DIATOM-BASED WATER QUALITY PERFORMANCE METRICS FOR BISCAYNE BAY

FINAL REPORT TO EVERGLADES NATIONAL PARK

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Evelyn Gaiser[1,2], Anna Wachnicka[1,3], Christine Taylor[1] & Raphael Travieso[1]

[1] Southeast Environmental Research Center, Florida International University, Miami, FL 33199,

[2] Department of Biological Sciences, Florida International University, Miami, FL 33199

[3] Department of Earth Sciences, Florida International University, Miami, FL 33199

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I. PROJECT PERSONNEL

Investigators:
Evelyn Gaiser (PI) – project oversight
Anna Wachnicka (Graduate Student) – sampling, diatom identification, data analysis, report preparation

Technical Support (FIU):
Christine Taylor
Rafael Travieso
Franco Tobias
David Jones
Filipe Zuniga
Carlos Tudela

Contract Manager (ENP):
Mike Zimmerman (Contract Manager)
Jacqueline Bell-Willock (Contracting Officer)

Administrative Contact (FIU):
Patricia Alvarez, Director
Division of Sponsored Research and Training
Florida International University, Miami, FL 33199
305-348-2494 (ph); 305-348-4117 (fax)

II. PROJECT SUMMARY

The sources, timing, delivery and quality of water flowing into Biscayne Bay have been greatly altered by diversion of freshwater from its natural course through freshwater wetlands lining the coastline. The distribution of offshore planktonic and benthic communities has changed considerably as a result. Current restoration goals will attempt to restore the natural flow and quality of freshwater delivered to Biscayne Bay. Biological performance metrics are a necessary tool to determine the success of actual or planned hydrologic alterations on ecosystem recovery. Diatoms are widespread, diverse and abundant in Biscayne Bay and are powerful indicators of environmental change in both freshwater and marine systems. They preserve in sediments for thousands of years, and because of their strong relationship to environmental parameters, can be used to make highly accurate predictions of the direction of environmental change over long time periods.

The purposes of this study were fourfold:

1. ***To produce models that allow prediction of environmental changes (in salinity, water quality and habitat structure) from diatom species composition***
2. ***To map the distribution of current water quality and diatom-predicted water quality parameters across Biscayne Bay***
3. ***To use diatom responses to water quality to predict the trajectory of environmental and ecological change under various management scenerios***
4. ***To determine the predictive ability of these models to infer trajectories of past environmental change from diatoms in the sediment record in order to determine baselines targets for environmental restoration***

A total of 618 diatom taxa were identified from Biscayne Bay, and the composition of their assemblages varied predictably throughout the Bay and between two sampling seasons. As much as 80% of variability in salinity across the Bay can be explained by diatom community composition, with an accuracy within 2.5 ppt. Models predicting water column and soil phosphorus concentration are almost as accurate (R^2=0.72, accuracy 0.09 µM; R^2=0.63, accuracy 61 µg/g). These predictions were spatially mapped across the Biscayne Bay region to show the strong concordance of actual and diatom-predicted water quality values. In addition to producing strong predictive models for water quality variables, diatoms showed a high degree of habitat specificity. Certain species were predictably associated with the water column, plant surfaces and the benthos during particular times of the year. These well-defined habitat associations can be added to paleoecological inference models to interpret past habitat structure, in addition to water quality, with a high-degree of accuracy.

The resultant strong diatom-based quantitative prediction models for salinity and phosphorus were applied to predict past environmental conditions from the sequence of diatom assemblages from a sediment core from Card Bank. The models performed well, owing to very high species richness, habitat specificity and a large degree of overlap between the assemblages in the sediments and modern calibration datasets. **We conclude that diatoms are among the most reliable proxies of environmental information in Biscayne Bay and should, therefore, be employed in future paleoecological and monitoring activities to increase the resolution and accuracy of target setting and change detection in this region.**

III. PROJECT OVERVIEW

The ecology of Biscayne Bay has been greatly affected in the last few decades by changes in water quality and quantity flowing into the bay from the adjacent ecosystems. Rapid population growth and related construction of landfills and canal drainage structures in the early 1900s substantially altered the surface- and ground-water hydrologic systems and resulted in alteration of the quantity and quality of water flowing into Biscayne Bay (Meeder & Boyer, 2001). Dredging of the deep water channels in the northern portion of the bay, construction of Haulover Cut and the enlargement of Government Cut that took place in the last few decades resulted in alteration of water circulation and increased salinity conditions especially in North part of the bay (Meeder & Boyer, 2001). In light of current efforts to restore the Everglades and the adjacent ecosystems (including Biscayne Bay) to pre-developmental conditions, it is important to have a good understanding of the natural state, thus paleoecological reconstructions have become increasingly important to management decisions. In order to make inferences of past environmental conditions a comprehensive understanding of the effects of the stress factors mentioned above on the environmental history of Biscayne Bay ecosystem is essential.

Diatoms have long been recognized as powerful and sensitive ecological indicators of changing environmental conditions due to their ubiquitous occurrence in high numbers, high species diversity and reliable preservation in paleosediments (Battarbee, 1986, Denys, 1984, Denys & De Wolf, 1999). They have well-defined optima and narrow tolerances for many environmental variables and respond quickly to any environmental changes which make them useful in quantifying environmental characteristics with a high degree of certainty (Dixit et al., 1992). The purpose of this study was to develop models relating diatom communities to water quality and habitat structure in Biscayne Bay. By collecting diatoms from a variety of habitat types and relating their assemblages to water quality (salinity, pH, water depth, nutrient availability) and substrate type (epiphytes, benthos, plankton) this study provides:

- ***Predictive models that allow quantification of environmental changes from diatom species composition***
- ***Maps of the distribution of diatom-predicted water quality parameters across Biscayne Bay***
- ***Predictions of trajectories of compositional change under various management scenerios***
- ***Determine the resourcefulness of diatom-based models in providing inferences of trajectories of past environmental change from the sedimented diatom record***

This study provides spatially-explicit maps that can be used to track responses to water quality changes in Biscayne Bay and temporally-explicit predictions of the direction of ecological change under different management scenarios.

IV. PROJECT METHODOLOGY

Study area

Biscayne Bay is a shallow estuary (2 to 6 m depth) located along the southeastern portion of Florida (Fig. 2). It is bordered to the east by a ridge formed by the Key Largo limestone, to the northwest by a ridge of the Oolite member of the Mimi limestone, and to the southwest by the low platform of the Everglades (Wanless, 1976). The adjacent coastline is a mangrove swamp bounded to the west by drainage canals. The bay originated approximately 6000 YBP as a result of sea level rise during the Holocene transgression (Meeder & Boyer, 2001). It can be divided into three major parts: North, Central and South (Cantillo et al., 2000). The Northern bay is a heavily urbanized area that experienced the biggest environmental changes in the last few decades (Meeder & Boyer, 2001). The Central bay is less disturbed with a fairly well vegetated bottom (Cantillo et al., 2000). The Southern bay is isolated from urban development, except the Turkey Point Power Plant facility, and has seen the greatest decline in freshwater inputs due to the construction of the L31E levee and US1 highway (Meeder & Boyer, 2001).

Sampling methods

Collection of modern samples from across Biscayne Bay was conducted in dry and wet seasons (April and October, 2005), since the largest changes in water quality occur between these parts of the year. As a result of this assumption the largest alterations in diatom communities are also expected to be observed seasonally. Samples were collected at 58 sites from across the bay. A total of 26 sites (sites B101 – B135) were located very close to existing Southeast Environmental Research Center (SERC) Water Quality Monitoring Network (WQMN) study sites and the remaining 32 sites followed the location of the sites previously studied by Meeder & Boyer (2001, Sites B1 - B32). Site locations follow distinct salinity and nutrient gradients and the water quality data are available for most of them at the WQMN web site (http://serc.fiu.edu/wqmnetwork/).

Three types of samples were collected from each site: sediments, plants and plankton. Additionally 120 ml of water was collected for nutrient analysis from sites which are not monitored by any ongoing research programs (collection followed procedures for nutrients analysis used at Nutrient Analysis Laboratory at SERC). Three ca. 1 cm thick sediment samples were collected using a calibrated syringe, 3 cm in diameter with tip cut off, and combined together in a plastic bag (1 cm of sediment corresponds to approximately 10 years of sedimentation). The syringe was pushed into the sediment and at the same time the sediment was sucked up inside. To sample the epiphytic community, at least 10 plant blades of the dominant plant species were cut off from the bottom and combined into one sample (following standard procedures of plants collection used in the Periphyton Laboratory, FIU). Plankton was collected on a 20 µm mesh by pumping water through the plastic pipe in which the mesh was placed (equipment designed in Stable Isotope Laboratory, FIU). The pumping continued until the mesh was clogged and the water started to rise up in the pipe. All samples were placed in a cooler filled with ice and transported to the FIU Periphyton Laboratory analysis. Water quality data, such as temperature, salinity, oxygen content, pH and turbidity, were collected during each sampling using multiparameter sonde YSI 6600 EDS. Additional data, such as Global

Positioning System (GPS) coordinates of the sampling sites, collection time, sediment type at the bottom, vegetation type, vegetation percent cover, dominant plant species and overall condition at the sites, were also recorded. Water depth was measured using a hand-held sonar device. Analysis of water and sediment TP, Total Nitrogen (TN), and Total Carbon (TC) have been analyzed in the Nutrient Analysis Laboratory at SERC.

Laboratory methods

Sediment samples were homogenized to break down large particles, epiphytes were removed from the plant blades using razor blade and plankton accumulated on the mesh was removed with dionized water (DI water). A 10ml volume of slurry obtained from each of the sample type was collected for diatom analysis. A 120ml volume was dried at 80ºC for at least 3 days in the oven, grounded and sent to Nutrient Analysis Laboratory at SERC for TP, TN and TC analysis.

The epiphytic and benthic material were placed in the 500ml beakers and oxidized following procedures recommended by Battarbee (1986). Carbonate, metal salts and oxides were removed by treatment with 10% Hydrochloric Acid (HCl). Approximately 30ml of acid was added to the beakers and left for 24hr. DI water was then added and samples were decanted every 8hr until the pH became neutral. Organic mater was removed by oxidation with 30% Hydrogen Peroxide (H_2O_2). Hydrogen Peroxide was added to the beakers, left for 24hr and then samples were washed at least five times with DI water every 8hr. Although Battarbee's (1986) procedure includes heating of the samples on the hot plate, this was avoided to prevent breakage and dissolution of the valves. Plankton material was not oxidized to avoid diatom valve dissolution or breakage since the planktonic diatoms have usually very delicate cell walls and can be easily destroyed. Approximately 1ml of slurry was placed on the No.1 coverslips, air dried and mounted onto glass slides using Naphrax®. At least 500 diatom valves were counted on each slide at the randomly chosen transacts. Identification and enumeration was made using Zeiss Axioscope at 1008x magnification (N.A. = 1.4). Diatom identification was based on local and standard literature (Appendix 1).

Statistical methods

Abundance data for each species were expressed as a proportion of the total (i.e., relative abundances) because different volumes of sediment and water samples were collected and the absolute numbers of individuals would not be comparable between samples (Clark & Warwick 2001). Only taxa with occurring in more than 5% of samples and having a mean relative abundance of over 0.5% were included in analysis, since the occurrence of the rare species could be due to chance. All data were moderately transformed (4th root transformed) to down-weight the importance of highly abundant species and to ensure that the rarer species will also contribute to the results of the analysis, relativized by the coefficient of variation (CV), and checked for outliers (Clark & Warwick 2001, McCune & Grace, 2002). Non-metric multidimensional scaling (NMDS) (Kruskal & Wish, 1978) with the Sørensen similarity index (Bray & Curtis, 1957) was used to explore the spatial and temporal patterns in modern diatom species composition. The NMDS was chosen above other ordination methods because it is a good method to use when data are not normally distributed (Clark & Warwick 2001, Quinn & Keough, 2002) and because it relieves the "zero-truncation problem" (Beals, 1984) which

plagues all other ordination methods (PCA, CCA, DCA) of heterogeneous data sets (McCune & Grace, 2002). Water quality data were ln-transformed before the analysis and revitalized by the maximum value to normalize the water quality variables that were measured in different units to the same scale (McCune & Grace 2002). The dimensionality of all NMDS solutions were assessed using the Monte Carlo test (McCune & Grace, 2002). The above mentioned analysis was used to help to identify the environmental variables that can be justifiably reconstructed on statistical grounds (Battarbee et al., 2001). The ordination diagrams were used to examine the species – environment relationships and allowed taxa characteristic of particular environmental conditions to be identified. The significances of the spatial and temporal differences between the assemblages which were visualized in the NMDS ordinations were tested by analysis of similarities (ANOSIM). Spearman rank correlation analysis and the Kruskal-Wallis test were used to test for independence among environmental variables, since the variation in other environmental factors can affect the accuracy of the inferred variables of interest (Gaiser et. al., 1998). The Mantel test was used to test the significance of the correlation between two similarity matrices (taxa and environmental matrices) of the same dimensions by evaluating results from repeated randomization (McCune & Grace, 2002). Indicator species analysis was used to identify diatom taxa which significantly influence site groupings (Dufrene & Legendre, 1997). This method identifies indicator species based on the concentration of species abundances in a particular group and on the faithfulness of occurrence in that group (Dufrene & Legendre, 1997). All taxa with indicator values above 40% of perfect indication (100 is perfect indicator) and $p<0.05$ were considered as good indicators. Indicator values were tested for statistical significance (p-value) using Monte Carlo randomization technique (McCune & Grace, 2002). All of the above mentioned analyses were performed using PC-ORD Version 4 (McCune & Mefford, 1999), Primer Version 5.2.9. (Clark & Warwick, 2002), and SPSS Version 13.0.
In order to determine the appropriate method (linear- or unimodal) for developing diatom-based prediction models, the length of the gradients, expressed in standard deviation units (SD), for the environmental variables of interest were determined using Detrended Canonical Correspondence Analysis (DCCA) (Birks, 1993). Because the length of the gradient was more than 2 standard deviation (SD) units, the unimodal-based techniques were expected to outperform the linear-based methods, and therefore they were chosen for models development. The Weighted Averaging (WA) procedure, which assumes such a unimodal response, was used to calculate the optimal conditions of the environmental variables mentioned above and the environmental ranges (tolerances) at which each taxon can live. The basic idea behind WA is that at a given value of the environmental variable, taxa that have optima nearest to that value will be the most abundant (Birks, 1993). To estimate each taxon optimum for each of the environmental variables the average of the values for sites in which the taxon occurs were calculated and weighted by the taxon's relative abundance (abundance-weighted mean). Each taxon's tolerance was estimated as the abundance-weighted standard deviation of the environmental variables of interest (Birks, 1993). Weighted Averaging Partial Least Squares procedure (WA PLS) with leave-one-out cross validation method was chosen to build statistical prediction models that was used to reconstruct past environmental conditions in Card Bank, Biscayne Bay. The major advantage in using this method for calibration over WA method is that it often produces calibration models with lower root mean square error of prediction (RMSEP) and low average and maximum bias as assessed by leave-one-out cross validation (Birks, 1998). The major reason for the superior performance of WA PLS over WA is because WA suffers from the "edge effect" that result in over-estimation of optima at the high end and under-estimation of the

optima at the lower end of the gradient resulting in bias in the residuals. WA PLS removes this "edge effect" by taking into account the residual correlations among biological data and improves the estimation of taxa optima (ter Braak et al. 1993). Species responses to each environmental variable have been plotted independently and visually examined for any trends. The predictive abilities of transfer function were assessed by examining the relationship between the observed and inferred values of salinity, water TP and sediment TP in the training set. Because calculation of the coefficient of determination (R^2) and the root mean square error (RMSE) on the basis of the training set data can be often overly-optimistic (the same data are used to generate and evaluate the model), the more reliable error estimate – the root mean square error of prediction (RMSEP) was calculated using leave-one-out cross validation to test the true ability of the transfer function (Birks et al., 1990, Dixon, 1993). The leave-one-out split-sampling technique involves randomly splitting the modern data into a training set and the test set and it uses the training set to predict the environmental variable of interest for all samples in the test set (Birks, 1995). The simplest models that contained the smallest useful PLS components, which were characterized by the minimal values of RMSEP and average and maximum bias, and the maximum value of jack-knife coefficient of determination ($R^2_{(jack\text{-}knife)}$), were considered the best prediction models. To be considered useful, a component had to give the reduction of RMSEP of at least 5% compared to the previous component (ter Braak & Juggins, 1993; Birks, 1998; Brooks & Birks, 1999). Test for bias were performed by plotting the residuals between the observed values of the environmental variables of interest against each of the other environmental factors measured, and visually inspected for any relationships (Gaiser et. al., 1998). The transfer function analyses were done in C2 Version 1.4.2. (Juggins, 2005). The reconstruction of salinity (ppt.), WTP and STP for samples collected from Card Bank (CBA) sediment core have been based on the assumption that the diatom taxa in the core samples are well represented in the training set. The strongest prediction models for these variables have been applied to core samples in order to obtain the estimated values for the above mentioned environmental variables.

Mapping

The observed and predicted values of distinct environmental variables, such as salinity, water depth and phosphorus, and the changes in distribution of several diatom indicator species have been mapped using spatial modeling and analysis in Arcview GIS 3.2a. The Inverse Distance Weighted (IDW) interpolator method has been used to interpolate between points. It weights the points closer to the processing cell greater than those farther away. A specified number of points, or optionally all points within a specified radius, can be used to determine the output value for each location (Arcview GIS 3.2a Tutorials). The output cell size was 0.002434 decimal degrees and the number of neighbors was 12 points.

V. PROJECT FINDINGS

Sampling sites across Biscayne Bay differed between each other in the environmental conditions, predominant vegetation type and the sediment type. Water quality parameters varied spatially and temporarily (Table 1). Sites located closest to the coast (Sites 1-32) experienced high salinity conditions in the dry season (over 35 ppt.) and low salinity conditions in the wet season (below 13 ppt.) (Fig. 12 a, b). Turbidity was also higher at most sites located near the coast in the wet season (up to 3.5 NTU) compared to the dry season (<1 NTU) (Fig. 13 a, b). Water temperature was much cooler in dry season across the entire bay (less than 25°C) than in wet season (more than 28°C) (Fig. 14 a, b). Vegetation cover did not changed much seasonally, but it varied spatially, with highest percent vegetation cover in the central part of the bay (80-100%) and lowest in southeast and northeast part of the bay (0-30%) (Fig. 15 a, b). Most of the water parameters were highly correlated with each other in the dry and wet season (Tables 2, 3). Also, most of the water parameters exhibited significant correlations with zones but not with habitats (Tables 2, 3).

Over 600 diatom species have been identified from 58 sites across Biscayne Bay during the wet and dry season sampling periods (Appendix 2), but after removing rare and infrequently occurring taxa the number of species included in analysis was reduced to 221 species representing 52 genera (Tables 8-10). The most common genera which include the highest number of species were: *Mastogloia* (53 taxa), *Amphora* (33 taxa), and *Nitzschia* (19 taxa). The dominant taxa were: *Hyalosynedra laevigata*, *Cocconeis placentula*, *Reimerotrix floridensis*, *Brachysira aponina* and *Fragilaria* cf. *waernii*. Most of the species (1/3 of the total) were rare (found in less than 5% of all samples) or had low relative abundances (less than 0.5%).

Analysis of similarity (ANOSIM) identified temporal and spatial differences in diatom species composition among sampling sites. The differences between zones, seasons and habitats were distinct but not statistically significant (R=0.29) (Fig. 2). The differences among seasons and habitats were stronger when the seasonal factor was removed, with significant differences between diatom communities occupying different habitats in the dry season (R=0.65) (Fig. 3a), and less strong in the wet season (R=0.36) (Fig. 4a). Clear separation was identified between diatom assemblages associated with different habitats in Zone 1 and Zone 2 in both seasons. The differences between diatom assemblages living in different habitats in dry season Zone 1 and Zone 2 were very strong (R=0.82 and R=0.78 respectively) (Fig. 3). The same differences in wet season were less strong but still significant especially in Zone 2 (R=0.43 for Zone 1 and R=0.68 for Zone 2) (Fig. 4b). All of the above differences were captured in two dimensional NMDS with low stress values (Figs 2 - 4) because the three dimensional solutions did not result in appreciable reduction of stress. Five vectors shown in NMDS space captured most of the variation in the diatom communities in Biscayne Bay with two variables (salinity and depth) explaining most of the variation. The length and the angles of the vectors correspond to the direction and strength of the relationship (Fig. 2).

Indicator species analysis (ISA) identified diatom species that are characteristic for different habitats in different seasons and zones (Tables 4 - 7, Plates 1 - 15). The highest number of indicator species was always associated with benthos and the lowest usually with epiphyton. Open bay sites (Zone 2) in dry season contain the highest number of benthic and epiphytic

indicator taxa comparing to any other zone or season (Table 4, Plates 5-8). Zone 2 had a higher number of indicator species (Tables 5, 7, Plates 6-8, 12-15) compared to Zone 1 (Tables 4, 6, Plates 1-4, 9-11). Indicator species display distinct differences in distribution and relative abundance between the sampling seasons (Fig. 5 a-d). Some of the indicator taxa were widespread across the bay in one of the seasons and with more restricted distributions in another season.

Patterns are also distinct in the responses of individual diatom species to changing salinity, water TP and sediment TP conditions (Tables 8-10). Salinity (ppt.) optima estimated by WA regression model for each taxon included in analysis ranged from 18.4 ppt. for *Amphora gigantea* var. *fusca* to 35.4 ppt. for *Neodelphineis* sp. 01BB. Taxa displayed wide rage of estimated tolerances between 0.7 ppt. for *Amphora complexa* and 7.9 ppt. for *Nitzschia microcephala* (Table 8). Water TP (µM) optima varied between 0.1203 µM for *Auricula complexa* and 0.5763 µM for *Pinnunavis yarrensis*. The tolerances ranged from 0.0009 µM for *Auricula complexa* to 0.2148 µM for *Mastogloia ovata* (Table 9). The lowest optimum for sediment TP (µg/g) was 38.93 µg/g for *Nitzschia sublineari* and the highest was 265.43 µg/g for *Achnanthes submarina.* The tolerances varied between 30.71 µg/g for *Mastogloia staurophora* and 157.83 µg/g for *Proschkinia bulnheimii.*

The strongest prediction models, developed based on the WA PLS regression, were for salinity (ppt.), water TP (µM) and sediment TP (µM). The salinity model predicts values of salinity from diatoms within very small prediction error estimated by jack-knife cross validation (RMSEP=2.5 ppt.) (Fig. 6 a). Although residuals do not show a linear trend (Fig. 6 b) and they show slight overestimation for the sites with low salinity values and underestimation for sites with high salinity values, the model is still strong (R^2=0.80) and can be successfully used for reconstruction of the past salinity conditions in the bay (Fig. 16). Water TP prediction model was less strong comparing to salinity model (R^2=0.72) and it also exhibited some overestimation for sites with low TP and underestimation for sites with higher TP values, but it still can predict values within ±0.09 (µM) water TP units (Fig. 7 a, b). Sediment TP (µg/g) prediction model can predict past TP condition with prediction error equal 61.49 (µg/g) and just like the water TP model it is less strong than salinity model (R^2=0.63) (Fig. 8 a). The residuals are also show no linear trend with some overestimated values for sites with low TP values and some underestimated values for sites with high TP values (Fig. 8 b). All of the diatom - based prediction values for salinity, water TP and sediment TP were mapped spatially against the observed values, and the over- and underestimated values for the water quality parameters can be easily observed (Figs 9 – 11).

VI. PROJECT IMPLICATIONS

The diatom flora found in near shore sites in Biscayne Bay contain taxa which have been previously reported in adjacent mangrove area and the Everglades mashes, whereas taxa reported from the sites in central and east part of the bay conform to the diatom communities of the Florida Keys (Montgomery, 1978), upper Florida Bay (DeFelice & Lynts, 1978), and Bahamas (Hein et al. in review). The epiphytic diatom species found on different seagrass types were also similar to the ones previously reported in Biscayne Bay by Reyes-Vasquez (1970) and epiphytic species found by Frankovich et al. (in press) on *Thalassia testudinum* in Florida Bay.

