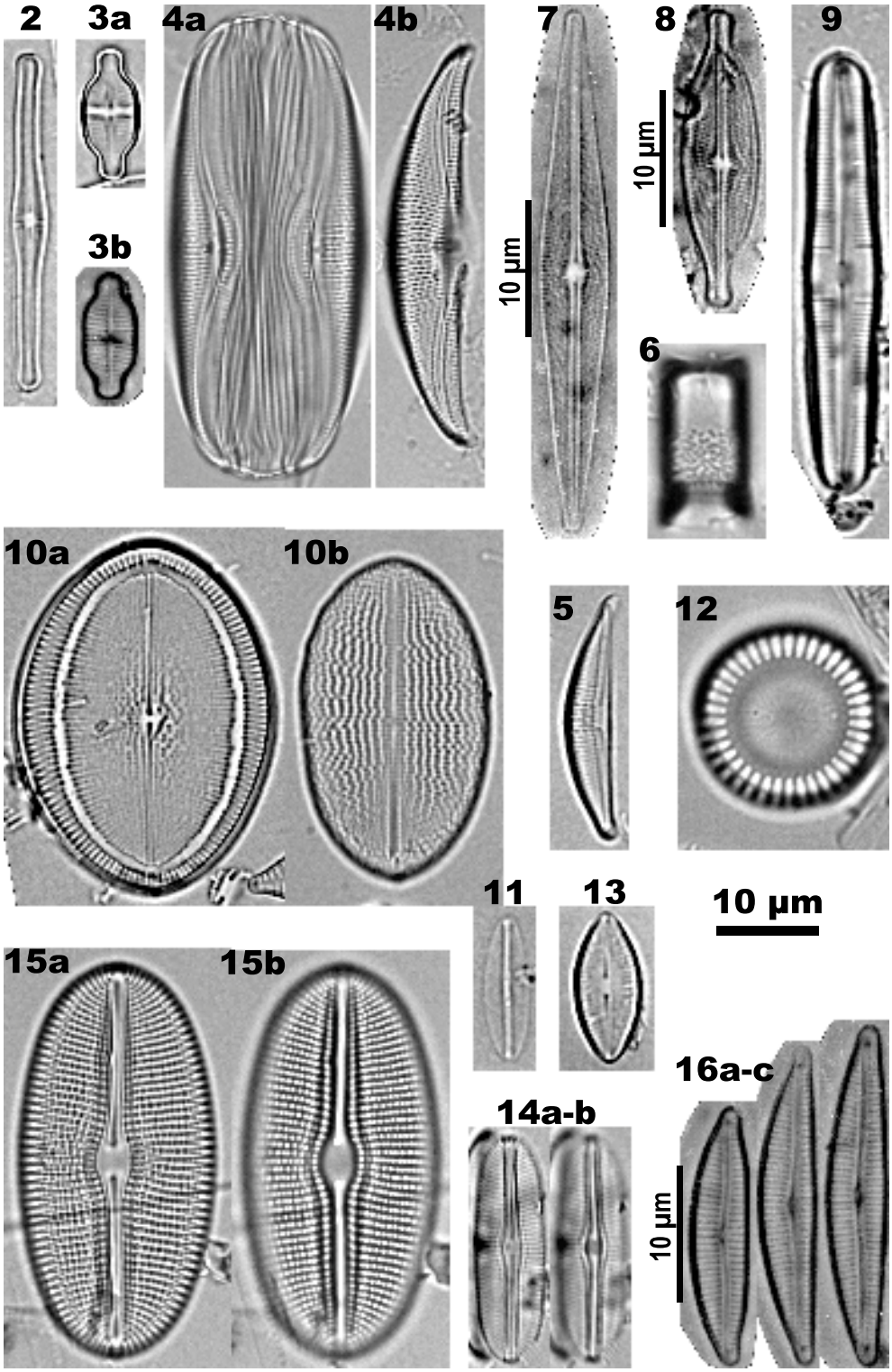


Fig. 1. The Everglades in southern Florida. Water Conservation Area 2A (WCA-2A) is directly southeast of the Everglades Agricultural Area. Locations of sediment cores, floating algal mat samples, and experimental mesocosms in WCA-2A are specified.