Seasonal changes in the diatom flora occupying nearshore areas of the bay are most likely due to the changes in hydrological conditions related to the fluctuating water quality and quantity of water flowing to the bay from the natural creeks, canals and ground water. The more distinct differences between diatom species communities living in different habitats in dry season comparing to the wet season is most probably related to smaller horizontal and vertical mixing of the water column and related to that lower turbidity. Also, the abundance and spatial distribution of the indicator taxa seem to be driven by the same factors. Like in many other studies on diatom community composition (Sunbäck & Snoeijs, 1991, Snoeijs, 1999), salinity appears to be the most important water parameter that determines the community structure of diatoms along the gradient in Biscayne Bay. Differences in macro-nutrient availability are also reflected in species composition. Although vegetation type varied across the bay, there was no detectable effect of vegetation type on diatom species composition. Taxa with high salinity, WTP and STP optima were not necessary absent from parts of the bay having lower values for these hydrological parameters. This situation was most likely a result of horizontal water movement rather than wide tolerance for these parameters. Some diatom species identified by ISA as indicative for one of the designated habitats in dry season were designated as indicative for another habitat in the wet season. These sometimes confusing results were probably related to vertical water mixing associated with atmospheric condition in this part of the year and settling of the epiphytic and planktonic species at the bottom after death. The dominance of taxa indicative for benthic habitats over species assigned to plankton and epiphyton is probably a result of more stable hydrological conditions at the bottom compared to the water column.

In addition to finding the special and seasonal differences in species composition and abundance as a function of changing hydrological condition in the bay, the diatoms were found out to be a reliable tool for estimation and prediction of salinity, WTP and STP condition in the bay in the past and the present. The diatom-based WA PLS prediction models were able to predict to high degree of certainty most of the variation in the above mentioned water parameters. Although the models produced some under-and overestimated values at the higher and lower ends of the gradients, the models are very important and useful tools in reconstruction of past environments of Biscayne Bay. All the problems are most probably related to the complex hydrological conditions acting on diatom communities in the bay, and were reported in earlier studies as well.

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VIII. TABLES

Table 1. Summary of environmental characteristics for sites sampled for diatoms in Biscayne Bay during spring and summer 2005.

Environmental variables	No. of sites	Min.	Max.	Mean	St. Dev.
Salinity (ppt.)	331	12.45	40.17	31.98	7.24
pH	331	6.73	8.23	7.82	0.31
Temperature (°C)	331	22.10	36.00	26.95	3.23
Turbidity (NTU)	331	0.00	3.15	0.38	0.58
Depth (m.)	331	0.09	4.27	1.46	1.14
Vegetation cover (%)	331	1.00	100.00	77.92	25.58
Wet season WTN (µM)	58	3.69	45.37	21.14	9.74
Wet season WTP (µM)	58	0.11	0.78	0.38	0.18
Wet season WTOC (µM)	58	145.23	1064.17	386.19	170.36
Dry season STN (µg/g)	58	985.83	45465.53	5219.11	6018.89
Dry season STP (µg/g)	58	1.00	426.44	126.92	100.88
Dry season STC (µg/g)	58	47027.54	974262.16	120679.03	117201.85

Table 2. Spearman rank correlation coefficients (quantitative variables) matrix and Kruskall-Wallis values (categorical variables) among environmental variables measured in the dry season. * indicates significant correlation at α<0.05.

Quantitative Variables	**Salinity**	**pH**	**Temp.**	**Turbidity**	**Depth**	**Veg. cov.**	**STN**	**STP**	**STC**	
Salinity	1									
pH	-.455*	1								
Temp.	0.024	-.279*	1							
Turbidity	-0.036	0.053	-.151*	1						
Depth	.284*	0.056	.181*	.168*	1					
Veg. cov.	-0.008	.269*	-.383*	0.051	-0.105	1				
STN	-.472*	0.096	-0.061	-.214*	-.621*	.241*	1			
STP	-.545*	.194*	-.181*	-0.086	-.648*	0.031	.782*	1		
STC	-.231*	0.032	.157*	0.055	-.193*	0.105	.635*	.506*	1	
Categorical Variables										
Zone	41.44*	5.47*	18.45*	7.77*	123.83*	8.60*	77.59*	100.16*	8.21*	Chi-Square
	0.00	0.02	0.00	0.01	0.00	0.00	0.00	0.00	0.00	Asymp. Sig.
Habitat	0.14	0.19	0.09	0.04	0.20	0.54	0.31	0.10	0.01	Chi-Square
	0.93	0.91	0.96	0.98	0.90	0.77	0.86	0.95	1.00	Asymp. Sig.

Table 3. Spearman rank correlation coefficients (quantitative variables) matrix and Kruskall-Wallis values (categorical variables) among environmental variables measured in wet season. * indicates significant correlation at α<0.05.

Quantitative Variables	**Salinity**	**pH**	**Temp.**	**Turbidity**	**Depth**	**Veg. cov.**	**WTN**	**WTP**	**WTOC**	
Salinity	1									
pH	.736*	1								
Temp.	-.210*	-.260*	1							
Turbidity	-.319*	-.295*	0.106	1						
Depth	.618*	.628*	-.368*	-0.143	1					
Veg. cov.	0.094	-0.103	.159*	-.320*	-.167*	1				
WTN	-.560*	-.322*	-0.093	.169*	-.230*	.224*	1			
WTP	-.777*	-.641*	.186*	.298*	-.752*	0.077	.412*	1		
WTOC	-.732*	-.583*	-0.016	.164*	-.667*	0.025	.451*	.843*	1	
Categorical Variables										
Zone	71.88*	61.71*	6.24*	3.79	118.03*	9.04*	16.84*	119.00*	90.91*	Chi-Square
	0.00	0.00	0.01	0.05	0.00	0.00	0.00	0.00	0.00	Asymp. Sig.
Habitat	2.53	2.83	0.02	1.78	1.29	0.16	0.48	1.65	1.57	Chi-Square
	0.28	0.24	0.99	0.41	0.53	0.92	0.79	0.44	0.46	Asymp. Sig.

Table 4. Dry season Zone 1 (nearshore) indicator species of planktonic, epiphytic and benthic environments in Biscayne Bay, identified by Indicator Species Analysis.

Taxon name	Indicator value (IV)	p-value
Plankton		
Reimerotrix floridensis	84.2	0.001
Microtabella sp. 01BB	74.2	0.001
Thalassiophysa hyalina var. *insecta*	71.7	0.001
Entomoneis cf. *pseudoduplex*	70.8	0.001
Licmophora pfannkucheae	67.3	0.001
Entomoneis peludosa	63.8	0.001
Pleurosigma cf. *elongata*	51.0	0.001
Microtabella interrupta	49.2	0.003
Nitzschia microcephala	45.3	0.001
Nitzschia longissima var. *parva*	43.7	0.001
Cocconeis sp. 01FB	42.0	0.001
Amphora coffeaeformis	41.9	0.002
Hyalosynedra laevigata	41.1	0.008
Epiphyton		
Cocconeis placentula	70.5	0.001
Nitzschia libentruthii	67.1	0.001
Amphora sp. 05FB	66.9	0.001
Amphora sp. 05BB	60.1	0.001
Hyalosynedra laevigata var. *angusta*	57.4	0.001
Cocconeis woodii	55.2	0.001
Mastogloia pusilla	52.5	0.001
Nitzshia dissipata var. *media*	46.9	0.001
Navicula durrenbergiana	44.1	0.001
Amphora tenerrima	41.0	0.013
Benthos		
Rhopalodia gibberula	67.3	0.001
Cyclotella distinguenda	65.6	0.001
Oestrupia powellii	65.5	0.001
Mastogloia pisciculus	61.1	0.001
Grammatophora oceanica	56.9	0.001
Caloneis excentrica	54.9	0.001
Mastogloia ovalis	50.7	0.001
Mastogloia erythraea	49.6	0.001
Amphora floridae	47.4	0.001
Mastogloia crucicula	47.0	0.002
Amphora cf. *proteus*	43.9	0.001
Frustulia sp. 01L	43.8	0.001
Rhopalodia pacifica	42.9	0.001
Seminavis robusta	41.8	0.001
Rhabdonema adriaticum	41.4	0.001
Seminavis latior	40.5	0.001

Table 5. Dry season Zone 2 (offshore) indicator species of planktonic, epiphytic and benthic environments in Biscayne Bay, identified by Indicator Species Analysis.

Taxon name	Indicator value (IV)	p-value
Plankton		
Microtabella sp. *01BB*	74.7	0.001
Nitzschia closterium	74.4	0.001
Reimerotrix floridensis	72.4	0.001
Microtabella interrupta	71.3	0.001
Amphora cf *laevis*	52.3	0.001
Licmophora cf. *debilis*	51.4	0.001
Thalassiophysa hyalina var. *insecta*	51.0	0.001
Licmophora pfannkucheae	49.1	0.001
Striatella unipunctata	45.4	0.001
Haslea ostrearia	40.8	0.001
Nitzschia longissima var. *parva*	40.0	0.001
Epiphyton		
Cocconeis placentula	70.6	0.001
Seminavis delicatula	67.2	0.001
Synedra fulgens	56.4	0.001
Amphora sp. 05BB	54.9	0.001
Nitzshia dissipata var. *media*	53.8	0.001
Brachysira aponina	53.7	0.001
Neosynedra tortosa	53.5	0.001
Mastogloia barbadensis	50.1	0.001
Mastogloia crucicula	49.4	0.001
Licmophora cf. *proboscidea*	49.0	0.001
Licmophora remulus	46.9	0.011
Mastogloia ovalis	45.5	0.002
Nitzschia angularis	41.9	0.028
Mastogloia cyclops	41.6	0.004
Benthos		
Dimeregramma dubium	86.3	0.001
Amphora caribaea	67.8	0.001
Amphora corpulenta var. *capitata*	66.7	0.001
Diploneis suborbicularis	65.1	0.001
Grammatophora oceanica	61.0	0.001
Mastogloia rostellata	57.9	0.001
Rhopalodia pacifica	56.3	0.001
Cymatosira lorenziana	52.0	0.001
Grammatophora cf. *angulosa*	51.3	0.001
Oestrupia powellii	50.0	0.001
Mastogloia ovata	48.6	0.001
Mastogloia delicatula	48.4	0.001
Frustulia sp. 01L	48.2	0.001

Mastogloia lacrimata	46.9	0.001
Nitzschia marginulata var. *didyma*	46.3	0.001
Diploneis smithii	44.9	0.001
Mastogloia bahamensis	44.5	0.001
Synedra bacillaris	43.9	0.010
Mastogloia corsicana	43.5	0.007
Mastogloia punctifera	43.4	0.001
Mastogloia varians	42.1	0.001
Cocconeis sp. 01FB	41.5	0.008
Diploneis crabro	40.1	0.002

Table 6. Wet season Zone 1 (nearshore) indicator species of planktonic, epiphytic and benthic environments in Biscayne Bay, identified by Indicator Species Analysis.

Taxon name	Indicator value (IV)	p-value
Plankton		
Synedra sp. 03BB	67.7	0.001
Cyclotella choctawhatcheana	55.1	0.001
Licmophora normaniana	46.8	0.005
Thalassiophysa hyalina var. *insecta*	41.9	0.001
Epiphyton		
Brachysira aponina	71.3	0.001
Cocconeis placentula	58.0	0.001
Mastogloia cyclops	53.1	0.001
Navicula durrenbergiana	51.5	0.001
Amphora tenerrima	44.1	0.009
Benthos		
Cyclotella distinguenda	59.5	0.001
Grammatophora oceanica	59.1	0.001
Amphicocconeis disculoides	56.9	0.001
Mastogloia cf. *strigilis*	56.9	0.001
Rhopalodia pacifica	55.8	0.001
Caloneis excentrica	48.2	0.001
Diploneis didyma	48.2	0.001
Hyalosynedra laevigata	47.0	0.001
Mastogloia crucicula	47.0	0.004
Fragilaria geocollegarum	46.9	0.001
Mastogloia bahamensis	40.9	0.001
Diploneis crabro	40.3	0.001

Table 7. Wet season Zone 2 (offshore) indicator species of planktonic, epiphytic and benthic environments in Biscayne Bay, identified by Indicator Species Analysis.

Taxon name	Indicator value (IV)	p-value
Plankton		
Chaetoceros sp. 02BB	79.2	0.001
Microtabella sp. 01BB	76.1	0.001
Nitzschia closterium	74.4	0.001
Reimerothrix floridensis	68.9	0.001
Amphora abludens	67.4	0.001
Microtabella interrupta	65.9	0.001
Entomoneis pseudoduplex	61.0	0.001
Cyclotella choctawhatcheana	59.5	0.001
Haslea cf. *ostrearia*	51.7	0.001
Synedra sp. 03BB	45.8	0.001
Navicula durrenbergiana	44.6	0.003
Nitzschia sigma	42.0	0.003
Gyrosigma sp. 01BB	41.8	0.002
Amphora cf. *leavis*	41.1	0.001
Epiphyton		
Cocconeis placentula	71.5	0.001
Mastogloia crucicula	52.8	0.001
Synedra bacillaris	51.7	0.002
Mastogloia pseudolatecostata	46.7	0.001
Amphora tenerrima	45.9	0.005
Seminavis delicatula	45.7	0.001
Mastogloia corsicana	44.9	0.002
Mastogloia ovalis	42.0	0.008
Mastogloia punctifera	41.3	0.002
Mastogloia barbadensis	40.4	0.002
Benthos		
Dimeregramma dubium	71.4	0.001
Rhopalodia pacifica	65.8	0.001
Nitzschia grossestriata	63.8	0.001
Fragilaria geocollegarum	53.4	0.001
Cymatosira lorenziana	52.3	0.001
Mastogloia bahamensis	51.8	0.001
Amphora gramenosum	50.8	0.001
Mastogloia cf. *strigilis*	50.2	0.001
Seminavis robusta	49.1	0.001
Amphora hamata	48.9	0.001
Amphora graeffeana var. F02	48.4	0.001
Navicula directa	45.4	0.003
Nitzschia marginulata var. *didyma*	42.6	0.001
Amphora corpulenta var. *capitata*	42.2	0.001
Amphora indentata	42.2	0.001
Mastogloia emarginata	41.4	0.001

Diploneis vacilans	41.3	0.013
Diploneis chersonensis	40.4	0.001
Amphora caribaea	40.1	0.001
Mastogloia lacrimata	40.0	0.005

Table 8. Number of occurrences (No. Occ.), relative abundances (Max. Abund.), estimated WA salinity optima and tolerances (WA Sal. Opt. & WA Sal. Tol.) and Hill's N2 measure of abundance of 221 of the most common Biscayne Bay diatom species. Taxa order based on estimated WA salinity optima.

Taxon name	No. Occ.	Max. Abund.	WA Sal. Opt.	WA Sal. Tol.	Hill's N2
Amphora gigantea var. *fusca*	8	0.0267	18.4	4.3	7.0
Cyclotella meneghiniana	16	0.0904	18.6	4.5	10.8
Nitzschia capitata	6	0.0681	19.3	6.7	4.5
Achnanthes sp. 06L31E	27	0.1308	19.5	5.1	16.6
Seminavis eulensteinii	27	0.1057	19.5	4.8	17.8
Cyclotella distinguenda	73	0.4104	20.2	4.9	37.9
Fragilaria tenera	38	0.3641	20.3	4.2	16.7
Rhopalodia gibberula	22	0.0677	20.7	4.9	16.8
Pinnunavis yarrensis	13	0.1149	20.8	3.9	6.2
Navicula palestinae	26	0.0817	20.8	4.5	17.5
Achnanthes submarina	13	0.0597	21.2	7.1	9.1
Mastogloia elegans	46	0.1316	21.7	4.6	27.4
Fragilaria cf. *waernii*	102	0.5774	21.7	4.5	48.6
Nitzschia sublinearis	19	0.2015	21.8	7.1	7.8
Coscinodiscus oculus iridis	17	0.0440	22.0	7.8	14.5
Caloneis excentrica	45	0.0952	22.2	5.9	29.1
Mastogloia halophila	62	0.1489	22.3	4.9	39.2
Oestrupia powellii	22	0.0566	22.5	6.4	15.1
Licmophora normaniana	62	0.4349	22.6	4.4	22.2
Navicula pseudocrassirostis	63	0.0951	22.9	5.0	41.2
Caloneis sp. 02BB	8	0.0674	23.0	5.3	4.8
Synedra sp. 01FB	21	0.0745	23.1	4.8	15.8
Thalassiophysa hyalina var. *insecta*	17	0.0883	23.3	4.7	12.8
Rhopalodia acuminata	3	0.0157	23.5	4.8	2.9
Amphora lineolata	20	0.2660	23.6	7.1	6.3
Seminavis witkowskii	8	0.0267	24.1	4.1	7.3
Climaconeis colemaniae	49	0.1500	24.2	4.7	28.4
Amphora aponina	103	0.2174	24.3	5.8	67.4
Cyclotella choctawhatcheana	130	0.5133	24.5	6.4	62.1
Mastogloia nabulosa	31	0.0590	24.6	5.8	23.7
Seminavis robusta	63	0.0525	24.7	6.0	50.0
Diploneis didyma	29	0.0444	24.7	5.6	23.6
Amphora arenaria	20	0.0263	24.8	5.6	17.8
Frustulia sp. 01L	15	0.0361	24.8	6.7	13.4
Parlibellus panduriformis	33	0.0359	24.8	5.7	28.1
Nitzschia frustulum	16	0.0652	24.8	5.2	11.3
Amphicocconeis disculoides	44	0.1867	24.8	6.9	24.3
Mastogloia pusilla	94	0.0982	25.1	5.6	68.4
Amphora cymbifera var. *heritierarum*	33	0.0748	25.1	5.8	24.0
Amphora tenerrima	140	0.4161	25.2	5.1	88.8

Brachysira aponina	137	0.7389	25.3	4.3	53.1
Amphora cf. *proteus*	19	0.0526	25.4	5.6	14.9
Grammatophora oceanica	78	0.3551	25.4	5.7	36.3
Achnanthes danica	6	0.0282	25.5	4.1	5.1
Cocconeis placentula	145	0.8358	25.7	6.4	61.1
Diploneis smithii	19	0.0357	25.7	4.9	16.4
Cocconeis placentula var. *euglipta*	6	0.0256	25.8	7.0	5.1
Mastogloia sirbonensis	5	0.0445	25.8	4.1	3.4
Amphora pseudohyalina	8	0.1073	25.9	4.5	3.9
Synedra fasciculata	11	0.0658	26.0	6.1	7.3
Navicula durrenbergiana	112	0.3746	26.0	4.5	59.5
Mastogloia pisciculus	34	0.0445	26.2	4.6	27.8
Rhabdonema adriaticum	46	0.2793	26.3	6.6	21.8
Synedra sp. 03BB	32	0.1899	26.3	4.2	22.9
Nitzschia microcephala	15	0.0748	26.3	7.9	9.1
Entomoneis alata	20	0.0601	26.4	6.8	15.6
Mastogloia erythreae	90	0.1302	26.5	4.8	58.9
Fragilaria geocollegarum	43	0.1551	26.6	4.1	23.6
Nitzschia sigma	86	0.2200	26.8	5.0	48.3
Nitzschia maxima	8	0.0263	26.8	3.2	7.3
Proschkinia bulnheimii	19	0.0443	26.9	3.6	16.6
Mastogloia ovalis	113	0.3641	26.9	4.8	57.0
Nitzschia libentruthii	94	0.2258	27.0	3.7	52.2
Toxarium hennedyanum	13	0.0355	27.0	6.8	11.2
Rhopalodia pacifica	84	0.2348	27.1	4.9	52.4
Mastogloia beufortiana	32	0.0526	27.1	5.3	25.8
Plagiotropis lepidoptera	37	0.0445	27.1	4.1	31.3
Hyalosynedra laevigata	159	0.4236	27.1	5.3	127.7
Trachyneis aspera	12	0.0357	27.2	3.7	9.2
Cocconeis scutellum	64	0.0885	27.2	6.0	44.8
Amphora floridae	46	0.0872	27.3	4.0	31.1
Surirella fastuosa	20	0.0361	27.4	5.8	17.0
Licmophora sp.01BB	3	0.0265	27.4	7.3	2.6
Amphora sp. 47BB	14	0.0267	27.5	3.9	12.8
Cocconeis woodii	8	0.0157	27.5	6.2	7.7
Mastogloia biocellata	79	0.0806	27.5	4.5	57.0
Navicula sp. 04BB	14	0.0440	27.5	5.0	12.1
Amphora coffeaeformis	34	0.0748	27.5	4.2	28.0
Mastogloia erythreae var. *grunowii*	23	0.0883	27.5	4.5	16.3
Mastogloia cyclops	105	0.1018	27.6	4.5	74.3
Diploneis crabro	26	0.0680	27.6	4.5	18.3
Fallacia litoricola	11	0.0265	27.6	6.6	9.9
Navicula longa var. *irregularis*	28	0.0447	27.7	5.1	23.4
Amphora gramenosum	11	0.0441	27.7	2.7	8.9
Mastogloia acutiuscula	33	0.0525	27.7	4.7	25.1
Amphora vadosinum	16	0.0445	27.7	3.4	13.1
Mastogloia angusta	23	0.0668	27.7	3.5	16.8
Diploneis litoralis var. *clathrata*	44	0.0524	27.7	4.4	35.0

Mastogloia crucicula	135	0.2597	27.7	4.5	83.3
Mastogloia strigosa	95	0.2456	27.8	4.9	48.6
Mastogloia sp. 14FB	15	0.0595	27.8	2.8	11.0
Rhaphoneis bilineata	9	0.0352	27.8	4.0	8.0
Nitzshia cf. rosenstockii	13	0.0522	27.8	1.8	10.4
Dimeregramma minor	11	0.0734	27.8	6.7	7.0
Mastogloia sp. 10FB	44	0.0602	27.9	4.5	34.2
Biddulphia pulchella	20	0.0748	27.9	3.2	13.3
Actinocyclus ehrenbergii	12	0.0432	27.9	3.4	9.5
Synedra bacillaris	94	0.2127	28.0	5.0	56.9
Amphora sp. 05FB	81	0.2009	28.0	3.8	49.1
Seminavis latior	12	0.0263	28.0	6.6	10.5
Nitzshia dissipata var. *media*	43	0.0945	28.0	4.1	33.1
Pleurosigma cf. *elongatum*	29	0.0812	28.1	4.0	21.4
Mastogloia frickei	32	0.0447	28.1	3.9	26.4
Mastogloia delicatula	21	0.0356	28.1	3.0	18.3
Amphora corpulenta var. *capitata*	43	0.1076	28.1	3.3	28.3
Amphora hamata	49	0.1104	28.1	3.8	32.1
Amphora semperparolum	27	0.0601	28.2	3.4	21.6
Seminavis gracilenta	20	0.0597	28.2	3.6	15.3
Mastogloia gibbosa	20	0.0519	28.2	2.2	15.8
Mastogloia sp. 06BB	8	0.0359	28.3	3.0	7.2
Chaetoceros sp. 02BB	30	0.2398	28.3	7.1	14.6
Navicula directa	78	0.1078	28.3	4.3	54.7
Synedra tabulata	26	0.1348	28.4	3.3	17.0
Petroneis marina	8	0.0157	28.4	4.8	7.6
Seminavis delicatula	29	0.0676	28.5	5.3	21.3
Mastogloia punctifera	84	0.0883	28.5	4.1	57.5
Diploneis vacilans	85	0.0811	28.6	4.5	62.2
Amphora securicula	36	0.0748	28.6	3.9	26.7
Amphora gramenosum	31	0.0723	28.6	3.9	22.2
Synedra fulgens	45	0.1248	28.7	4.6	24.3
Mastogloia bahamensis	42	0.0949	28.7	3.4	25.2
Mastogloia fimbriata	20	0.0445	28.7	5.4	16.0
Mastogloia sp. 02BB	10	0.0257	28.8	3.1	9.4
Amphora sp. 02BB	34	0.0813	28.8	2.3	23.6
Diploneis suborbicularis	30	0.0360	28.8	5.0	25.7
Mastogloia pseudolacrimata	13	0.0264	28.8	4.0	11.1
Protokeelia cholnokyana	6	0.0526	28.8	2.9	4.5
Mastogloia laminaris	32	0.0815	28.9	3.1	22.7
Mastogloia lacrimata	48	0.0517	28.9	3.4	39.7
Seminavis strigosa	97	0.1113	29.0	4.3	72.3
Cyclotella striata	19	0.0929	29.0	3.8	11.8
Mastogloia lineata	38	0.0663	29.0	2.9	29.8
Mastogloia cribrosa	50	0.1762	29.0	4.0	25.3
Mastogloia sp. 12FB	32	0.0951	29.0	3.8	21.1
Seminavis cyrtorapha	20	0.0656	29.1	1.9	13.6
Amphora sp. 05BB	74	0.2813	29.1	3.1	43.9

Mastogloia rostellata	46	0.0595	29.1	3.4	34.6
Mastogloia discontinua	57	0.1318	29.1	2.7	33.1
Cocconeis sp. 01FB	61	0.1198	29.2	3.4	44.9
Nitzschia improvisa	48	0.1128	29.2	3.9	30.9
Mastogloia latecostata	5	0.0357	29.3	2.1	4.3
Navicula sp. 11BB	8	0.0443	29.3	6.1	6.1
Nitzschia fontifuga	78	0.2539	29.3	3.4	44.9
Mastogloia ovata	7	0.0341	29.3	3.5	6.3
Mastogloia varians	17	0.0510	29.4	2.9	14.0
Mastogloia foliolum	8	0.0157	29.4	3.8	7.5
Nitzschia grossestriata	38	0.1129	29.4	4.4	22.8
Climaconeis riddleae	5	0.0428	29.4	4.6	4.6
Amphora indentata	16	0.0673	29.4	2.7	10.5
Haslea ostrearia	21	0.0601	29.4	4.1	16.6
Mastogloia barbadensis	44	0.0820	29.4	2.2	30.1
Nitzschia marginulata var. *didyma*	17	0.0441	29.5	4.4	13.2
Opephora pacifica	13	0.0606	29.5	5.9	9.3
Toxarium undulatum	52	0.2228	29.6	4.7	28.5
Mastogloia emarginata	23	0.0359	29.6	3.2	20.5
Mastogloia corsicana	101	0.2178	29.6	3.4	61.1
Entomoneis pseudoduplex	40	0.1670	29.6	3.1	26.0
Microtabella interrupta	72	0.2245	29.6	4.1	44.0
Synedra crystalina	15	0.0264	29.7	5.0	13.3
Mastogloia binotata	47	0.0562	29.7	3.2	34.7
Amphora graeffeana var. F02	28	0.0997	29.7	3.1	19.9
Neosynedra tortosa	12	0.2421	29.7	4.8	5.4
Reimerothrix floridensis	99	0.3165	29.8	3.7	48.8
Nitzschia angularis	84	0.1252	29.8	3.8	60.9
Dimeregramma hyalinum	7	0.1134	29.8	5.4	4.6
Navicula sp. 21FB	43	0.0806	29.8	3.5	31.1
Fallacia florinae	15	0.0523	29.8	4.3	12.0
Cyclotella tuberculata	7	0.0666	29.8	5.2	5.1
Campylodiscus sp. 01BB	9	0.0262	29.9	2.3	8.3
Amphora bigibba var. *capitata*	22	0.0727	29.9	2.4	16.1
Amphora sp. 03BB	12	0.0436	30.0	2.1	10.7
Striatella unipunctata	12	0.0264	30.0	4.0	10.9
Diploneis chersonensis	17	0.0359	30.0	3.6	14.7
Mastogloia goessii	29	0.0526	30.0	3.5	23.0
Mastogloia rimosa	17	0.0526	30.1	3.2	12.1
Amphora acutiuscula	7	0.0443	30.1	4.9	5.6
Surirella scalaris	4	0.0356	30.2	3.5	3.4
Mastogloia pseudolatecostata	37	0.0747	30.2	3.6	26.1
Pleurosigma formosum var. *balearica*	11	0.0511	30.2	5.2	8.5
Amphora abludens	34	0.2677	30.2	3.5	16.4
Tryblionella coarctata	83	0.1823	30.2	3.3	56.5
Cocconeis britanica	25	0.1498	30.3	3.5	13.4
Mastogloia angulata	13	0.0357	30.3	6.1	11.0

Grammatophora angulosa	24	0.0521	30.4	3.7	18.7
Amphora cf. *leavis*	17	0.0601	30.5	2.1	12.5
Microtabella sp. 01BB	32	0.1585	30.5	2.9	22.4
Dimeregramma dubium	44	0.3850	30.5	3.5	18.4
Gyrosigma sp. 01BB	18	0.0445	30.6	3.4	14.5
Licmophora pfannkucheae	31	0.2677	30.7	4.7	15.8
Mastogloia staurophora	12	0.0517	30.7	3.4	8.8
Nitzschia closterium	22	0.0787	30.7	4.4	14.9
Nitzschia longissima f. parva	24	0.0662	30.8	4.4	16.7
Mastogloia jalinecki	9	0.0259	30.9	2.5	8.1
Amphora caribaea	13	0.1070	31.0	2.6	8.0
Nitzschia sp. 02BB	17	0.0361	31.0	2.7	13.6
Mastogloia cocconeiformis	12	0.0157	31.0	3.5	11.3
Amphora decussata	8	0.0261	31.1	2.8	7.1
Cymatosira lorenziana	38	0.2535	31.2	3.4	19.3
Synedra brockmanni	8	0.0355	31.2	2.5	6.9
Cocconeis barleyi	13	0.0360	31.2	2.2	10.8
Mastogloia asperuloides	14	0.0443	31.2	3.4	11.2
Mastogloia subaffirmata	2	0.0157	31.2	3.8	2.0
Navicula hagelsteinii	8	0.0597	31.4	2.1	5.1
Mastogloia ignorata	12	0.0357	31.7	3.6	10.6
Amphora ostrearia var. *vitrea*	6	0.0265	31.7	2.7	5.3
Licmophora remulus	34	0.1590	31.8	3.0	18.0
Campylodiscus ralfsii	19	0.0514	31.8	3.2	15.0
Caloneis sp. 01BB	1	0.0259	32.4	4.3	1.0
Licmophora cf. *proboscidea*	7	0.2348	32.9	2.5	3.1
Paralia sulcata	6	0.0601	33.1	2.8	4.2
Amphora hyalina	2	0.0259	33.5	2.2	1.9
Auricula complexa	2	0.0264	33.7	0.7	1.6
Neodelphineis sp. 01BB	1	0.0093	35.4	4.3	1.0

Table 9. Number of occurrences (No. Occ.), relative abundances (Max. Abund.), estimated WA water total phosphorus (WTP) (µM) optima and tolerances (WA WTP. Opt. & WA WTP. Tol.) and Hill's N2 measure of abundance of 221 of the most common Biscayne Bay diatom species. Taxa order based on estimated WA phosphorus optima.

Taxon name	No. Occ.	Max	WA WTP Opt.	WA WTP Tol.	Hill's N2
Auricula complexa	2	0.0264	0.1203	0.0009	1.6
Licmophora cf. *proboscidea*	7	0.2348	0.1283	0.0169	3.1
Licmophora sp.01BB	3	0.0265	0.1403	0.0248	2.6
Neodelphineis sp. 01BB	1	0.0093	0.1589	0.1402	1.0
Licmophora pfannkucheae	31	0.2677	0.1621	0.0761	15.8
Nitzschia longissima f. *parva*	24	0.0662	0.1653	0.0539	16.7
Paralia sulcata	6	0.0601	0.1734	0.0780	4.2
Cyclotella tuberculata	7	0.0666	0.1745	0.0955	5.1
Mastogloia asperuloides	14	0.0443	0.1752	0.0833	11.2
Licmophora remulus	34	0.1590	0.1755	0.0951	18.0
Surirella scalaris	4	0.0356	0.1793	0.0393	3.4
Mastogloia staurophora	12	0.0517	0.1814	0.0590	8.8
Dimeregramma dubium	44	0.3850	0.1819	0.0873	18.4
Mastogloia foliolum	8	0.0157	0.1828	0.0895	7.5
Mastogloia ignorata	12	0.0357	0.1858	0.0910	10.6
Nitzschia closterium	22	0.0787	0.1861	0.0827	14.9
Gyrosigma sp. 01BB	18	0.0445	0.1889	0.0989	14.5
Mastogloia jalinecki	9	0.0259	0.1905	0.1043	8.1
Cocconeis barleyi	13	0.0360	0.1914	0.0581	10.8
Grammatophora angulosa	24	0.0521	0.1937	0.0843	18.7
Neosynedra tortosa	12	0.2421	0.1940	0.1021	5.4
Navicula hagelsteinii	8	0.0597	0.1961	0.1006	5.1
Campylodiscus ralfsii	19	0.0514	0.2046	0.0938	15.0
Dimeregramma minor	11	0.0734	0.2053	0.1415	7.0
Cymatosira lorenziana	38	0.2535	0.2058	0.0877	19.3
Nitzschia marginulata var. *didyma*	17	0.0441	0.2071	0.0925	13.2
Amphora hyalina	2	0.0259	0.2075	0.0552	1.9
Amphora abludens	34	0.2677	0.2102	0.1151	16.4
Toxarium undulatum	52	0.2228	0.2110	0.1393	28.5
Synedra crystalina	15	0.0264	0.2131	0.1553	13.3
Campylodiscus sp. 01BB	9	0.0262	0.2154	0.1096	8.3
Amphora decussata	8	0.0261	0.2170	0.1151	7.1
Striatella unipunctata	12	0.0264	0.2176	0.1499	10.9
Amphora gramenosum	28	0.0997	0.2188	0.1099	19.9
Mastogloia subaffirmata	2	0.0157	0.2195	0.1395	2.0
Amphora cf. *proteus*	17	0.0601	0.2215	0.1238	12.5
Climaconeis riddleae	5	0.0428	0.2240	0.1459	4.6
Synedra fulgens	45	0.1248	0.2246	0.1361	24.3
Seminavis cyrtorapha	20	0.0656	0.2281	0.1258	13.6
Mastogloia angulata	13	0.0357	0.2290	0.1614	11.0
Navicula sp. 21FB	43	0.0806	0.2321	0.1141	31.1

Mastogloia cocconeiformis	12	0.0157	0.2330	0.1348	11.3
Entomoneis pseudoduplex	40	0.1670	0.2355	0.1299	26.0
Fallacia florinae	15	0.0523	0.2359	0.1317	12.0
Caloneis sp. 01BB	1	0.0259	0.2370	0.1402	1.0
Amphora indentata	16	0.0673	0.2380	0.1049	10.5
Amphora caribaea	13	0.1070	0.2384	0.0993	8.0
Nitzschia grossestriata	38	0.1129	0.2407	0.1333	22.8
Amphora ostrearia var. *vitrea*	6	0.0265	0.2413	0.1671	5.3
Microtabella interrupta	72	0.2245	0.2417	0.1372	44.0
Mastogloia goessii	29	0.0526	0.2423	0.1558	23.0
Seminavis delicatula	29	0.0676	0.2436	0.1223	21.3
Cyclotella striata	19	0.0929	0.2442	0.1341	11.8
Mastogloia varians	17	0.0510	0.2443	0.1326	14.0
Tryblionella coarctata	83	0.1823	0.2446	0.1180	56.5
Synedra brockmanni	8	0.0355	0.2449	0.1450	6.9
Mastogloia beufortiana	47	0.0562	0.2462	0.1304	34.7
Chaetoceros sp. 02BB	30	0.2398	0.2469	0.1718	14.6
Mastogloia lineata	38	0.0663	0.2483	0.1170	29.8
Nitzschia sp. 02BB	17	0.0361	0.2483	0.1253	13.6
Amphora acutiuscula	7	0.0443	0.2486	0.0885	5.6
Amphora sp. 03BB	12	0.0436	0.2493	0.1276	10.7
Mastogloia ovata	7	0.0341	0.2520	0.2148	6.3
Mastogloia sp. 12FB	32	0.0951	0.2527	0.1437	21.1
Rhaphoneis bilineata	9	0.0352	0.2537	0.1408	8.0
Mastogloia sp. 14FB	15	0.0595	0.2557	0.1187	11.0
Nitzschia angularis	84	0.1252	0.2563	0.1375	60.9
Microtabella sp. 01BB	32	0.1585	0.2564	0.1446	22.4
Actinocyclus ehrenbergii	12	0.0432	0.2566	0.1628	9.5
Mastogloia rostellata	46	0.0595	0.2567	0.1338	34.6
Mastogloia emarginata	23	0.0359	0.2568	0.1244	20.5
Reimerothrix floridensis	99	0.3165	0.2575	0.1391	48.8
Mastogloia pseudolatecostata	37	0.0747	0.2577	0.1349	26.1
Amphora bigibba var. *capitata*	22	0.0727	0.2590	0.1160	16.1
Synedra tabulata	26	0.1348	0.2593	0.1337	17.0
Cocconeis placentula var. *euglipta*	6	0.0256	0.2613	0.1537	5.1
Mastogloia laminaris	32	0.0815	0.2620	0.1142	22.7
Mastogloia pseudolacrimata	13	0.0264	0.2628	0.1358	11.1
Diploneis chersonensis	17	0.0359	0.2638	0.1501	14.7
Dimeregramma hyalinum	7	0.1134	0.2649	0.1472	4.6
Cocconeis britanica	25	0.1498	0.2656	0.1287	13.4
Mastogloia discontinua	57	0.1318	0.2674	0.1281	33.1
Nitzschia improvisa	48	0.1128	0.2702	0.1532	30.9
Amphora gramenosum	31	0.0723	0.2717	0.1231	22.2
Rhabdonema adriaticum	46	0.2793	0.2743	0.1822	21.8
Mastogloia biocellata	44	0.0820	0.2748	0.1371	30.1
Haslea ostrearia	21	0.0601	0.2785	0.1314	16.6
Mastogloia lacrimata	48	0.0517	0.2785	0.1339	39.7
Pleurosigma formosum var.	11	0.0511	0.2790	0.1277	8.5

balearica					
Synedra bacillaris	94	0.2127	0.2807	0.1649	56.9
Navicula directa	78	0.1078	0.2847	0.1566	54.7
Mastogloia corsicana	101	0.2178	0.2900	0.1482	61.1
Mastogloia sp. 06BB	8	0.0359	0.2907	0.0967	7.2
Amphora hamata	49	0.1104	0.2910	0.1465	32.1
Mastogloia gibbosa	20	0.0519	0.2917	0.1264	15.8
Cocconeis sp. 01FB	61	0.1198	0.2947	0.1516	44.9
Mastogloia rimosa	17	0.0526	0.2959	0.1465	12.1
Amphora graeffeana var. F02	11	0.0441	0.2961	0.1928	8.9
Amphora securicula	36	0.0748	0.2961	0.1411	26.7
Diploneis vacilans	85	0.0811	0.2961	0.1556	62.2
Mastogloia barbadensis	32	0.0526	0.2977	0.1498	25.8
Protokeelia cholnokyana	6	0.0526	0.2983	0.1303	4.5
Navicula sp. 11BB	8	0.0443	0.2986	0.2001	6.1
Seminavis latior	12	0.0263	0.2989	0.1544	10.5
Seminavis strigosa	97	0.1113	0.2990	0.1588	72.3
Nitzschia fontifuga	78	0.2539	0.2995	0.1481	44.9
Opephora pacifica	13	0.0606	0.3027	0.1813	9.3
Diploneis suborbicularis	30	0.0360	0.3034	0.1443	25.7
Mastogloia delicatula	21	0.0356	0.3054	0.1448	18.3
Mastogloia fimbriata	20	0.0445	0.3055	0.2051	16.0
Amphora floridae	46	0.0872	0.3107	0.1615	31.1
Amphora sp. 05BB	74	0.2813	0.3135	0.1520	43.9
Amphora sp. 02BB	34	0.0813	0.3157	0.1433	23.6
Mastogloia sp. 02BB	10	0.0257	0.3182	0.1282	9.4
Mastogloia frickei	32	0.0447	0.3189	0.1327	26.4
Frustulia sp. 01L	15	0.0361	0.3197	0.1269	13.4
Petroneis marina	8	0.0157	0.3207	0.1761	7.6
Diploneis litoralis var. *clathrata*	44	0.0524	0.3208	0.1445	35.0
Mastogloia sp. 10FB	44	0.0602	0.3220	0.1391	34.2
Mastogloia strigosa	95	0.2456	0.3222	0.1735	48.6
Nitzschia microcephala	15	0.0748	0.3244	0.1876	9.1
Toxarium hennedyanum	13	0.0355	0.3249	0.1834	11.2
Surirella fastuosa	20	0.0361	0.3250	0.1486	17.0
Mastogloia angusta	23	0.0668	0.3252	0.1698	16.8
Entomoneis alata	20	0.0601	0.3255	0.1998	15.6
Amphora corpulenta var. capitata	43	0.1076	0.3272	0.1391	28.3
Navicula sp. 04BB	14	0.0440	0.3279	0.1350	12.1
Amphora sp. 47BB	14	0.0267	0.3287	0.1705	12.8
Amphora cf. *leavis*	34	0.0748	0.3306	0.1401	28.0
Mastogloia bahamensis	42	0.0949	0.3308	0.1656	25.2
Mastogloia punctifera	84	0.0883	0.3318	0.1535	57.5
Amphora vadosinum	16	0.0445	0.3350	0.1358	13.1
Amphora semperparolum	27	0.0601	0.3363	0.1459	21.6
Seminavis gracilenta	20	0.0597	0.3366	0.1764	15.3
Cocconeis woodii	8	0.0157	0.3374	0.1773	7.7
Mastogloia crucicula	135	0.2597	0.3380	0.1578	83.3

Fallacia litoricola	11	0.0265	0.3385	0.1929	9.9
Pleurosigma cf. *elongatum*	29	0.0812	0.3392	0.1570	21.4
Mastogloia cribrosa	50	0.1762	0.3395	0.1629	25.3
Mastogloia binotata	79	0.0806	0.3419	0.1598	57.0
Hyalosynedra laevigata	159	0.4236	0.3423	0.1789	127.7
Mastogloia erythreae var. *grunowii*	23	0.0883	0.3445	0.1641	16.3
Navicula longa var. *irregularis*	28	0.0447	0.3480	0.1865	23.4
Cocconeis scutellum	64	0.0885	0.3502	0.1768	44.8
Grammatophora oceanica	78	0.3551	0.3524	0.1812	36.3
Nitzshia dissipata var. *media*	43	0.0945	0.3575	0.1700	33.1
Amphicocconeis disculoides	44	0.1867	0.3591	0.1622	24.3
Mastogloia cyclops	105	0.1018	0.3615	0.1684	74.3
Synedra sp. 03BB	32	0.1899	0.3641	0.1765	22.9
Coscinodiscus oculus iridis	17	0.0440	0.3679	0.1962	14.5
Mastogloia nabulosa	31	0.0590	0.3684	0.1963	23.7
Plagiotropis lepidoptera	37	0.0445	0.3690	0.1514	31.3
Mastogloia acutiuscula	33	0.0525	0.3733	0.1632	25.1
Nitzschia libentruthii	94	0.2258	0.3736	0.1463	52.2
Rhopalodia pacifica	84	0.2348	0.3744	0.1624	52.4
Cocconeis placentula	145	0.8358	0.3757	0.1831	61.1
Nitzschia sigma	86	0.2200	0.3764	0.1939	48.3
Mastogloia erythreae	90	0.1302	0.3771	0.1645	58.9
Diploneis smithii	19	0.0357	0.3791	0.1998	16.4
Mastogloia latecostata	5	0.0357	0.3814	0.1360	4.3
Trachyneis aspera	12	0.0357	0.3817	0.1401	9.2
Amphora sp. 05FB	81	0.2009	0.3834	0.1471	49.1
Mastogloia ovalis	113	0.3641	0.3840	0.1575	57.0
Parlibellus panduriformis	33	0.0359	0.3926	0.1819	28.1
Fragilaria geocollegarum	43	0.1551	0.3931	0.1609	23.6
Cyclotella choctawhatcheana	130	0.5133	0.3944	0.1949	62.1
Mastogloia pisciculus	34	0.0445	0.3944	0.1796	27.8
Synedra fasciculata	11	0.0658	0.3966	0.1841	7.3
Proschkinia bulnheimii	19	0.0443	0.3981	0.1402	16.6
Diploneis crabro	26	0.0680	0.4020	0.1669	18.3
Nitzschia maxima	8	0.0263	0.4025	0.1233	7.3
Biddulphia pulchella	20	0.0748	0.4064	0.1492	13.3
Seminavis robusta	63	0.0525	0.4094	0.1654	50.0
Mastogloia pusilla	94	0.0982	0.4134	0.1798	68.4
Amphora lineolata	20	0.2660	0.4151	0.1489	6.3
Amphora cymbifera var. *heritierarum*	33	0.0748	0.4172	0.1917	24.0
Navicula durrenbergiana	112	0.3746	0.4197	0.1716	59.5
Amphora coffeaeformis	19	0.0526	0.4211	0.1690	14.9
Amphora arenaria	20	0.0263	0.4258	0.1721	17.8
Achnanthes danica	6	0.0282	0.4313	0.1652	5.1
Amphora tenerrima	140	0.4161	0.4322	0.1566	88.8
Nitzshia cf. *rosenstockii*	13	0.0522	0.4348	0.0908	10.4

Brachysira aponina	137	0.7389	0.4379	0.1463	53.1
Nitzschia frustulum	16	0.0652	0.4380	0.1145	11.3
Diploneis didyma	29	0.0444	0.4388	0.1761	23.6
Amphora aponina	103	0.2174	0.4439	0.1912	67.4
Caloneis excentrica	45	0.0952	0.4597	0.1677	29.1
Mastogloia sirbonensis	5	0.0445	0.4618	0.1746	3.4
Thalassiophysa hyalina var. *insecta*	17	0.0883	0.4649	0.1646	12.8
Licmophora normaniana	62	0.4349	0.4663	0.1358	22.2
Climaconeis colemaniae	49	0.1500	0.4670	0.1653	28.4
Achnanthes submarina	13	0.0597	0.4796	0.1446	9.1
Rhopalodia gibberula	22	0.0677	0.4812	0.1320	16.8
Rhopalodia acuminata	3	0.0157	0.4909	0.1320	2.9
Nitzschia sublinearis	19	0.2015	0.4914	0.2108	7.8
Oestrupia powellii	22	0.0566	0.4927	0.1387	15.1
Seminavis witkowskii	8	0.0267	0.4978	0.0898	7.3
Synedra sp. 01FB	21	0.0745	0.5000	0.1438	15.8
Navicula pseudocrassirostis	63	0.0951	0.5068	0.1394	41.2
Mastogloia halophila	62	0.1489	0.5093	0.1313	39.2
Fragilaria tenera	38	0.3641	0.5111	0.1247	16.7
Nitzschia capitata	6	0.0681	0.5149	0.1014	4.5
Cyclotella distinguenda	73	0.4104	0.5188	0.1188	37.9
Navicula palestinae	26	0.0817	0.5197	0.1590	17.5
Amphora pseudohyalina	8	0.1073	0.5227	0.1873	3.9
Fragilaria cf. *waernii*	102	0.5774	0.5262	0.1366	48.6
Caloneis sp. 02BB	8	0.0674	0.5338	0.1986	4.8
Cyclotella meneghiniana	16	0.0904	0.5358	0.1294	10.8
Mastogloia elegans	46	0.1316	0.5478	0.1208	27.4
Achnanthes sp. 06L31E	27	0.1308	0.5485	0.1228	16.6
Seminavis eulensteinii	27	0.1057	0.5519	0.0936	17.8
Amphora gigantea var. *fusca*	8	0.0267	0.5599	0.0990	7.0
Pinnunavis yarrensis	13	0.1149	0.5763	0.0869	6.2

Table 10. Number of occurrences (No. Occ.), relative abundances (Max. Abund.), estimated WA sediment total phosphorus (STP) (µg/g) optima and tolerances (WA STP. Opt. & WA STP. Tol.) and Hill's N2 measure of abundance of 221 of the most common Biscayne Bay diatom species. Taxa order based on estimated WA phosphorus optima.