2
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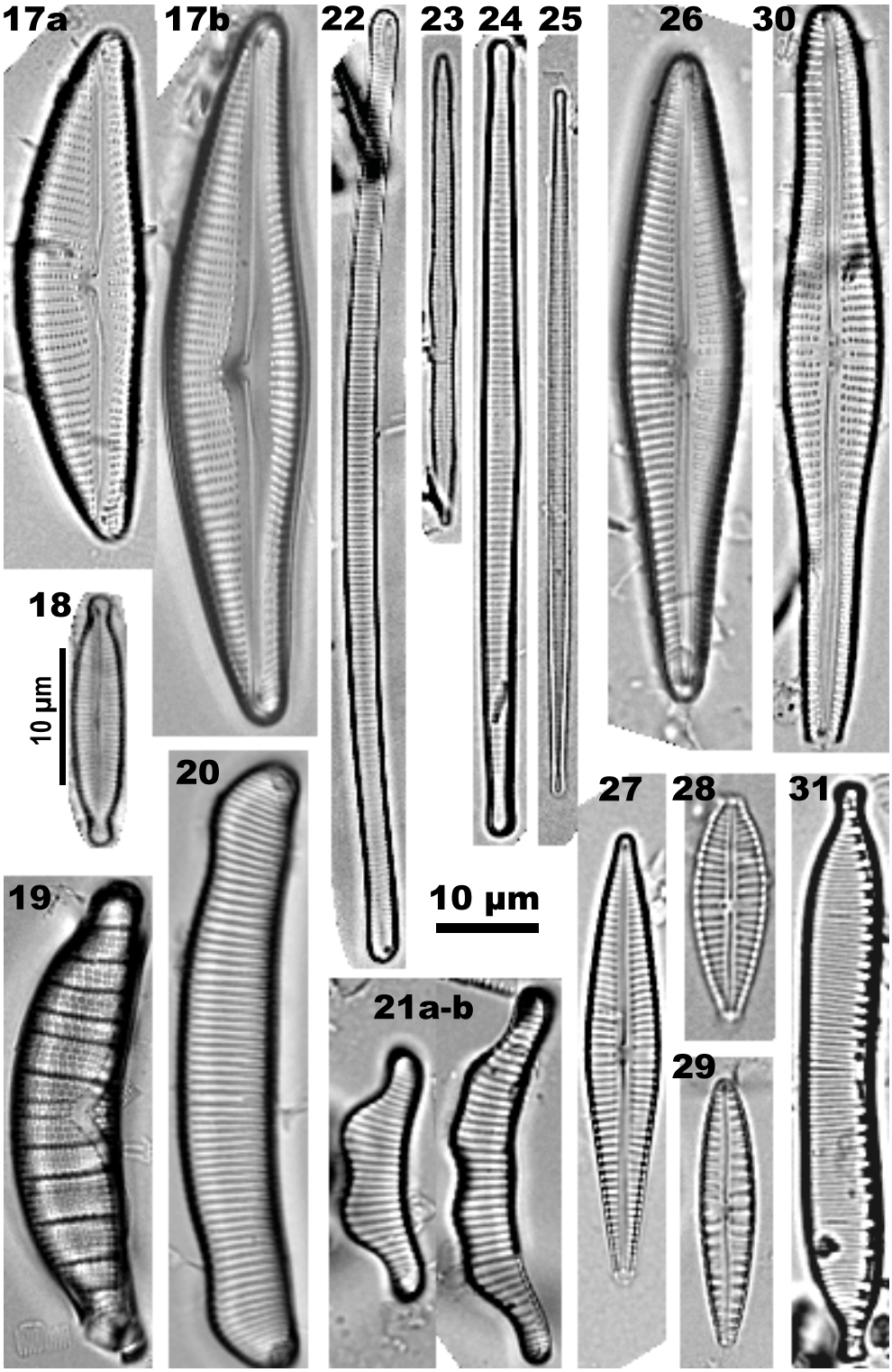
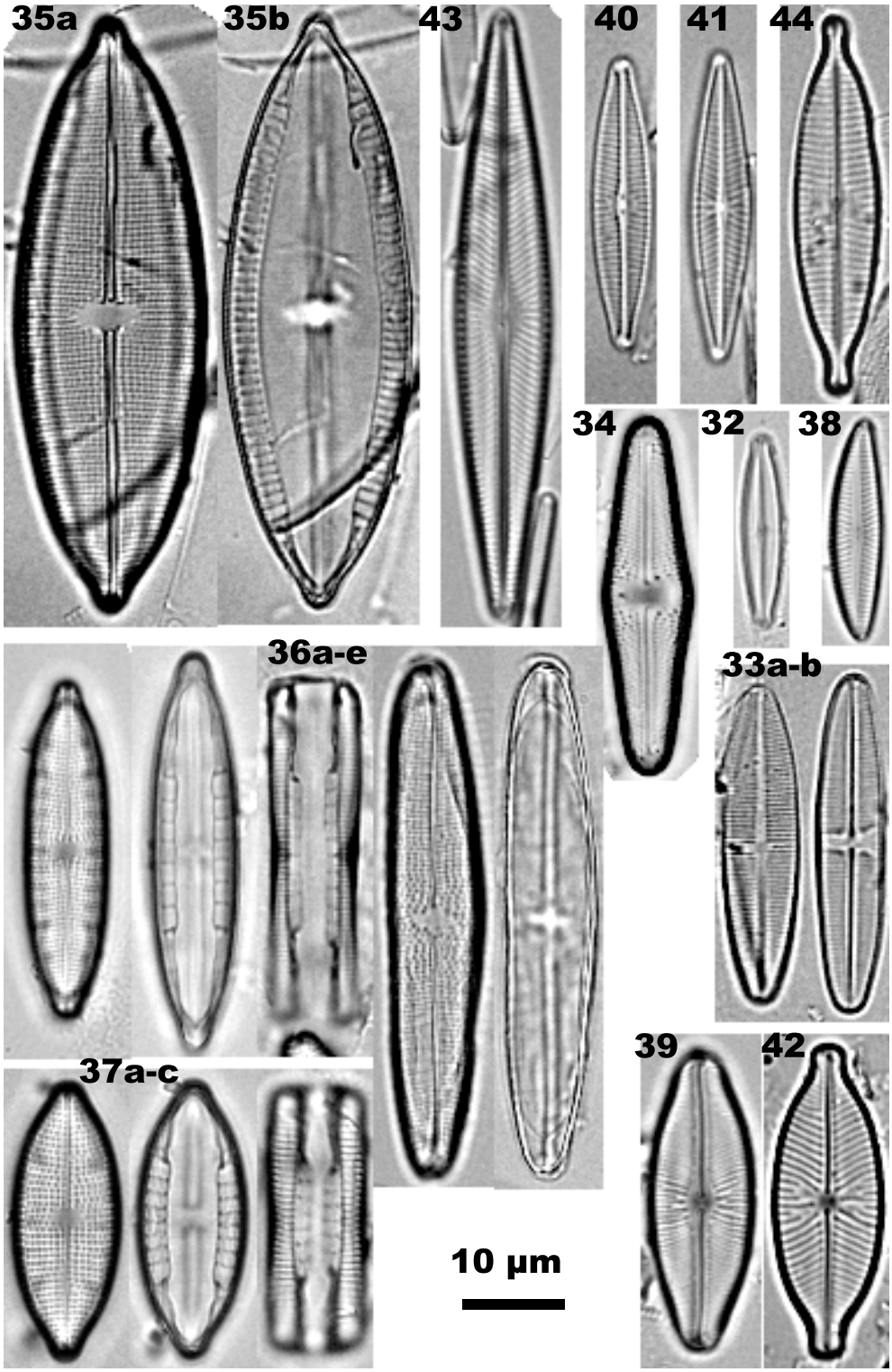