Taxon name	No. Occ.	Max	WA STP Opt.	WA STP Tol.	Hill's N2
Nitzschia sublinearis	7	0.0258	38.93	49.31	6.5
Amphora ostrearia var. *vitrea*	10	0.0356	39.58	48.87	8.7
Mastogloia asperuloides	16	0.0514	41.09	38.22	12.9
Synedra crystalina	11	0.0674	42.11	50.61	7.4
Mastogloia cocconeiformis	27	0.0515	43.94	39.95	21.8
Nitzschia marginulata var. *didyma*	20	0.0445	44.25	49.71	15.0
Dimeregramma hyalinum	15	0.1304	44.46	63.95	7.2
Paralia sulcata	7	0.0661	47.55	64.60	4.5
Rhaphoneis bilineata	11	0.0441	47.71	47.11	9.3
Mastogloia rostellata	30	0.0799	47.94	31.38	20.4
Protokeelia cholnokyana	16	0.0441	48.35	53.62	12.5
Mastogloia sp. 06BB	13	0.0446	48.59	48.95	10.1
Cocconeis britanica	16	0.0597	49.04	55.02	12.6
Mastogloia staurophora	21	0.0438	49.51	30.71	17.4
Mastogloia ovulum	21	0.0435	50.40	47.42	17.6
Cyclotella tuberculata	45	0.2393	50.87	52.23	24.2
Amphora bigibba var. *capitata*	15	0.0436	51.07	45.43	12.5
Licmophora cf. *proboscidea*	31	0.1430	52.47	51.80	19.0
Fragilaria tenera	34	0.1597	52.60	47.58	20.6
Surirella scalaris	20	0.0596	53.20	57.66	13.4
Mastogloia barbadensis	17	0.0264	53.59	53.38	15.0
Mastogloia foliolum	15	0.0264	53.64	58.71	13.0
Dimeregramma minor	10	0.0351	55.96	44.93	8.5
Mastogloia sp. 02BB	11	0.0265	56.79	49.70	10.1
Cymatosira lorenziana	42	0.5451	57.57	50.35	16.7
Amphora gramenosum	30	0.0926	57.61	56.85	19.0
Cocconeis barleyi	14	0.0422	58.76	50.44	12.4
Mastogloia sp. 14FB	15	0.0793	58.80	34.06	10.0
Navicula hagelsteinii	14	0.0357	59.79	40.57	11.8
Nitzschia grossestriata	41	0.0525	61.31	58.71	30.7
Mastogloia goessii	27	0.0522	62.55	51.68	20.6
Mastogloia discontinua	45	0.1354	63.36	34.53	27.4
Amphora caribaea	27	0.0673	64.12	40.16	18.8
Seminavis delicatula	50	0.1261	64.67	51.32	34.4
Actinocyclus ehrenbergii	12	0.0599	64.73	51.50	9.1
Mastogloia beufortiana	65	0.0676	65.36	55.87	50.5
Campylodiscus ralfsii	19	0.0514	65.52	59.08	15.6
Amphora abludens	14	0.0594	65.71	73.26	11.8
Mastogloia sp. 12FB	27	0.0670	66.24	55.78	19.9
Mastogloia lineata	30	0.0353	67.23	44.25	25.8
Climaconeis riddleae	21	0.0811	67.48	55.78	14.9

Campylodiscus sp. 01BB	18	0.0263	67.68	56.01	16.3
Amphora corpulenta var. *capitata*	43	0.1749	68.78	42.27	26.0
Mastogloia ignorata	32	0.0519	69.55	44.02	26.7
Mastogloia delicatula	28	0.0585	69.73	45.41	21.2
Synedra tabulata	13	0.0911	69.95	46.84	7.3
Amphora gramenosum	9	0.0600	70.71	90.32	6.3
Neosynedra tortosa	43	0.1747	71.30	56.21	24.3
Mastogloia rimosa	21	0.0443	71.49	37.96	17.2
Licmophora remulus	76	0.5240	71.69	63.20	29.1
Seminavis cyrtorapha	18	0.0705	72.79	40.62	12.6
Surirella fastuosa	26	0.0526	73.78	58.64	18.4
Synedra fulgens	70	0.2120	74.06	75.32	36.0
Cyclotella striata	10	0.0157	74.10	53.86	9.6
Mastogloia varians	17	0.0351	74.63	48.18	15.0
Amphora indentata	14	0.1191	74.64	71.10	8.3
Mastogloia frickei	24	0.0523	74.76	53.36	17.3
Navicula sp. 21FB	29	0.1123	75.04	85.85	17.6
Mastogloia subaffirmata	15	0.0357	75.53	52.57	13.5
Mastogloia fimbriata	54	0.0783	75.77	70.49	37.2
Amphora cf. *proteus*	30	0.1184	76.20	47.91	19.1
Mastogloia pseudolatecostata	37	0.0527	76.43	48.07	30.0
Hyalosynedra laevigata	15	0.1641	76.50	52.32	8.1
Mastogloia lacrimata	62	0.1331	76.62	65.56	37.9
Petroneis marina	9	0.0259	76.78	72.38	8.5
Mastogloia pseudolacrimata	26	0.0265	77.34	42.60	22.8
Mastogloia emarginata	12	0.0261	77.80	38.58	11.1
Navicula sp. 04BB	16	0.0600	78.18	57.19	11.9
Mastogloia corsicana	119	0.1742	78.64	64.13	76.1
Toxarium hennedyanum	30	0.1348	78.80	77.84	18.6
Tryblionella coarctata	95	0.1073	80.12	73.70	70.0
Mastogloia bahamensis	37	0.0789	81.32	61.20	26.0
Mastogloia ovata	42	0.0595	83.66	59.90	35.1
Cyclotella meneghiniana	6	0.0260	85.13	86.60	5.0
Neodelphineis sp. 01BB	17	0.0523	85.54	70.35	12.6
Cocconeis placentula	33	0.1853	85.91	79.74	13.3
Mastogloia strigosa	22	0.0928	86.49	68.24	15.7
Entomoneis pseudoduplex	21	0.0441	86.57	82.78	16.5
Mastogloia latecostata	18	0.0441	87.27	75.31	14.3
Reimerothrix floridensis	109	0.6414	87.38	72.97	55.9
Amphora graeffeana var. F02	17	0.0441	88.34	100.95	14.1
Diploneis smithii	38	0.0443	89.22	67.53	32.3
Diploneis chersonensis	29	0.0886	89.26	67.98	18.2
Mastogloia cribrosa	80	0.0775	90.62	71.81	61.7
Nitzschia sp. 02BB	15	0.0807	91.58	41.03	9.3
Amphora lineolata	6	0.0810	94.93	80.11	3.8
Amphora sp. 02BB	32	0.0524	95.55	66.63	23.9
Nitzschia fontifuga	38	0.1997	95.65	108.12	23.4
Navicula longa var. *irregularis*	39	0.0440	95.88	70.32	33.2

Diploneis litoralis var. *clathrata*	23	0.0443	96.75	89.08	18.6
Mastogloia biocellata	29	0.0527	97.02	79.43	23.0
Mastogloia punctifera	100	0.0940	97.05	70.63	68.7
Amphora vadosinum	12	0.0598	97.30	55.58	10.3
Amphora arenaria	21	0.0598	98.07	96.38	15.6
Toxarium undulatum	91	0.2446	98.07	88.83	50.8
Mastogloia acutiuscula	30	0.0673	98.86	53.49	22.7
Opephora pacifica	16	0.0597	99.69	79.08	12.0
Nitzschia closterium	36	0.0989	101.23	96.62	25.9
Mastogloia laminaris	14	0.0350	102.25	99.22	12.2
Amphora semperparolum	8	0.0351	102.50	47.89	6.7
Plagiotropis lepidoptera	47	0.1193	103.03	75.68	31.0
Nitzshia dissipata var. *media*	29	0.1658	103.35	94.97	17.9
Climaconeis colemaniae	44	0.1314	103.45	70.31	21.7
Biddulphia pulchella	15	0.1133	103.97	53.02	7.9
Mastogloia nabulosa	62	0.2601	104.76	82.08	34.8
Mastogloia binotata	65	0.1123	104.94	77.87	42.4
Nitzschia angularis	122	0.1175	104.94	91.38	79.7
Mastogloia gibbosa	32	0.0350	105.19	114.65	28.0
Licmophora pfannkucheae	73	0.1970	105.41	72.61	44.2
Grammatophora angulosa	10	0.0514	105.49	98.93	7.3
Caloneis sp. 01BB	19	0.0446	106.08	85.77	14.9
Cocconeis woodii	90	0.1590	106.15	72.35	57.2
Synedra brockmanni	14	0.0526	108.19	81.69	11.4
Nitzschia improvisa	43	0.0439	109.64	92.15	36.7
Nitzschia microcephala	23	0.2139	112.39	68.41	11.9
Mastogloia angulata	21	0.0519	112.57	95.79	16.2
Diploneis crabro	38	0.0673	113.90	101.52	27.8
Diploneis didyma	91	0.0738	115.49	102.72	69.9
Gyrosigma sp. 01BB	166	0.4125	119.42	93.56	134.4
Amphora sp. 03BB	25	0.0728	119.91	85.91	20.2
Fallacia florinae	8	0.0157	120.75	74.93	7.8
Mastogloia cyclops	121	0.0744	121.51	90.48	92.7
Nitzschia frustulum	34	0.1827	121.97	43.54	18.2
Amphora decussata	13	0.0265	122.06	127.33	11.7
Amphora hamata	63	0.0880	122.29	96.02	45.0
Amphora coffeaeformis	32	0.0673	122.55	91.22	23.7
Frustulia sp. 01L	64	0.2772	122.60	104.15	33.5
Licmophora sp.01BB	15	0.0599	123.15	91.71	12.4
Fragilaria geocollegarum	33	0.0675	123.32	76.08	24.1
Mastogloia sp. 10FB	52	0.0596	123.71	84.97	42.2
Mastogloia sirbonensis	27	0.0443	124.71	95.77	22.0
Rhopalodia pacifica	98	0.1997	124.81	95.35	67.8
Mastogloia crucicula	157	0.4256	125.43	87.94	91.4
Fragilaria cf. *waernii*	35	0.0671	125.52	85.23	25.3
Navicula directa	91	0.0669	126.02	95.54	72.2
Nitzschia longissima f. *parva*	18	0.1076	126.94	98.96	10.7
Amphora floridae	47	0.0594	127.21	93.44	37.0

Mastogloia erythreae var. *grunowii*	32	0.0673	128.73	107.10	24.3
Trachyneis aspera	9	0.0265	128.73	111.36	8.2
Mastogloia erythreae	96	0.2431	128.81	100.39	51.7
Seminavis gracilenta	31	0.0443	128.96	100.80	25.7
Amphora acutiuscula	23	0.0598	129.34	120.71	17.8
Diploneis vacilans	33	0.0522	130.00	105.46	28.0
Auricula complexa	26	0.0521	130.58	119.48	21.5
Seminavis witkowskii	1	0.0092	131.67	83.35	1.0
Nitzschia sigma	103	0.1899	132.01	90.94	63.6
Amphora sp. 05BB	54	0.1631	132.39	100.39	31.5
Brachysira aponina	50	0.1535	134.50	95.57	28.1
Mastogloia jalinecki	14	0.1643	136.99	99.28	7.6
Amphicocconeis disculoides	35	0.1531	138.76	101.01	17.1
Striatella unipunctata	44	0.1452	139.08	122.76	22.3
Amphora sp. 05FB	80	0.2582	139.22	104.05	45.3
Haslea ostrearia	40	0.3557	139.79	99.78	18.7
Microtabella interrupta	128	0.4979	143.21	99.17	70.1
Navicula durrenbergiana	96	0.2062	143.48	104.82	62.8
Seminavis latior	30	0.0523	144.34	112.58	24.8
Synedra bacillaris	126	0.2180	145.04	124.65	74.1
Nitzschia maxima	22	0.0984	145.39	124.25	13.7
Amphora gigantea var. *fusca*	11	0.0358	146.78	133.43	8.5
Mastogloia angusta	48	0.0813	148.19	96.01	35.3
Microtabella sp. 01BB	76	0.3556	148.43	111.46	41.9
Mastogloia ovalis	123	0.0921	149.20	98.02	93.6
Seminavis strigosa	1	0.0156	149.48	83.35	1.0
Thalassiophysa hyalina var. *insecta*	41	0.1845	149.94	113.24	25.1
Diploneis suborbicularis	44	0.0443	151.23	124.84	38.1
Grammatophora oceanica	35	0.0654	154.52	110.48	25.2
Parlibellus panduriformis	26	0.1310	154.64	91.75	12.1
Seminavis robusta	83	0.0813	157.44	110.65	63.2
Mastogloia pusilla	89	0.2018	158.19	103.99	53.1
Oestrupia powellii	48	0.1590	158.79	106.58	22.7
Dimeregramma dubium	28	0.1018	159.08	116.50	18.4
Cocconeis placentula var. *euglipta*	149	0.7531	159.74	101.84	72.2
Cocconeis sp. 01FB	106	0.3504	164.77	107.02	50.4
Amphora tenerrima	126	0.2562	164.95	107.86	81.3
Pleurosigma formosum var. *balearica*	26	0.0357	165.59	118.16	22.1
Amphora pseudohyalina	21	0.0744	165.81	110.35	12.6
Amphora hyalina	17	0.0436	166.00	109.05	16.1
Rhopalodia acuminata	14	0.0726	167.79	136.13	9.7
Mastogloia elegans	46	0.1435	170.64	87.77	29.9
Mastogloia halophila	48	0.0883	171.11	109.60	34.1
Amphora cymbifera var. *heritierarum*	15	0.0522	172.68	108.52	10.6

Mastogloia pisciculus	49	0.1480	173.30	96.57	30.1
Amphora securicula	49	0.0739	173.74	115.56	35.3
Nitzschia libentruthii	88	0.2635	175.34	111.27	49.6
Amphora cf. *leavis*	56	0.1148	175.60	121.10	38.6
Rhopalodia gibberula	63	0.1756	176.66	105.28	39.9
Amphora sp. 47BB	29	0.0447	177.50	115.22	24.8
Navicula palestinae	19	0.0604	179.44	87.14	14.6
Achnanthes danica	16	0.0747	180.87	125.38	9.8
Entomoneis alata	55	0.2605	185.51	117.99	25.3
Amphora aponina	54	0.0958	188.71	114.76	39.6
Navicula sp. 11BB	12	0.0948	190.50	157.37	6.3
Pleurosigma cf. elongatum	54	0.0750	193.06	115.97	42.4
Nitzschia macilenta	28	0.1181	193.34	97.67	22.2
Licmophora normaniana	34	0.0355	196.25	108.12	29.0
Fallacia litoricola	36	0.0744	197.42	94.85	24.7
Cyclotella distinguenda	29	0.2090	200.79	103.30	13.4
Caloneis excentrica	41	0.1194	201.11	100.55	25.0
Rhabdonema adriaticum	65	0.2701	201.26	110.81	31.9
Seminavis eulensteinii	13	0.1006	202.74	93.23	7.8
Proschkinia bulnheimii	6	0.0266	203.26	157.83	5.4
Caloneis sp. 02BB	19	0.0948	204.30	119.59	12.1
Coscinodiscus oculus iridis	40	0.2768	205.15	81.44	16.0
Synedra sp. 01FB	25	0.2358	210.21	104.69	9.5
Chaetoceros sp. 02BB	6	0.0731	211.71	149.01	3.7
Pinnunavis yarrensis	9	0.0359	213.13	97.43	7.4
Cyclotella choctawhatcheana	85	0.5015	215.24	99.19	46.2
Synedra fasciculata	41	0.0823	221.99	127.48	29.2
Achnanthes sp. 06L31E	10	0.0157	223.48	120.04	9.4
Cocconeis scutellum	46	0.1571	228.75	102.82	27.9
Navicula pseudocrassirostis	18	0.0264	239.65	106.69	16.7
Nitzshia cf. *rosenstockii*	36	0.1653	240.47	126.96	18.8
Nitzschia capitata	12	0.0677	262.61	118.20	9.2
Achnanthes submarina	7	0.0311	265.43	141.62	6.2

IX. FIGURE LEGENDS

Fig. 1. Map of Biscayne Bay showing location of the sampling sites.

Fig. 2. Ordination site scores grouped by habitat types in two dimensions generated by non-metric multidimensional scaling (NMDS) using the Bray – Curtis similarity metric. Vectors correspond to the direction of maximum correlation of environmental variables with NMDS site scores. Arrows indicate environmental variables that are significantly correlated with site scores.

Fig. 3. Ordination site scores of dry season diatom species relative abundances grouped by habitat types (a), and by habitat types and zones (b) in two dimensions generated by NMDS using Bray – Curtis similarity metric.

Fig. 4. Ordination site scores of wet season diatom species relative abundances grouped by habitat types (a), and by habitat types and zones (b) in two dimensions generated by NMDS using Bray – Curtis similarity metric.

Fig. 5. Maps showing seasonal changes in relative abundances of selected diatom indicator species: a) Distribution of *Reimerotrix floridensis* within Biscayne Bay in the dry season, b) Distribution of *Reimerotrix floridensis* within Biscayne Bay in the wet season, c) Distribution of *Tabularia* cf. *waernii* in epiphyton within Biscayne Bay in the dry season, d) Distribution of *Tabularia* cf. *waernii* in epiphyton within Biscayne Bay in the wet season.

Fig. 6. Plots of observed vs. jack-knife predicted wet season salinity (ppt.) (a) and observed vs. residuals (b) for the WAPLS regression model.

Fig. 7. Plots of observed vs. jack-knife predicted wet season water TP (µM) (a) and observed vs. residuals (b) for the WAPLS regression model.

Fig. 8. Plots of observed vs. jack-knife predicted dry season sediment TP (µM) (a) and observed vs. residuals (b) for the WAPLS regression model.

Fig. 9. Map of observed (a) and predicted from diatom species composition (b) distribution of wet season salinity (ppt) across the Biscayne Bay basin.

Fig. 10. Map of observed (a) and predicted from diatom species composition (b) distribution of wet season water TP (µM) across the Biscayne Bay basin.

Fig. 11. Map of observed (a) and predicted from diatom species composition (b) distribution of dry season sediment TP (µg/g) across the Biscayne Bay basin.

Fig. 12. Maps of observed distribution of dry (a) and wet (b) season salinity (ppt) across the study area.

Fig. 13. Maps of observed distribution of dry (a) and wet (b) season turbidity (NTU) across the study area.

Fig. 14. Maps of observed distribution of dry (a) and wet (b) season water temperature (°C) across the study area.

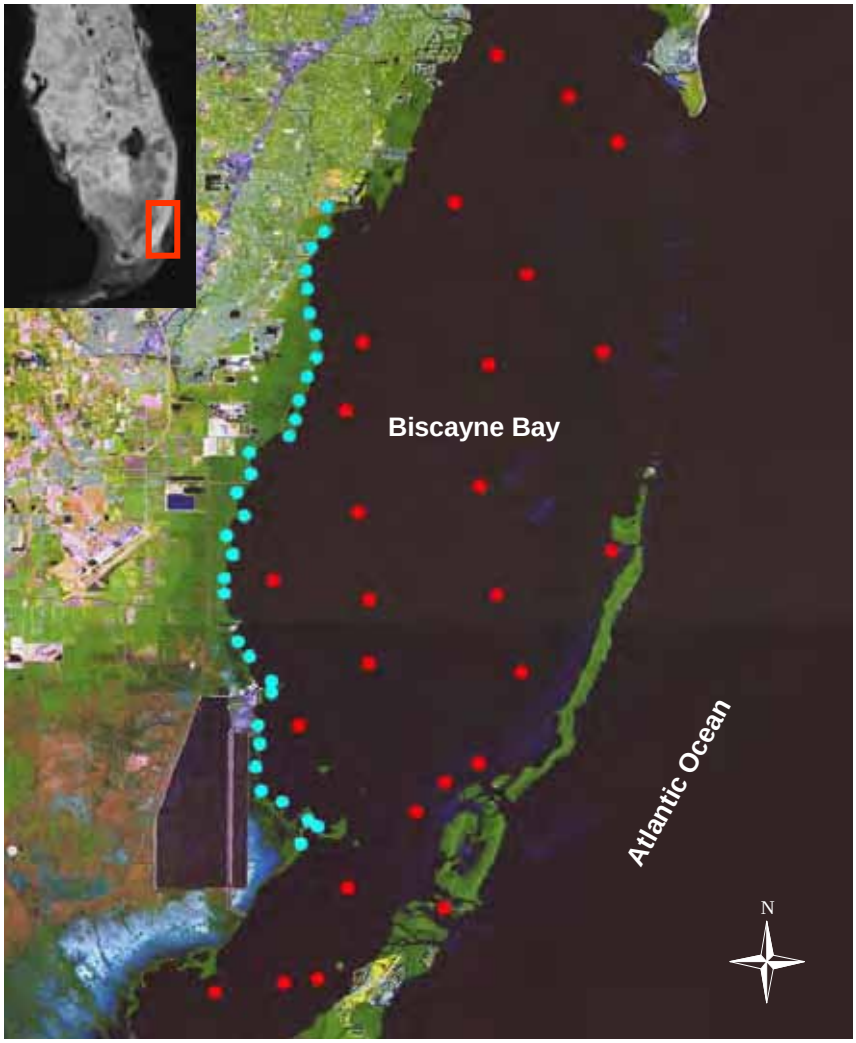
Fig. 15. Maps of observed distribution of dry (a) and wet (b) season vegetation cover (%) across the study area.

Fig. 16. Distribution of most abundant diatom species and reconstructed salinity (ppt.) in the Card Bank sediment core. Reconstructions based on the WAPLS salinity model created based on diatom taxa found in modern samples.

Fig. 17. Distribution of most abundant diatom species and reconstructed water TP (µM) in the Card Bank sediment core. Reconstructions based on the WAPLS WTP model created based on diatom taxa found in modern samples.

Fig. 18. Distribution of most abundant diatom species and reconstructed sediment TP (µg/g) in the Card Bank sediment core. Reconstructions based on the WAPLS STP model created based on diatom taxa found in modern samples.

Fig. 1.



Near shore sites (Zone 1)
Bay sites (Zone 2)

Fig. 2.