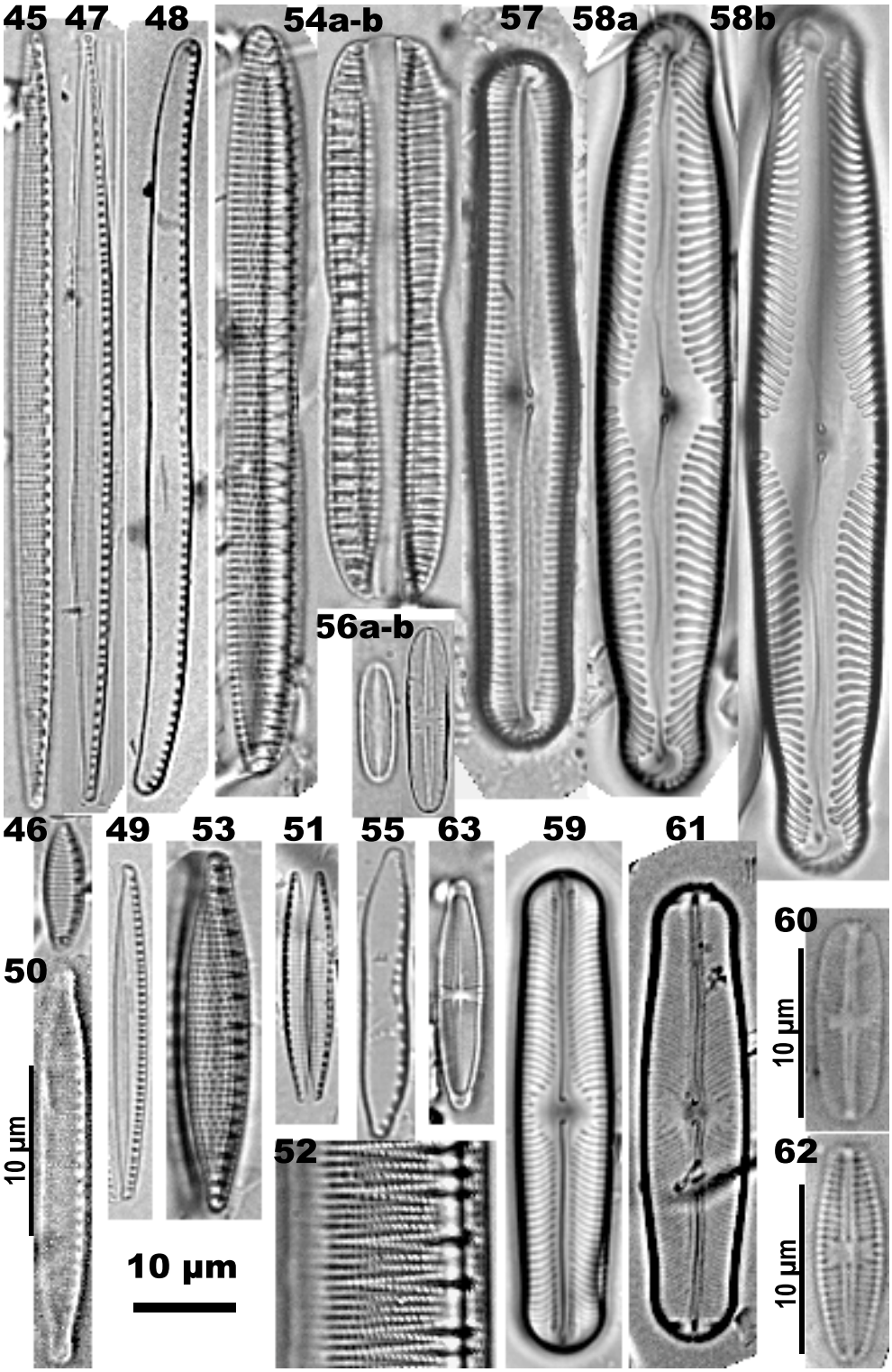
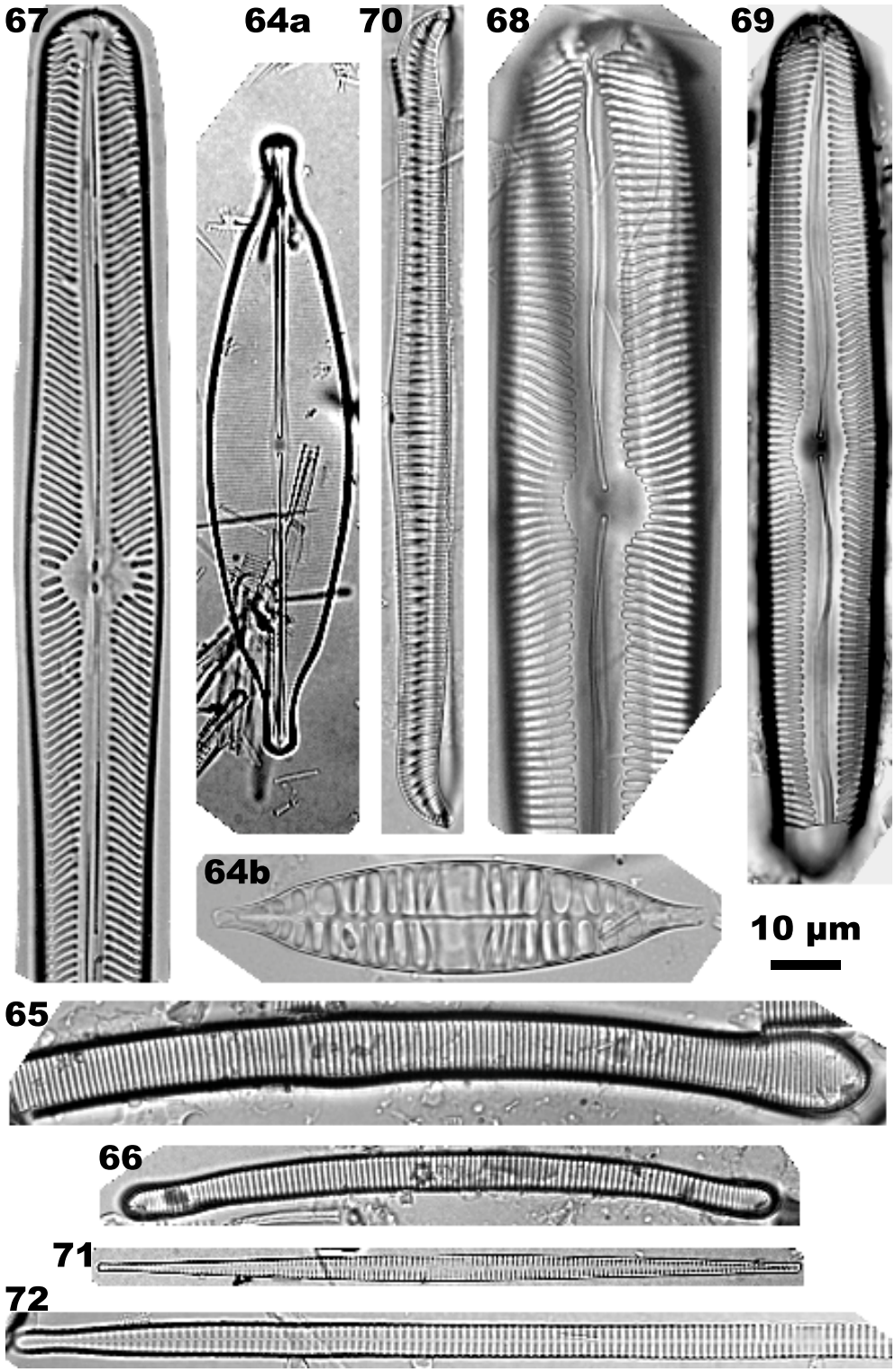