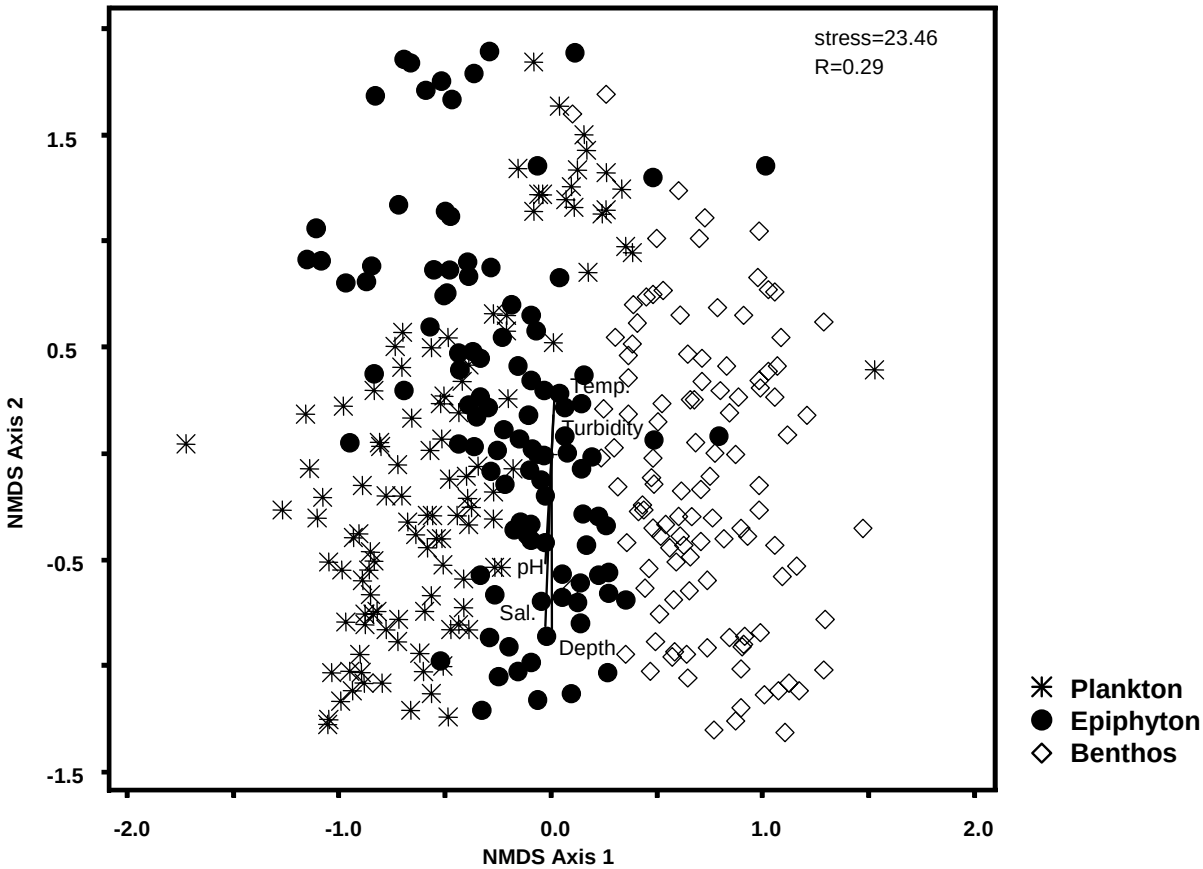

stress=23.46
R=0.29
Temp.
Turbidity
pH
Sal.
Depth
1.5
0.5
-0.5
-1.5
NMDS Axis 2
-2.0
-1.0
0.0
1.0
2.0
NMDS Axis 1
Plankton
Epiphyton
Benthos

Fig. 3.

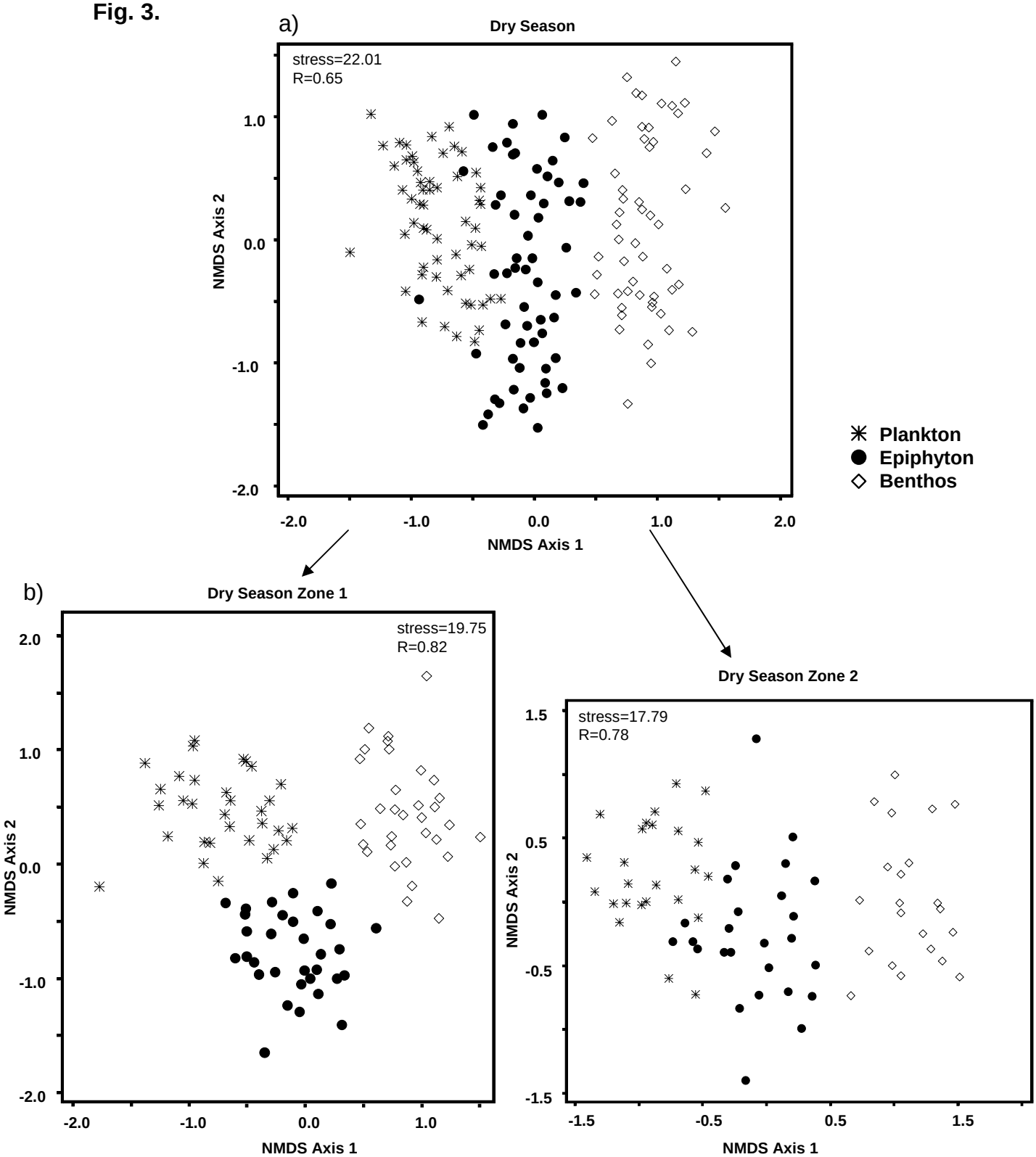

a)
Dry Season
stress=22.01
R=0.65
NMDS Axis 2
NMDS Axis 1
1.0
0.0
-1.0
-2.0
-2.0
-1.0
0.0
1.0
2.0
Plankton
Epiphyton
Benthos
b)
Dry Season Zone 1
stress=19.75
R=0.82
NMDS Axis 2
NMDS Axis 1
2.0
1.0
0.0
-1.0
-2.0
-2.0
-1.0
0.0
1.0
Dry Season Zone 2
stress=17.79
R=0.78
NMDS Axis 2
NMDS Axis 1
1.5
0.5
-0.5
-1.5
-1.5
-0.5
0.5
1.5

Fig. 4.

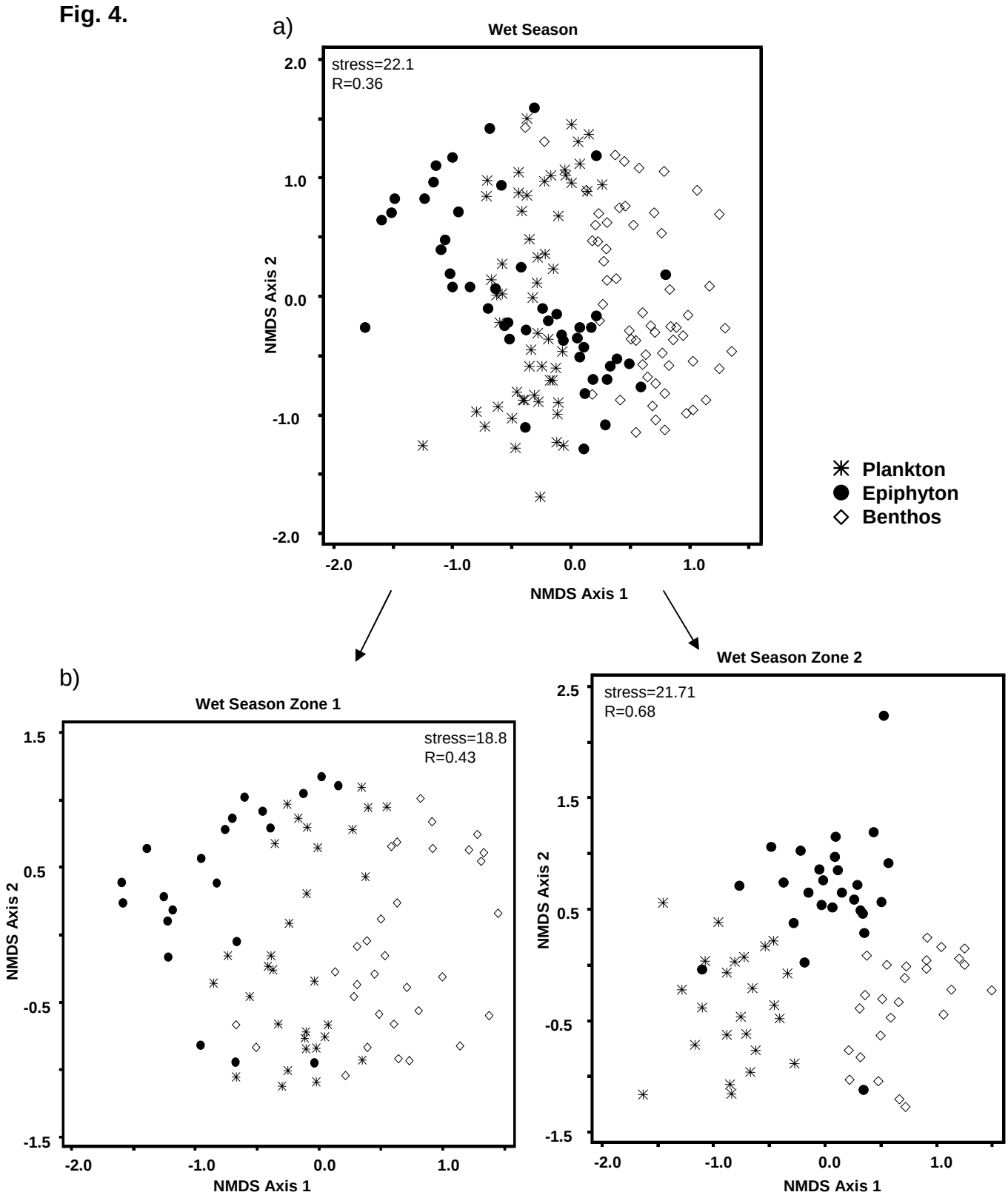

a)
Wet Season
stress=22.1
R=0.36
NMDS Axis 2
NMDS Axis 1
2.0
1.0
0.0
-1.0
-2.0
Plankton
Epiphyton
Benthos
b)
Wet Season Zone 1
stress=18.8
R=0.43
Wet Season Zone 2
stress=21.71
R=0.68
1.5
0.5
-0.5
-1.5
2.5

Fig. 5.

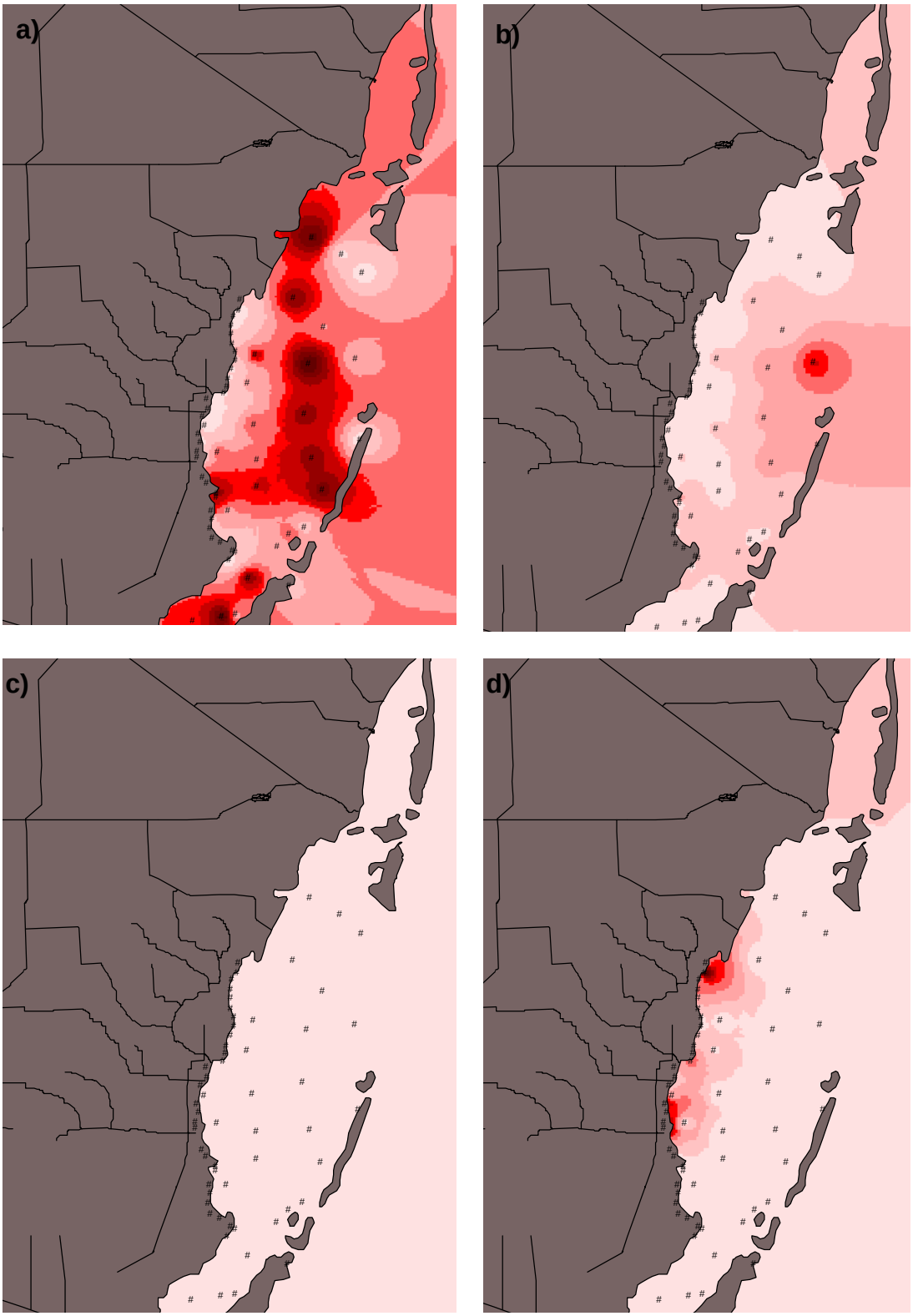


Fig. 6.

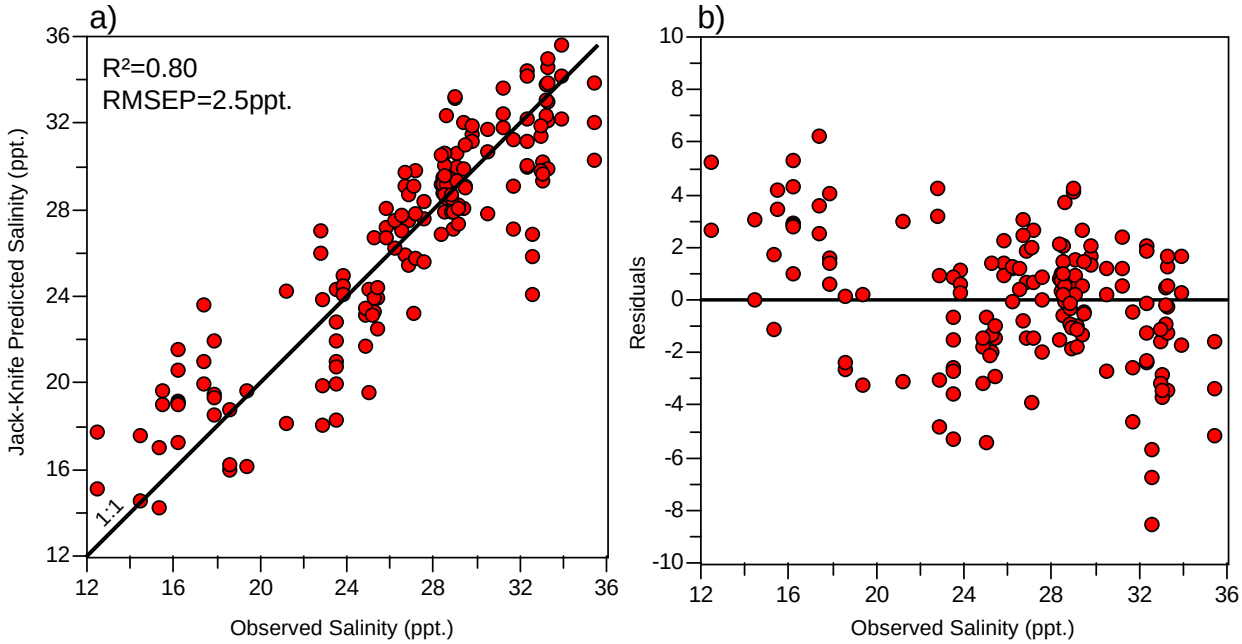

a)
R²=0.80
RMSEP=2.5ppt.
1:1
Jack-Knife Predicted Salinity (ppt.)
Observed Salinity (ppt.)
b)
Residuals
Observed Salinity (ppt.)

Fig. 7.

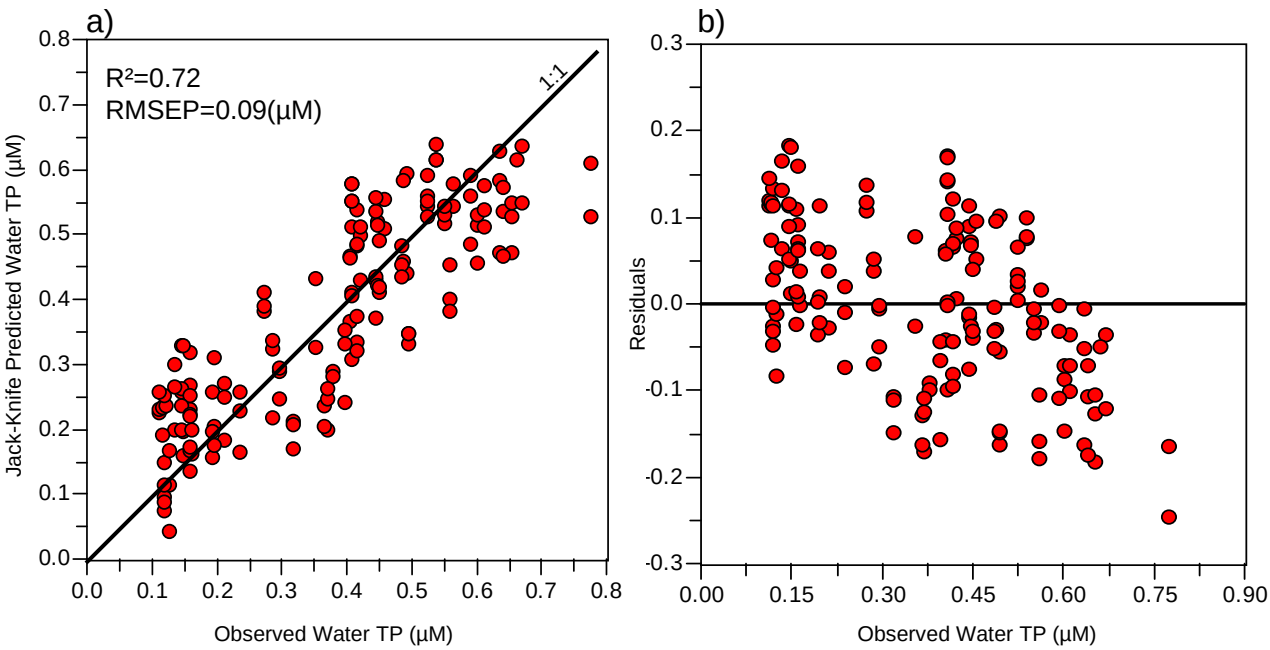

a)
R²=0.72
RMSEP=0.09(µM)
1:1
Jack-Knife Predicted Water TP (µM)
Observed Water TP (µM)
b)
Residuals
Observed Water TP (µM)

Fig. 8.

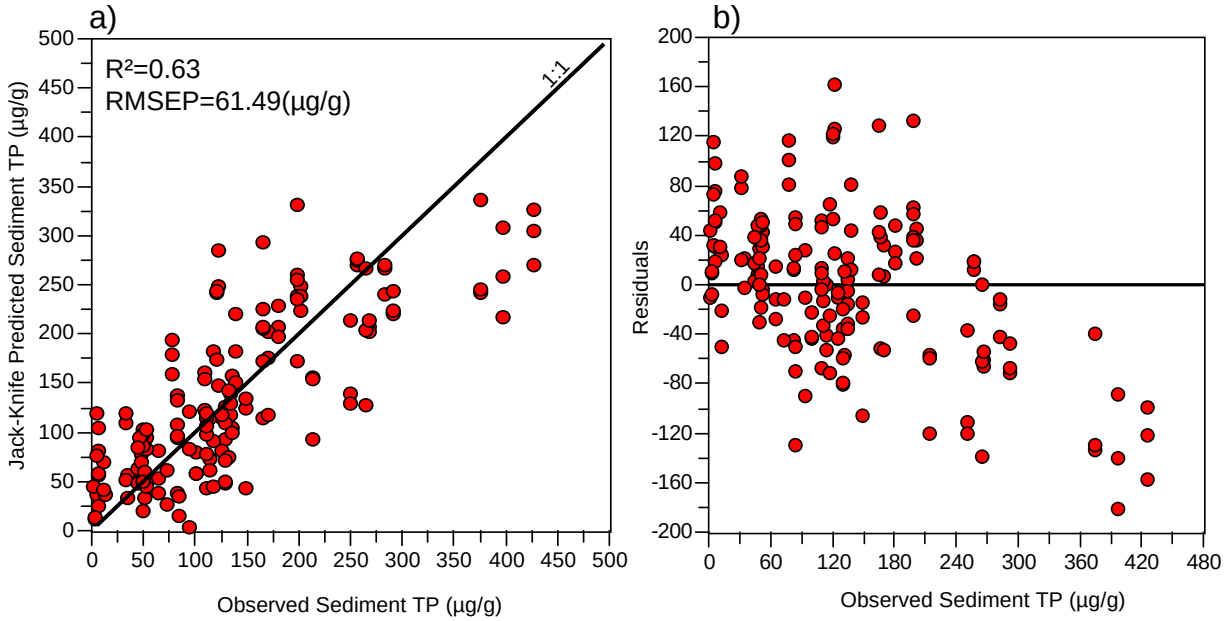

a)
R²=0.63
RMSEP=61.49(µg/g)
1:1
Jack-Knife Predicted Sediment TP (µg/g)
Observed Sediment TP (µg/g)
0
50
100
150
200
250
300
350
400
450
500
b)
Residuals
Observed Sediment TP (µg/g)
200
160
120
80
40
0
-40
-80
-120
-160
-200
0
60
120
180
240
300
360
420
480

Fig. 9.