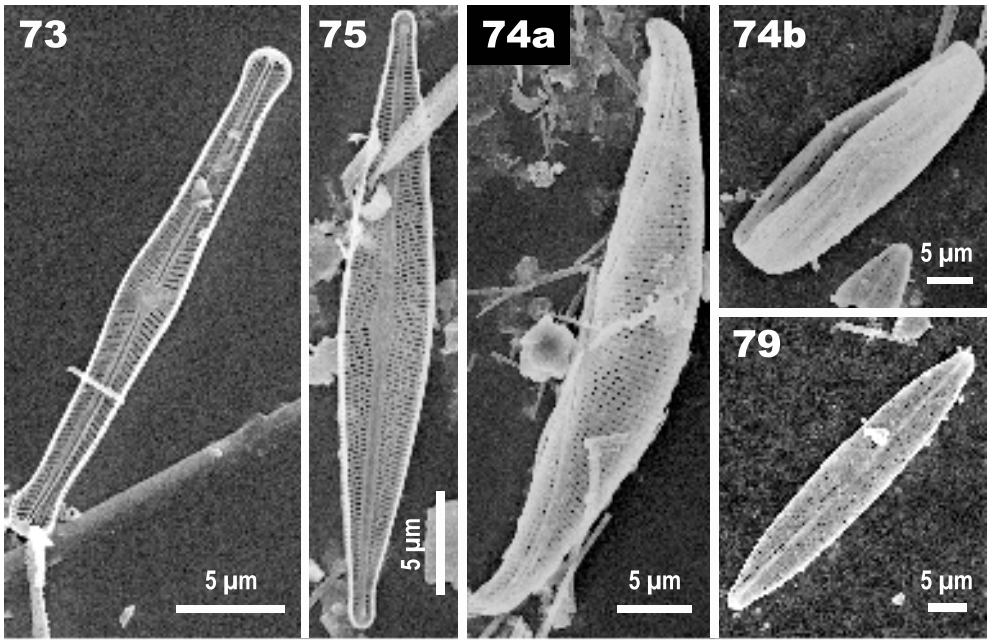
14a-b
16a-c
10 µm