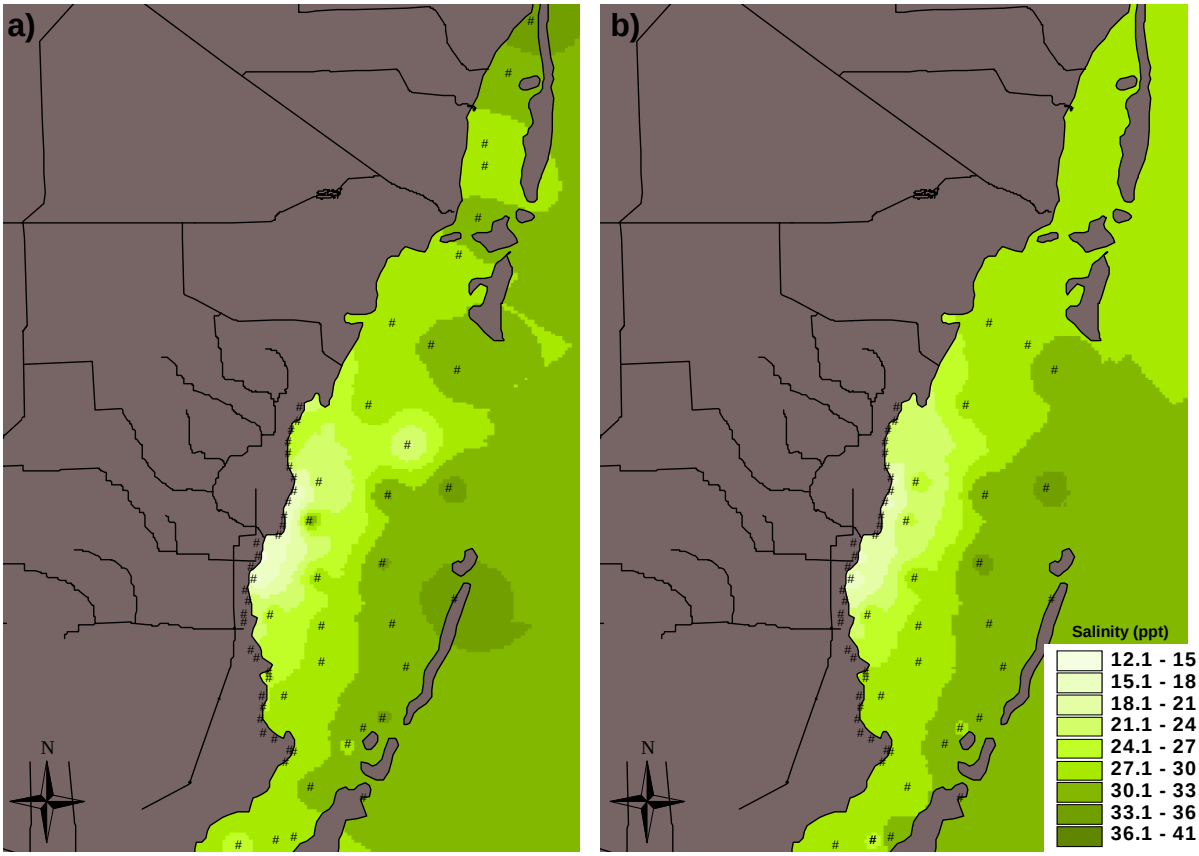

a)
b)
N
N
Salinity (ppt)
12.1 - 15
15.1 - 18
18.1 - 21
21.1 - 24
24.1 - 27
27.1 - 30
30.1 - 33
33.1 - 36
36.1 - 41

Fig. 10.

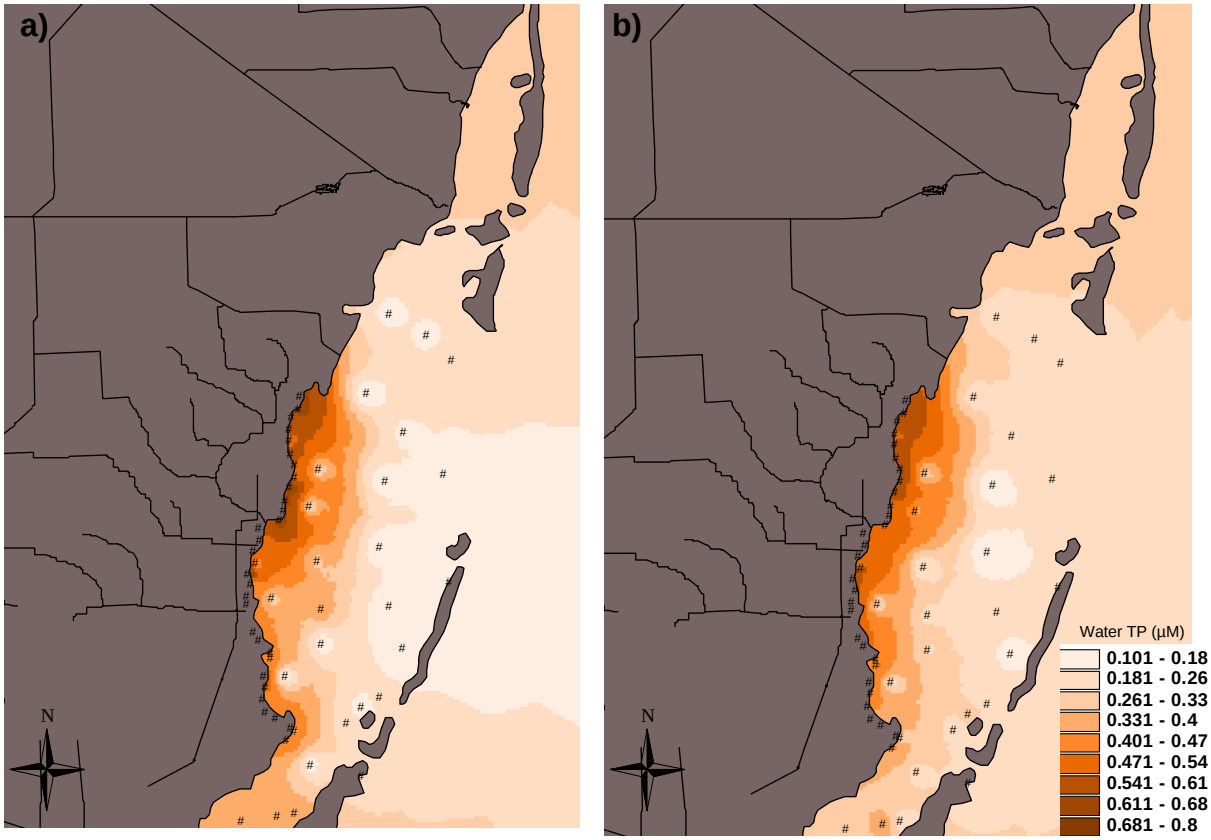

a)
b)
N
N
Water TP (µM)
0.101 - 0.18
0.181 - 0.26
0.261 - 0.33
0.331 - 0.4
0.401 - 0.47
0.471 - 0.54
0.541 - 0.61
0.611 - 0.68
0.681 - 0.8

Fig. 11.

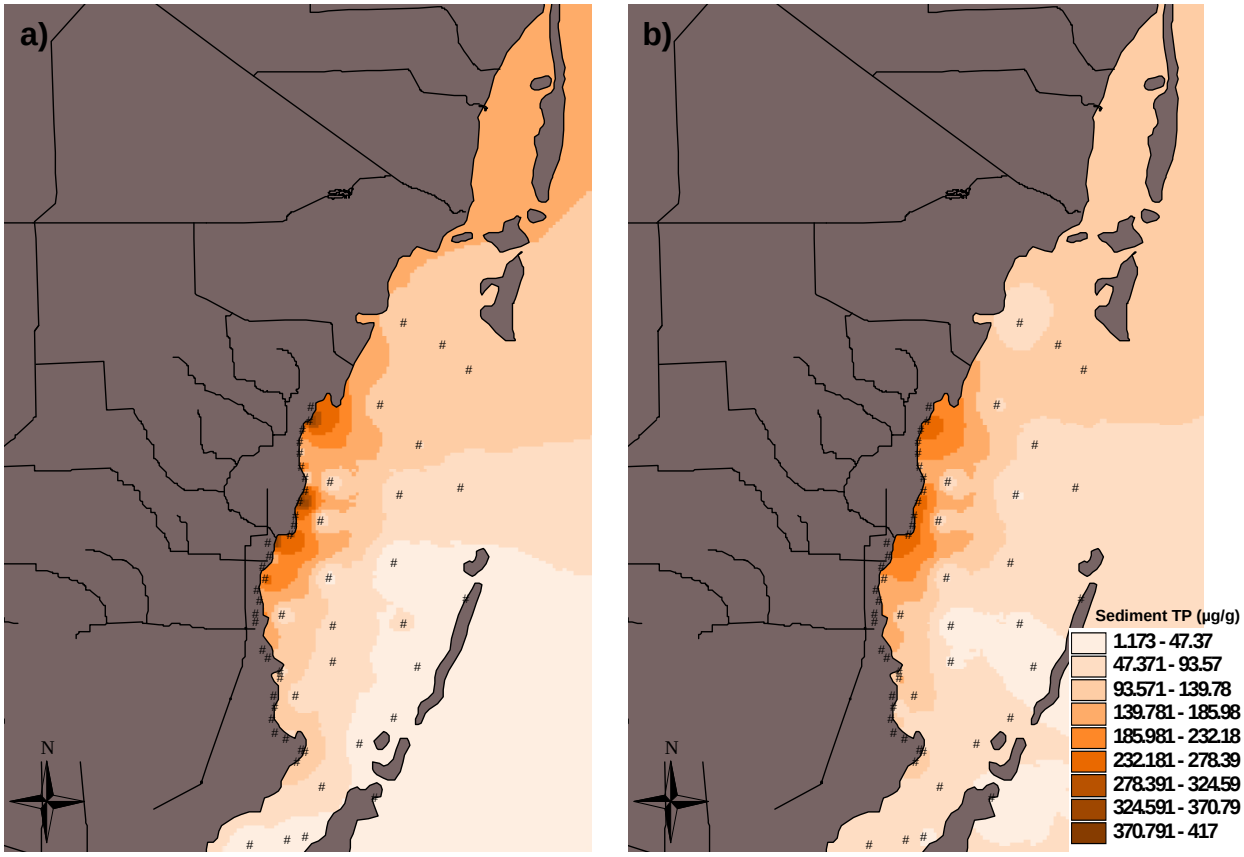

a)
b)
N
N
Sediment TP (µg/g)
1.173 - 47.37
47.371 - 93.57
93.571 - 139.78
139.781 - 185.98
185.981 - 232.18
232.181 - 278.39
278.391 - 324.59
324.591 - 370.79
370.791 - 417

Fig. 12.

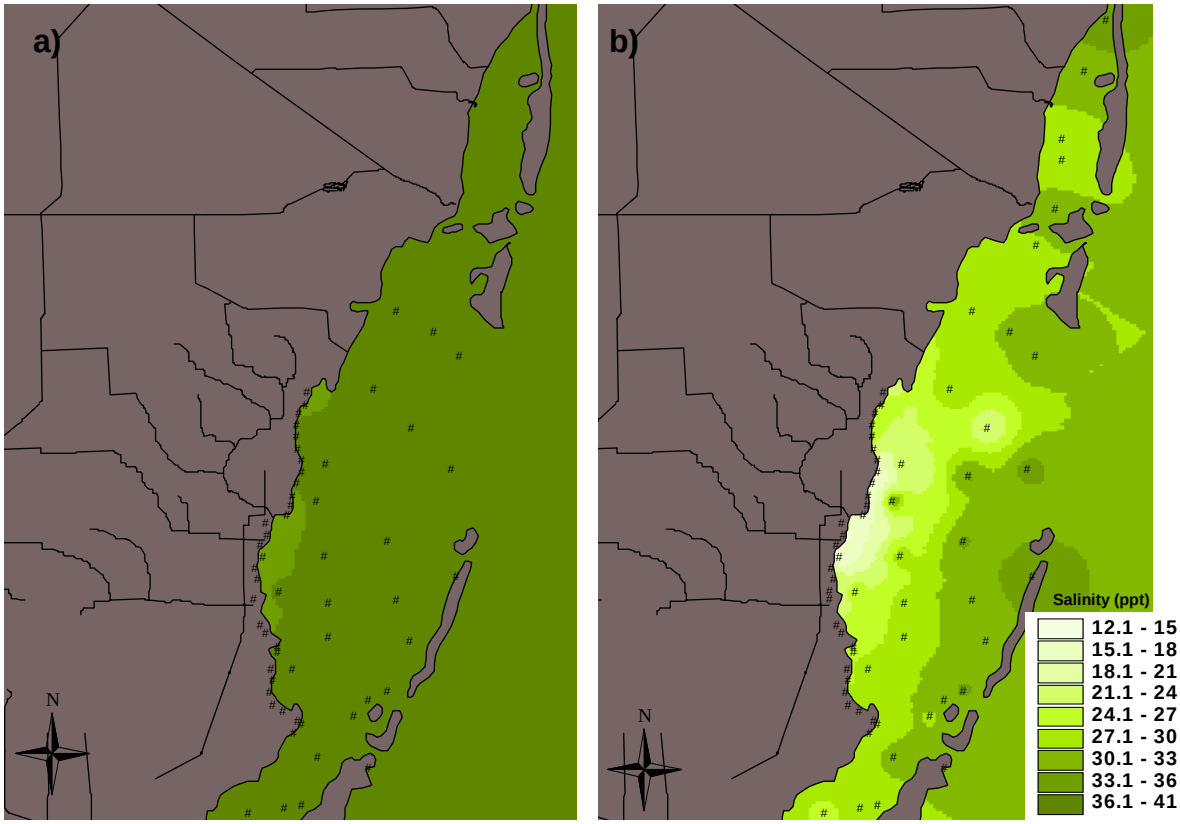

a)
b)
N
N
Salinity (ppt)
12.1 - 15
15.1 - 18
18.1 - 21
21.1 - 24
24.1 - 27
27.1 - 30
30.1 - 33
33.1 - 36
36.1 - 41

Fig. 13.

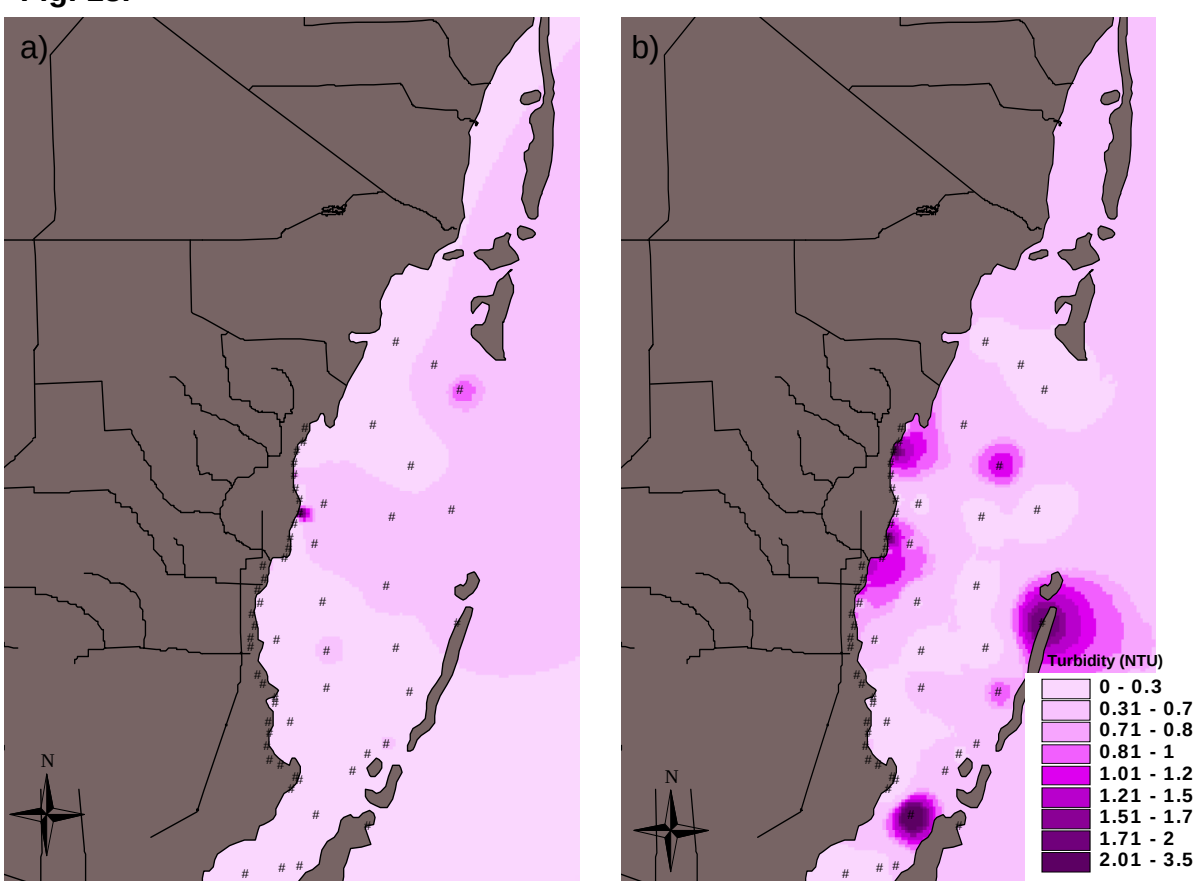

a)
b)
N
N
Turbidity (NTU)
0 - 0.3
0.31 - 0.7
0.71 - 0.8
0.81 - 1
1.01 - 1.2
1.21 - 1.5
1.51 - 1.7
1.71 - 2
2.01 - 3.5

Fig. 14.

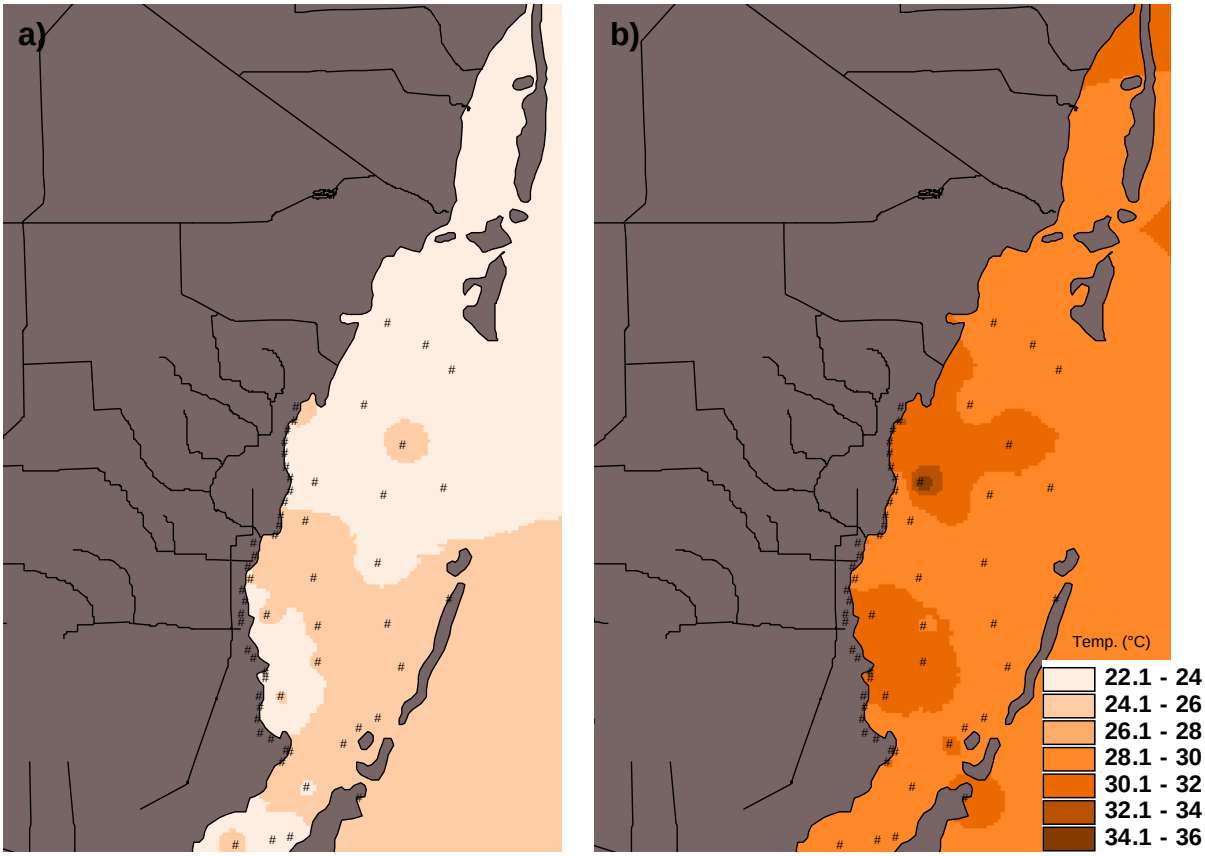

a)
b)
Temp. (°C)
22.1 - 24
24.1 - 26
26.1 - 28
28.1 - 30
30.1 - 32
32.1 - 34
34.1 - 36

Fig. 15.