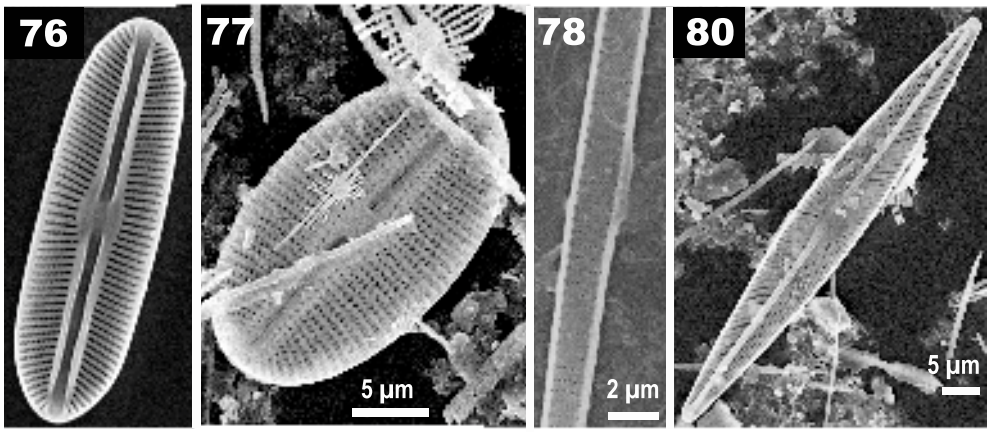

17a
17b
22
23
24
25
26
30
18
10 µm
20
27
28
31
19
10 µm
21a-b
29

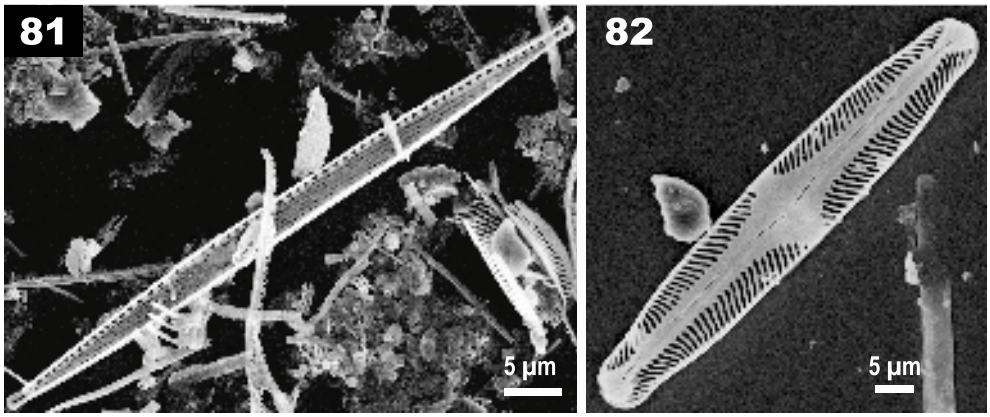

35a
35b
43
40
41
44
34
32
38
36a-e
33a-b
37a-c
39
42
10 µm


45
47
48
54a-b
57
58a
58b
56a-b
46
49
53
51
55
63
59
61
60
50
10 µm
52
10 µm
62
10 µm
10 µm


67
64a
70
68
69
64b
10 µm
65
66
71
72


73
5 µm
75
5 µm
74a
5 µm
74b
5 µm
79
5 µm


76
77
5 µm
78
2 µm
80
5 µm


81
5 µm
82
5 µm