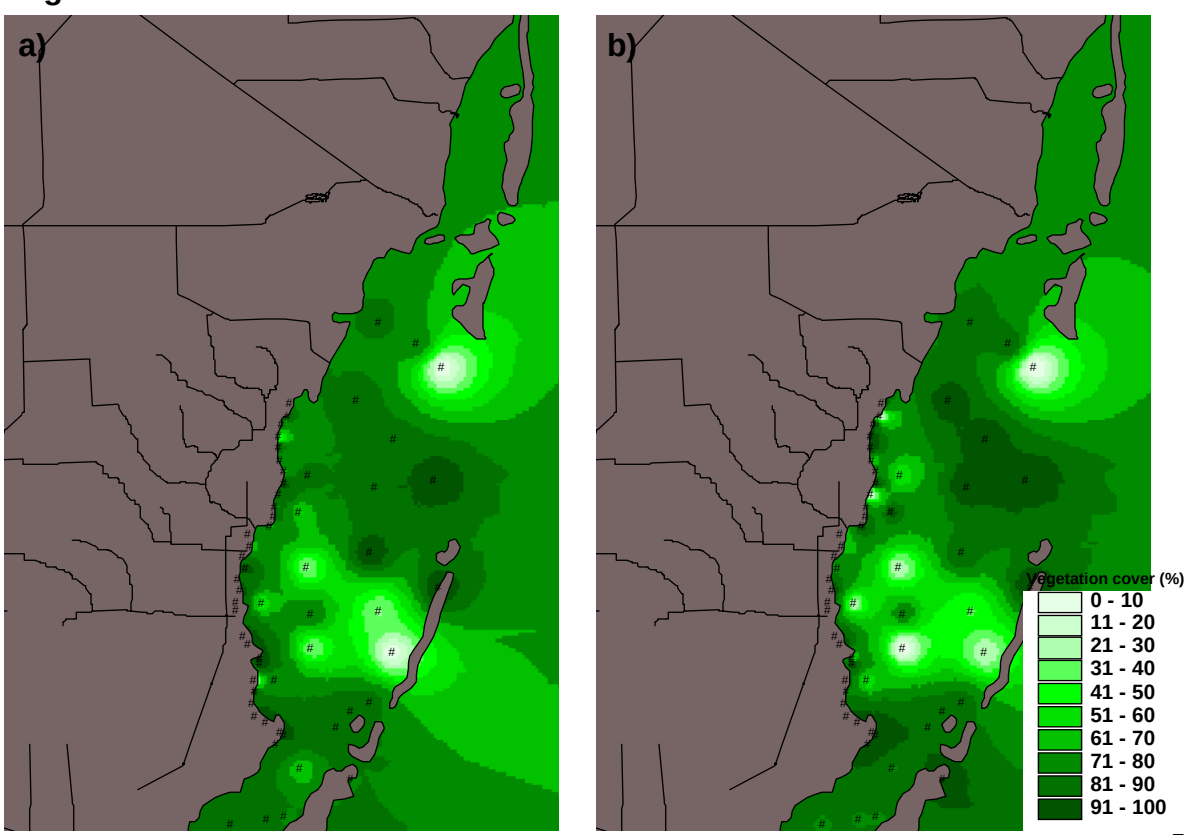

a)
b)
Vegetation cover (%)
0 - 10
11 - 20
21 - 30
31 - 40
41 - 50
51 - 60
61 - 70
71 - 80
81 - 90
91 - 100

Fig. 16

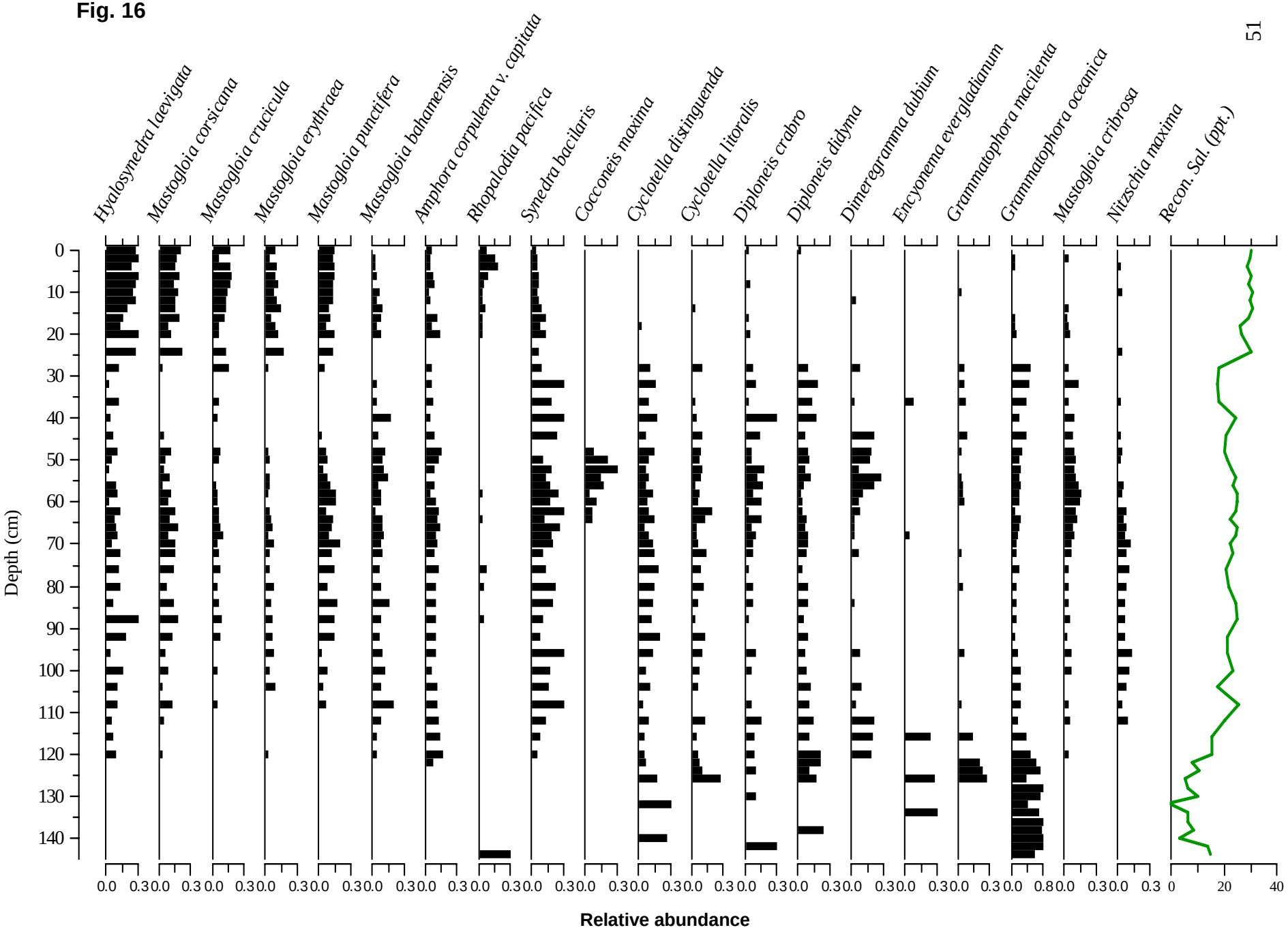

Hyalosynedra laevigata
Mastogloia corsicana
Mastogloia crucicula
Mastogloia erythraea
Mastogloia punctifera
Mastogloia bahamensis
Amphora corpulenta v. capitata
Rhopalodia pacifica
Synedra bacilaris
Cocconeis maxima
Cyclotella distinguenda
Cyclotella litoralis
Diploneis crabro
Diploneis didyma
Dimeregramma dubium
Encyonema evergladianum
Grammatophora macilenta
Grammatophora oceanica
Mastogloia cribrosa
Nitzschia maxima
Recon. Sal. (ppt.)
Depth (cm)
Relative abundance

Fig. 17

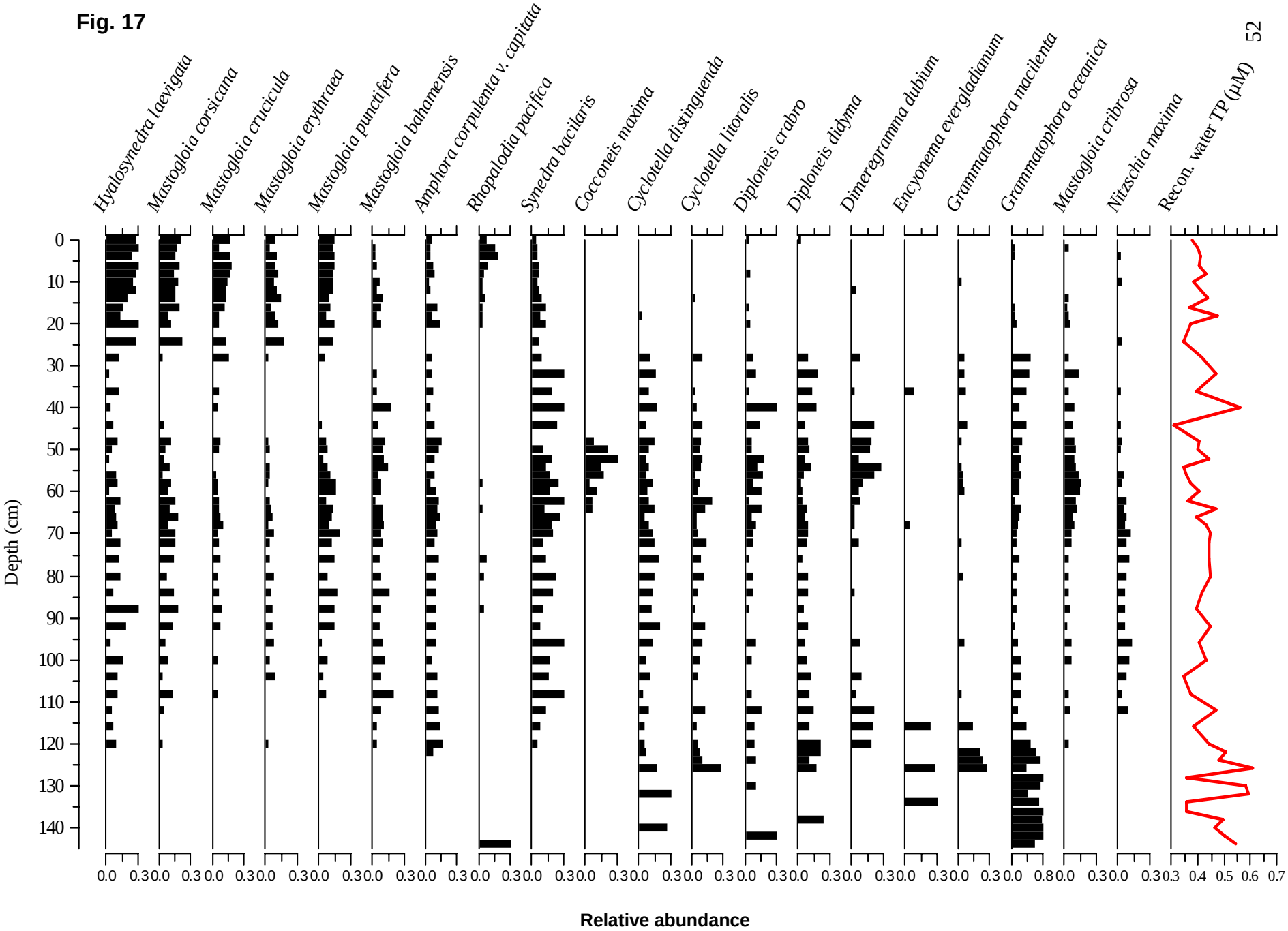
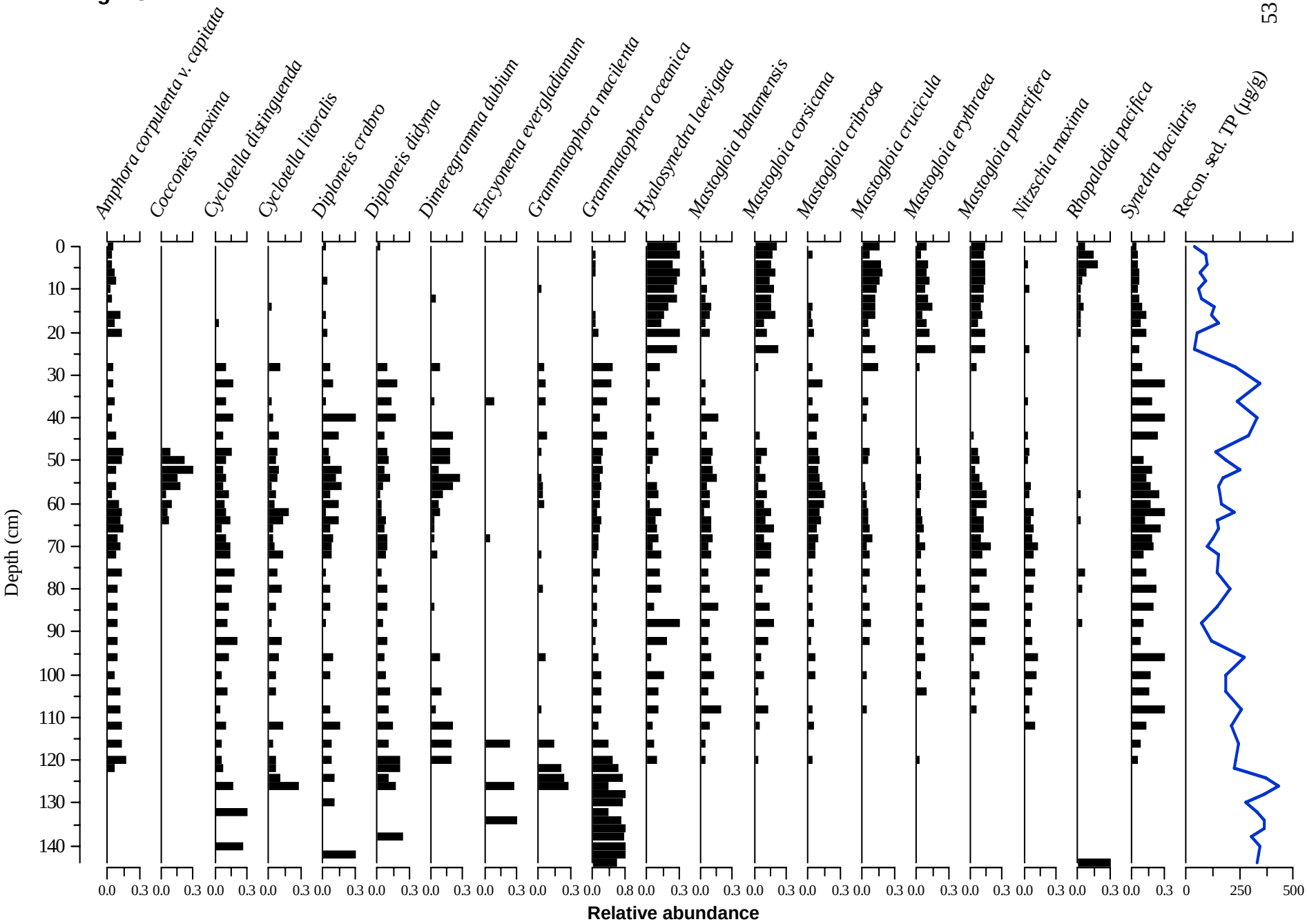

Hyalosynedra laevigata
Mastogloia corsicana
Mastogloia crucicula
Mastogloia erythraea
Mastogloia punctifera
Mastogloia bahamensis
Amphora corpulenta v. capitata
Rhopalodia pacifica
Synedra bacilaris
Cocconeis maxima
Cyclotella distinguenda
Cyclotella litoralis
Diploneis crabro
Diploneis didyma
Dimeregramma dubium
Encyonema evergladianum
Grammatophora macilenta
Grammatophora oceanica
Mastogloia cribrosa
Nitzschia maxima
Recon. water TP (µM)
Depth (cm)
Relative abundance

Fig. 18


Amphora corpulenta v. capitata
Cocconeis maxima
Cyclotella distinguenda
Cyclotella litoralis
Diploneis crabro
Diploneis didyma
Dimeregramma dubium
Encyonema evergladianum
Grammatophora macilenta
Grammatophora oceanica
Hyalosynedra laevigata
Mastogloia bahamensis
Mastogloia corsicana
Mastogloia cribrosa
Mastogloia crucicula
Mastogloia erythraea
Mastogloia punctifera
Nitzschia maxima
Rhopalodia pacifica
Synedra bacilaris
Recon. sed. TP (µg/g)
Depth (cm)
Relative abundance

XI. PLATE LEGENDS

Plate 1. Digital photographs of diatom taxa significantly associated with the dry season planktonic habitat of Zone 1. Scale bar = 10µm. 1) *Entomoneis peludosa,* 2) *Thalassiophysa hyalina* var. *Insecta,* 3) *Entomoneis* cf. *pseudoduplex,* 4) *Cocconeis* sp. 01FB, 5) *Microtabella* sp. 01BB, 6) *Microtabella interrupta,* 7) *Nitzschia microcephala,* 8) *Amphora coffeaeformis,* 9) *Hyalosynedra laevigata,* 10) *Pleurosigma* cf. *elongata,* 11) *Licmophora pfannkucheae,* 12) *Reimerotrix floridensis,* 13) *Nitzschia longissima* var. *parva.*

Plate 2. Digital photographs of diatom taxa significantly associated with the dry season epiphytic habitat of Zone 1. Scale bar = 10µm. 1) *Nitzschia libentruthii,* 2) *Nitzshia dissipata* var. *media,* 3) *Cocconeis placentula,* 4) *Cocconeis woodii,* 5) *Amphora* sp. 05BB, 6) *Amphora* sp. 05FB, 7) *Amphora tenerrima,* 8) *Mastogloia pusilla,* 9) *Navicula durrenbergiana,* 10) *Hyalosynedra laevigata* var. *angusta.*

Plate 3. Digital photographs of diatom taxa significantly associated with the dry season benthic habitat of Zone 1. Scale bar = 10µm. 1) *Rhopalodia gibberula,* 2) *Rhopalodia pacifica,* 3) *Rhabdonema adriaticum,* 4) *Grammatophora oceanica,* 5) *Cyclotella distinguenda,* 6) *Amphora* cf. *proteus,* 7) *Amphora floridae,* 8) *Seminavis latior,* 9) *Seminavis robusta.*

Plate 4. Digital photographs of diatom taxa significantly associated with the dry season benthic habitat of Zone 1. Continuation: 10) *Mastogloia erythraea,* 11) *Mastogloia pisciculus,* 12) *Mastogloia crucicula,* 13) *Mastogloia ovalis,* 14) *Oestrupia powellii,* 15) *Caloneis excentrica,* 16) *Frustulia* sp. 01L.

Plate 5. Digital photographs of diatom taxa significantly associated with the dry season planktonic habitat of Zone 2. Scale bar = 10µm. 1) *Microtabella* sp. *01BB,* 2) *Microtabella interrupta,* 3) *Haslea ostrearia,* 4) *Licmophora* cf. *debilis,* 5) *Thalassiophysa hyalina* var.

insecta, 6) *Striatella unipunctata,* 7) *Amphora* cf *laevis,* 8) *Nitzschia closterium,* 9) *Licmophora pfannkucheae,* 10) *Reimerotrix floridensis,* 11) *Nitzschia longissima* var. *parva.*

Plate 6. Digital photographs of diatom taxa significantly associated with the dry season epiphytic habitat of Zone 2. Scale bar = 10µm. 1) *Seminavis delicatula,* 2) *Licmophora* cf. *proboscidea,* 3) *Neosynedra tortosa,* 4) *Licmophora remulus,* 5) *Synedra fulgens,* 6) *Cocconeis placentula,* 7) *Amphora* sp. 05BB, 8) *Mastogloia barbadensis,* 9) *Mastogloia crucicula,* 10) *Mastogloia ovalis,* 11) *Mastogloia cyclops,* 12) *Brachysira aponina,* 13) *Nitzshia dissipata* var. *Media,* 14) *Nitzschia angularis.*

Plate 7. Digital photographs of diatom taxa significantly associated with the dry season benthic habitat of Zone 2. Scale bar = 10µm. 1) *Dimeregramma dubium,* 2) *Rhopalodia pacifica,* 3) *Grammatophora* cf. *angulosa,* 4) *Grammatophora oceanica,* 5) *Amphora corpulenta* var. *capitata,* 6) *Amphora caribaea,* 7) *Diploneis suborbicularis,* 8) *Mastogloia ovata,* 9) *Cymatosira lorenziana,* 10) *Oestrupia powellii,* 11) *Mastogloia rostellata.*

Plate 8. Digital photographs of diatom taxa significantly associated with the dry season benthic habitat of Zone 2. Continuation: 12) *Diploneis smithii, 13) Mastogloia varians, 14) Mastogloia delicatula,* 15) *Nitzschia marginulata* var. *didyma,* 16) *Cocconeis* sp. 01FB*, 17) Diploneis crabro, 18) Mastogloia lacrimata,* 19) *Frustulia* sp. 01L, 20) *Synedra bacillaris,* 21) *Mastogloia bahamensis,* 22) *Mastogloia corsicana, 23) Mastogloia punctifera.*

Plate 9. Digital photographs of diatom taxa significantly associated with wet season planktonic habitat of Zone 1. Scale bar = 10µm. 1) *Synedra* sp. 03BB, 2) *Licmophora normaniana,* 3) *Cyclotella choctawhatcheana,* 4) *Thalassiophysa hyalina* var. *insecta.*

Plate 10. Digital photographs of diatom taxa significantly associated with the wet season epiphytic habitat of Zone 1. Scale bar = 10µm. 1) *Brachysira aponina,* 2) *Cocconeis placentula,* 3) *Amphora tenerrima,* 4) *Mastogloia cyclops,* 5) *Navicula durrenbergiana.*

Plate 11. Digital photographs of diatom taxa significantly associated with the wet season benthic habitat of Zone 1. Scale bar = 10µm. 1) *Diploneis crabro,* 2) *Mastogloia* cf. *strigilis,* 3) *Diploneis didyma,* 4) *Caloneis excentrica,* 5) *Cyclotella distinguenda,* 6) *Grammatophora oceanica,* 7) *Hyalosynedra laevigata,* 8) *Rhopalodia pacifica,* 9) *Mastogloia bahamensis,* 10) *Fragilaria geocollegarum,* 11) *Amphicocconeis disculoides, 12) Mastogloia crucicula.*

Plate 12. Digital photographs of diatom taxa significantly associated with the wet season planktonic habitat of Zone 2. Scale bar = 10µm. 1) *Chaetoceros* sp. 02BB, 2) *Gyrosigma* sp. 01BB, 3) *Nitzschia sigma,* 4) *Nitzschia closterium,* 5) *Reimerothrix floridensis,* 6) *Synedra* sp. 03BB, 7) *Cyclotella choctawhatcheana,* 8) *Amphora abludens,* 9) *Amphora* cf. *leavis,* 10) *Entomoneis pseudoduplex,* 11) *Microtabella* sp. 01BB, 12) *Microtabella interrupta,* 13) *Navicula durrenbergiana,* 14) *Haslea* cf. *ostrearia.*

Plate 13. Digital photographs of diatom taxa significantly associated with the wet season epiphytic habitat of Zone 2. Scale bar = 10µm. 1) *Mastogloia Corsicana,* 2) *Mastogloia barbadensis,* 3) *Seminavis delicatula,* 4) *Amphora tenerrima,* 5) *Cocconeis placentula,* 6) *Mastogloia ovalis,* 7) *Mastogloia crucicula,* 8) *Mastogloia punctifera,* 9) *Mastogloia pseudolatecostata,* 10) *Synedra bacillaris.*

Plate 14. Digital photographs of diatom taxa significantly associated with the wet season benthic habitat of Zone 2. Scale bar = 10µm. 1) *Amphora caribaea,* 2) *Amphora hamata,* 3) *Amphora graeffeana* var. F02, 4) *Amphora indentata,* 5) *Amphora corpulenta* var. *capitata,* 6) *Seminavis robusta,* 7) *Nitzschia marginulata* var. *didyma,* 8) *Amphora gramenosum,* 9) *Nitzschia*

grossestriata, 10) *Dimeregramma dubium*, 11) *Diploneis vacilans*, 12) *Fragilaria geocollegarum*, 13) *Diploneis chersonensis*, 14) *Navicula directa.*

Plate 15. Digital photographs of diatom taxa significantly associated with the wet season benthic habitat of Zone 2. Continuation: 15) *Mastogloia lacrimata*, 16) *Mastogloia bahamensis*, 17) *Cymatosira lorenziana*, 18) *Mastogloia emarginata*, 19) *Rhopalodia pacifica*, 20) *Mastogloia* cf. *strigilis.*

Plate 1.

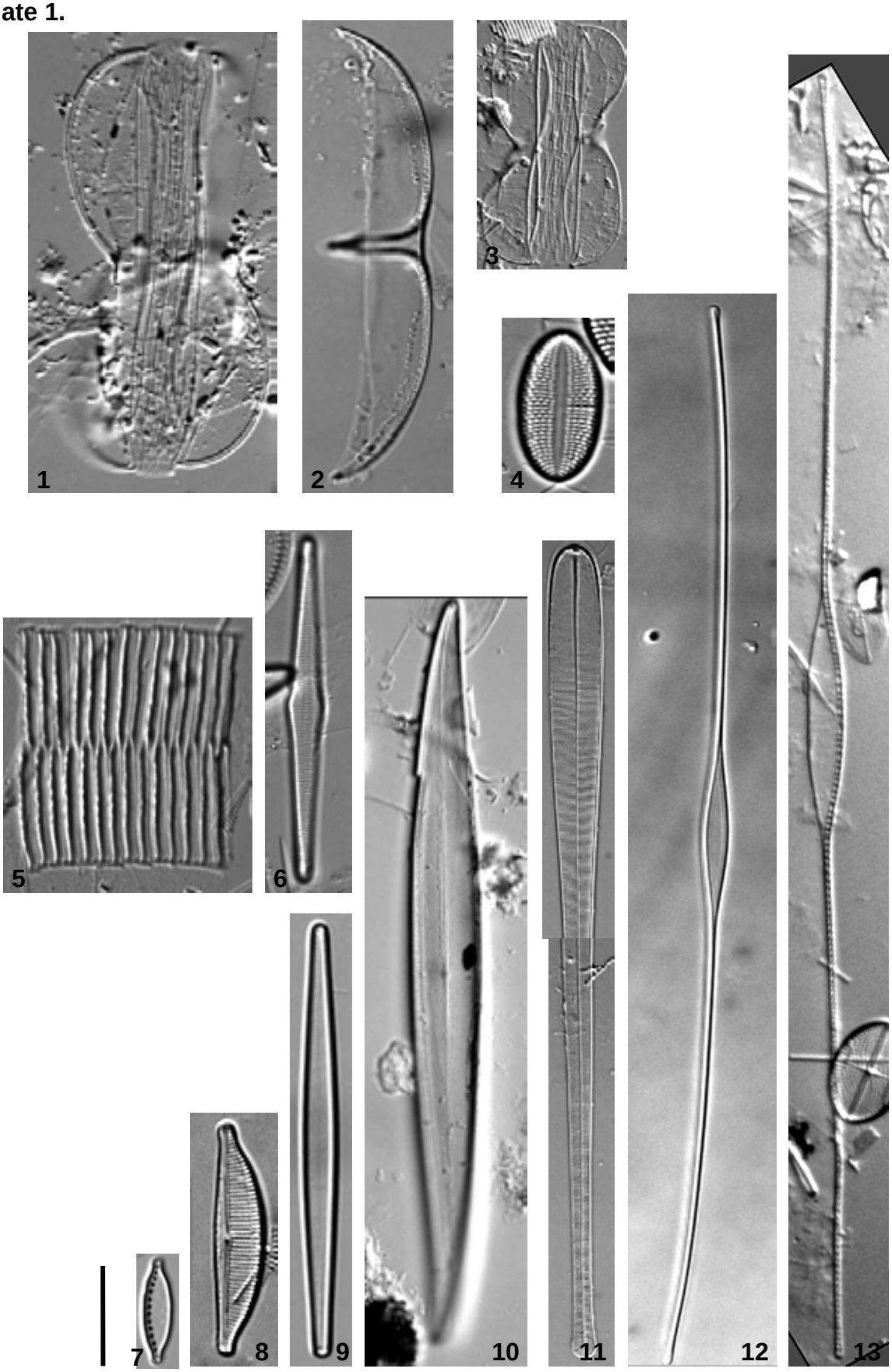


Plate 2.

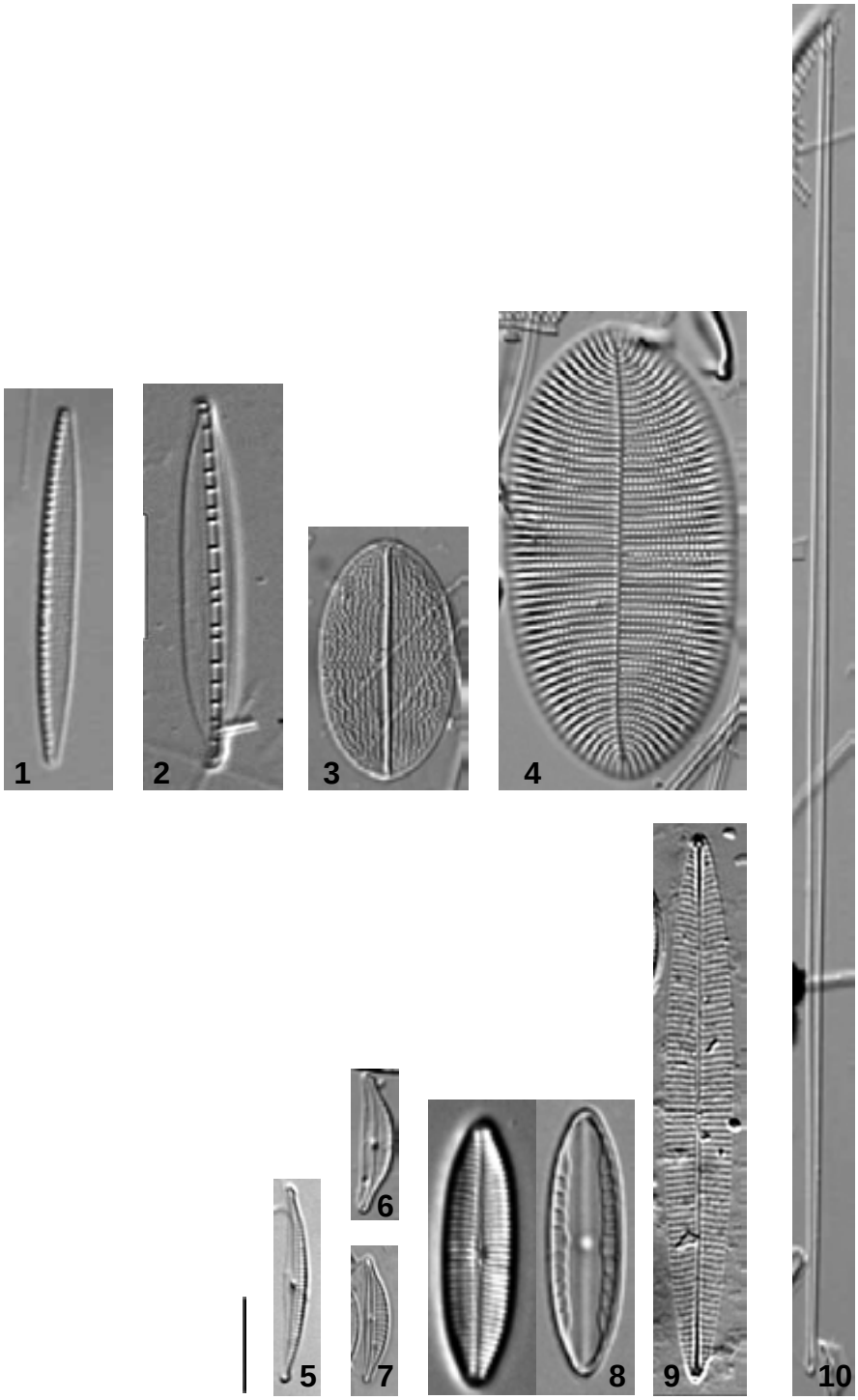


Plate 3.

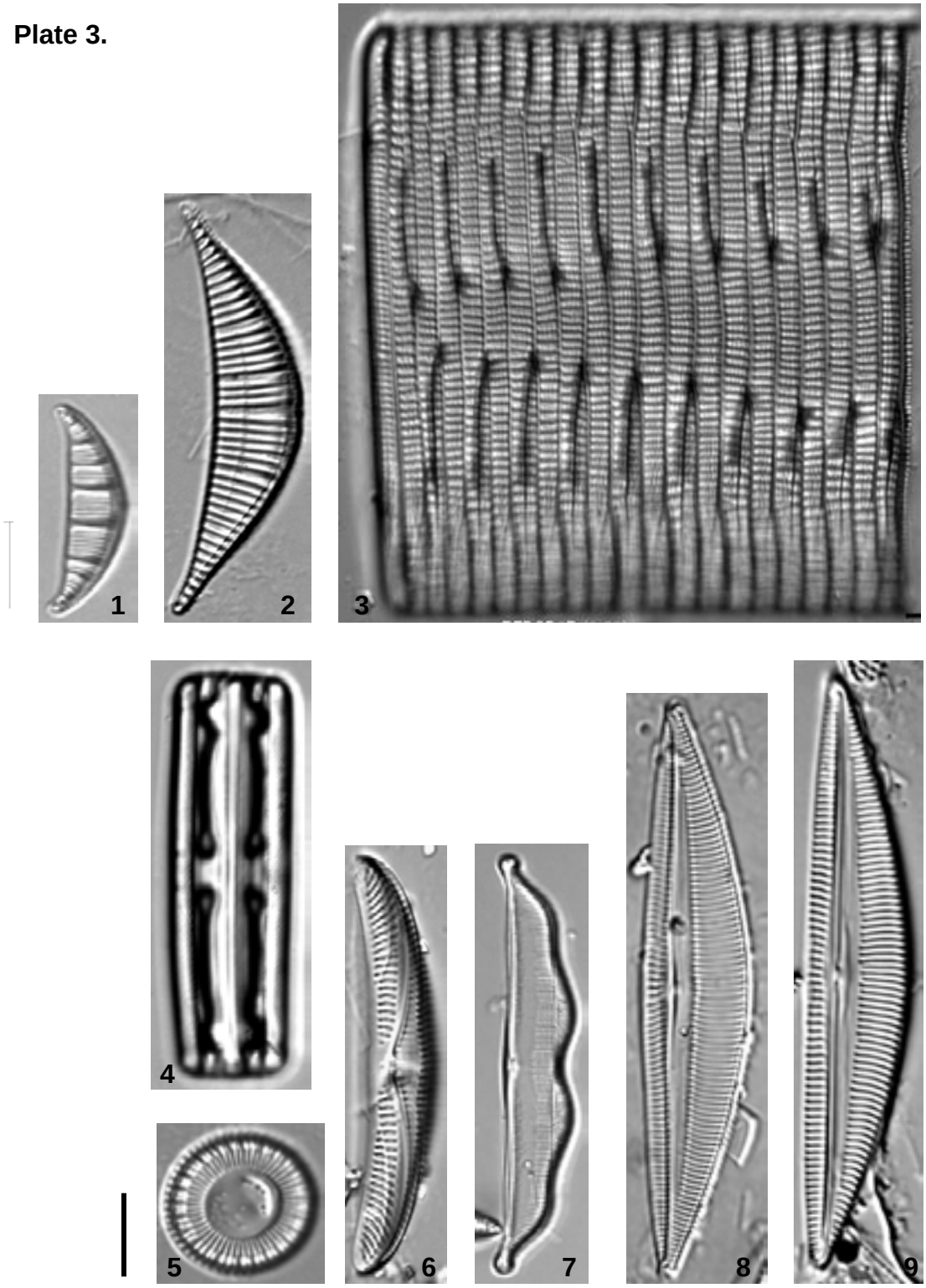


Plate 4.

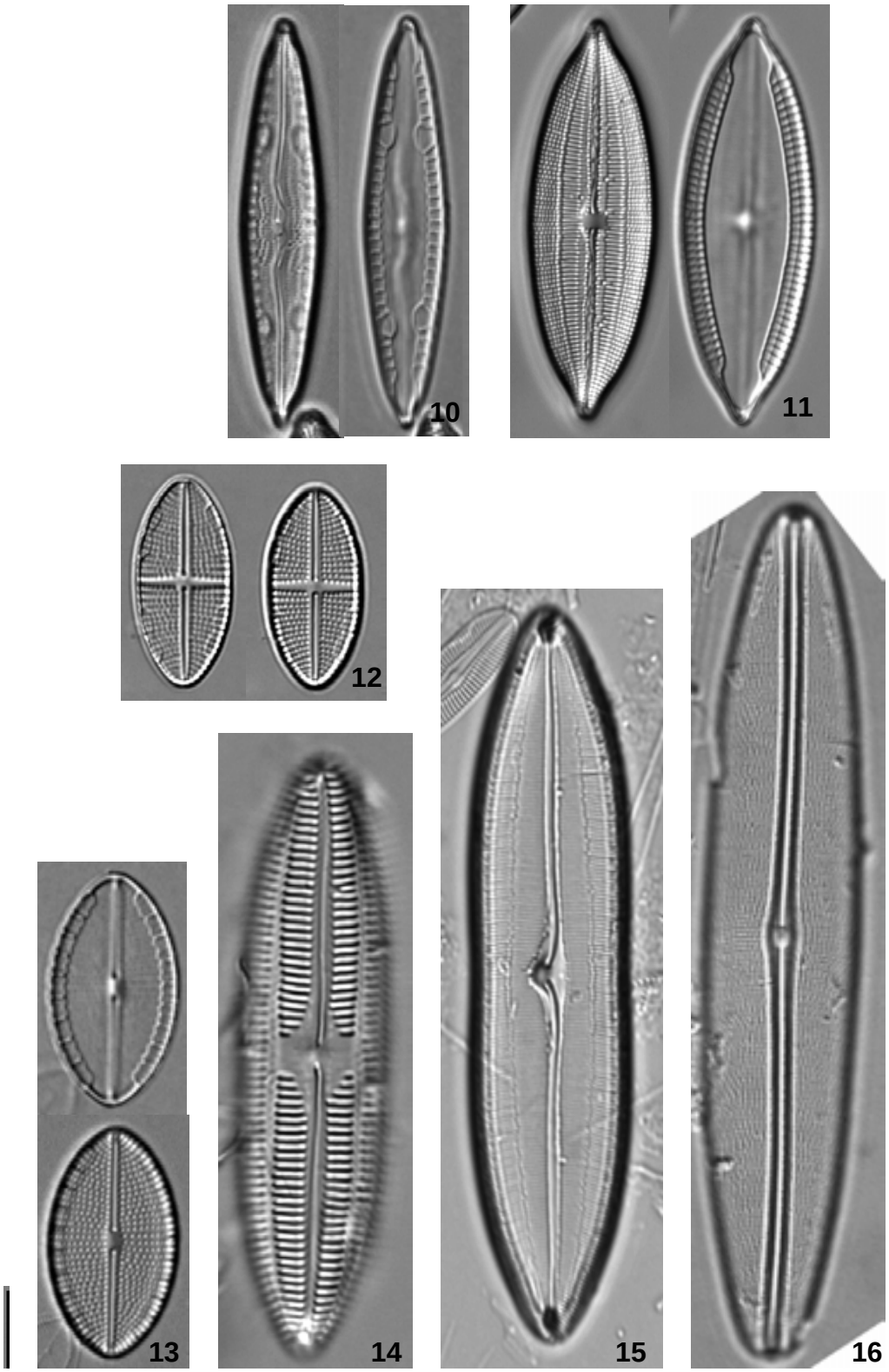


Plate 5.

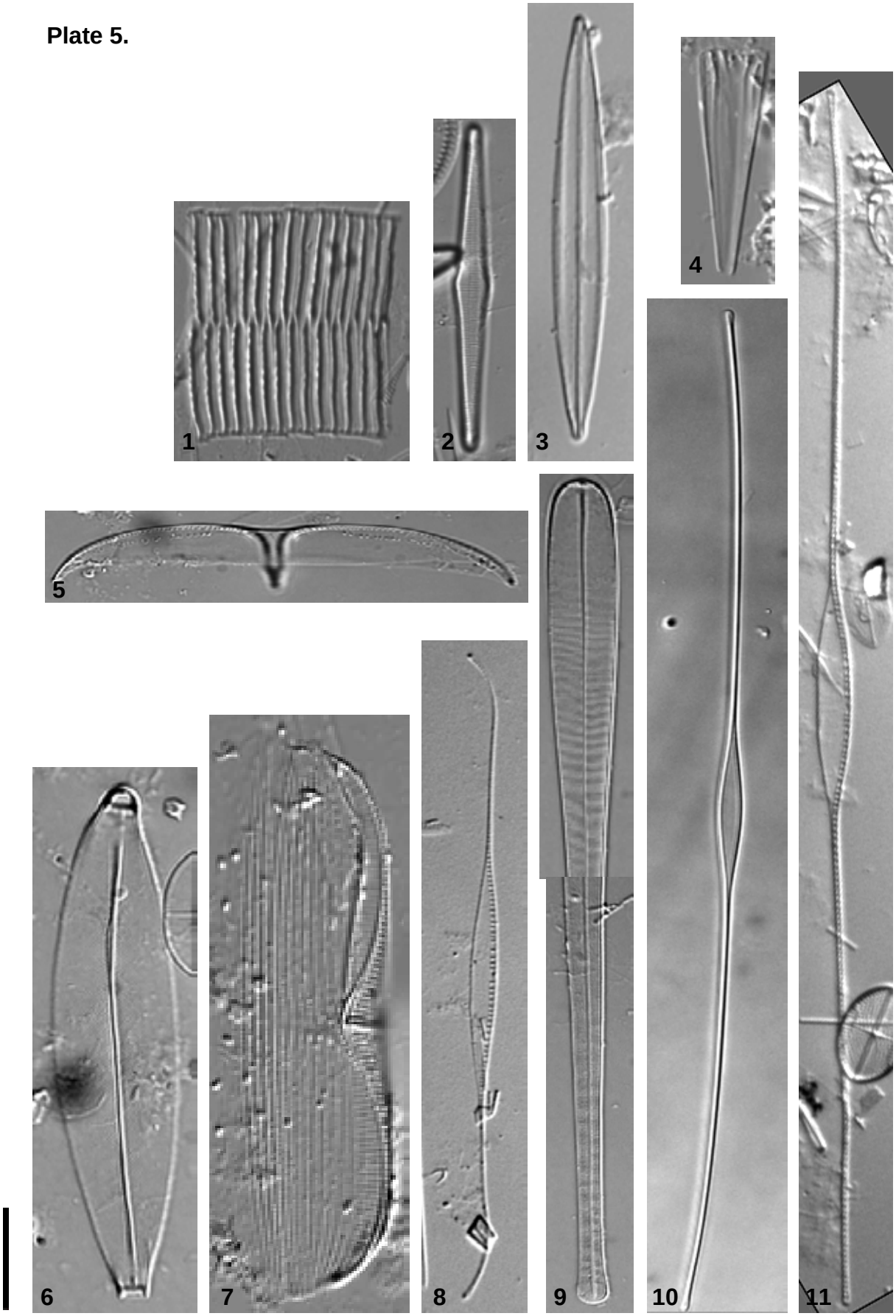


Plate 6.

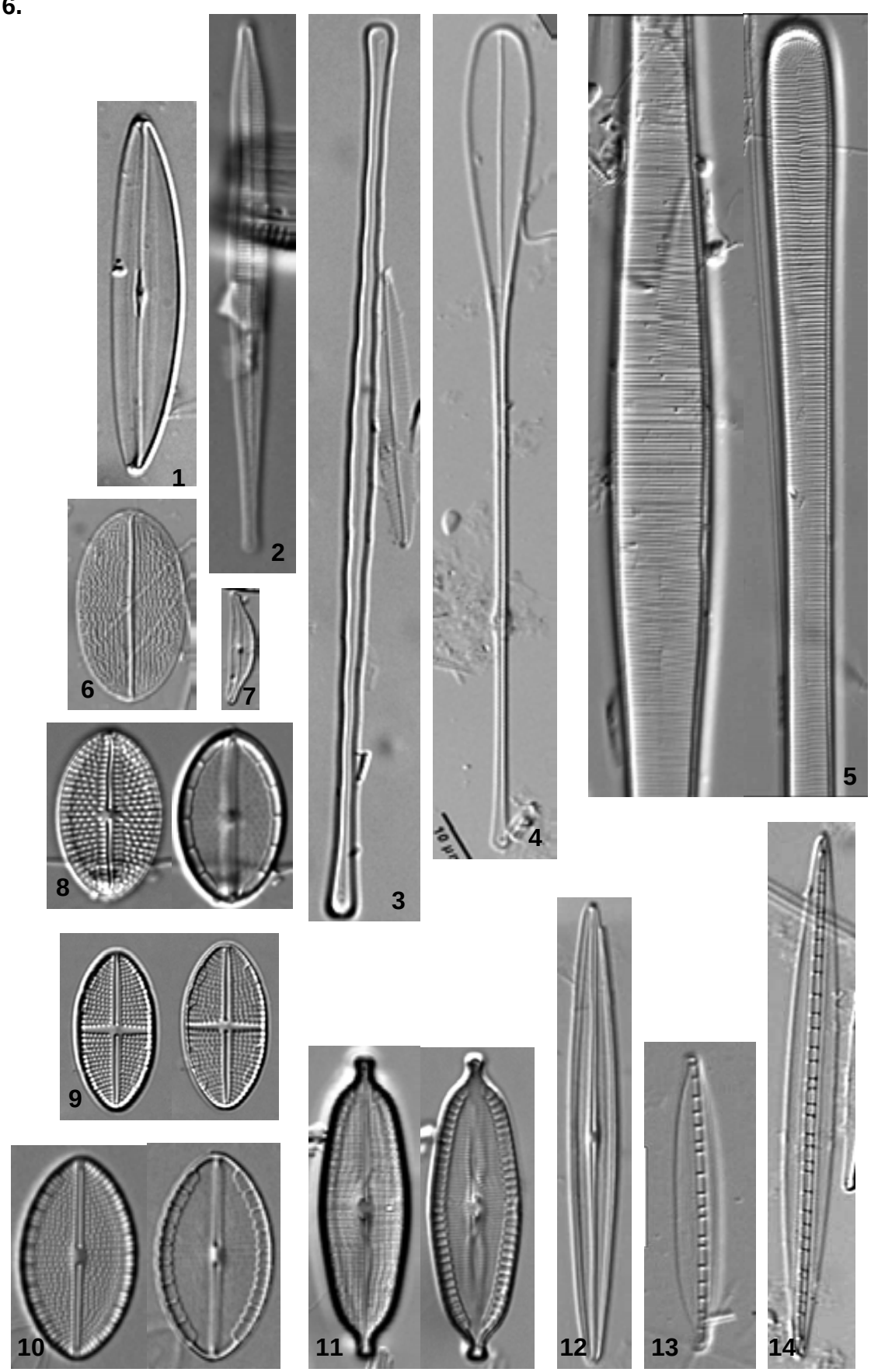


Plate 7.

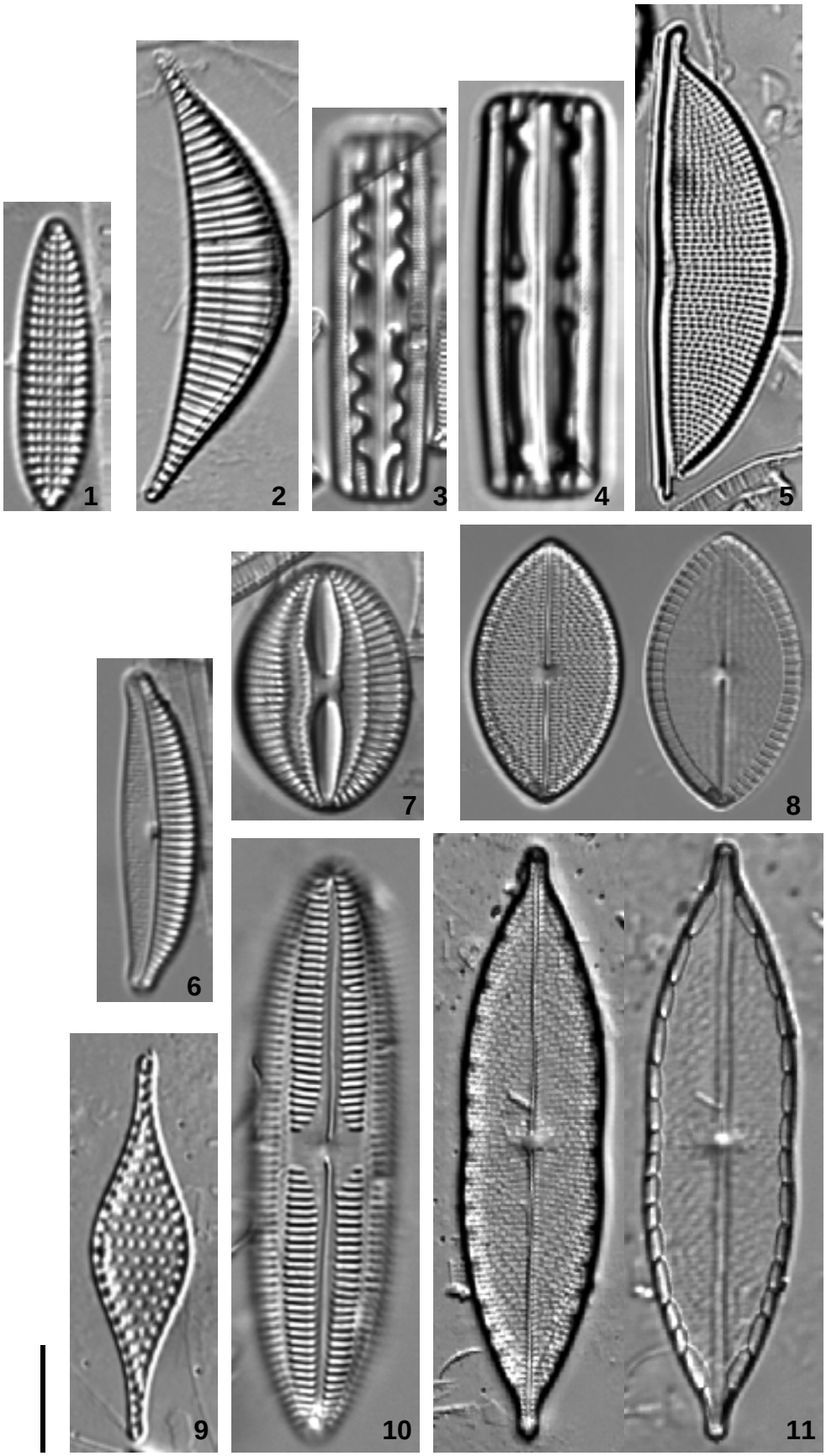


Plate 8.

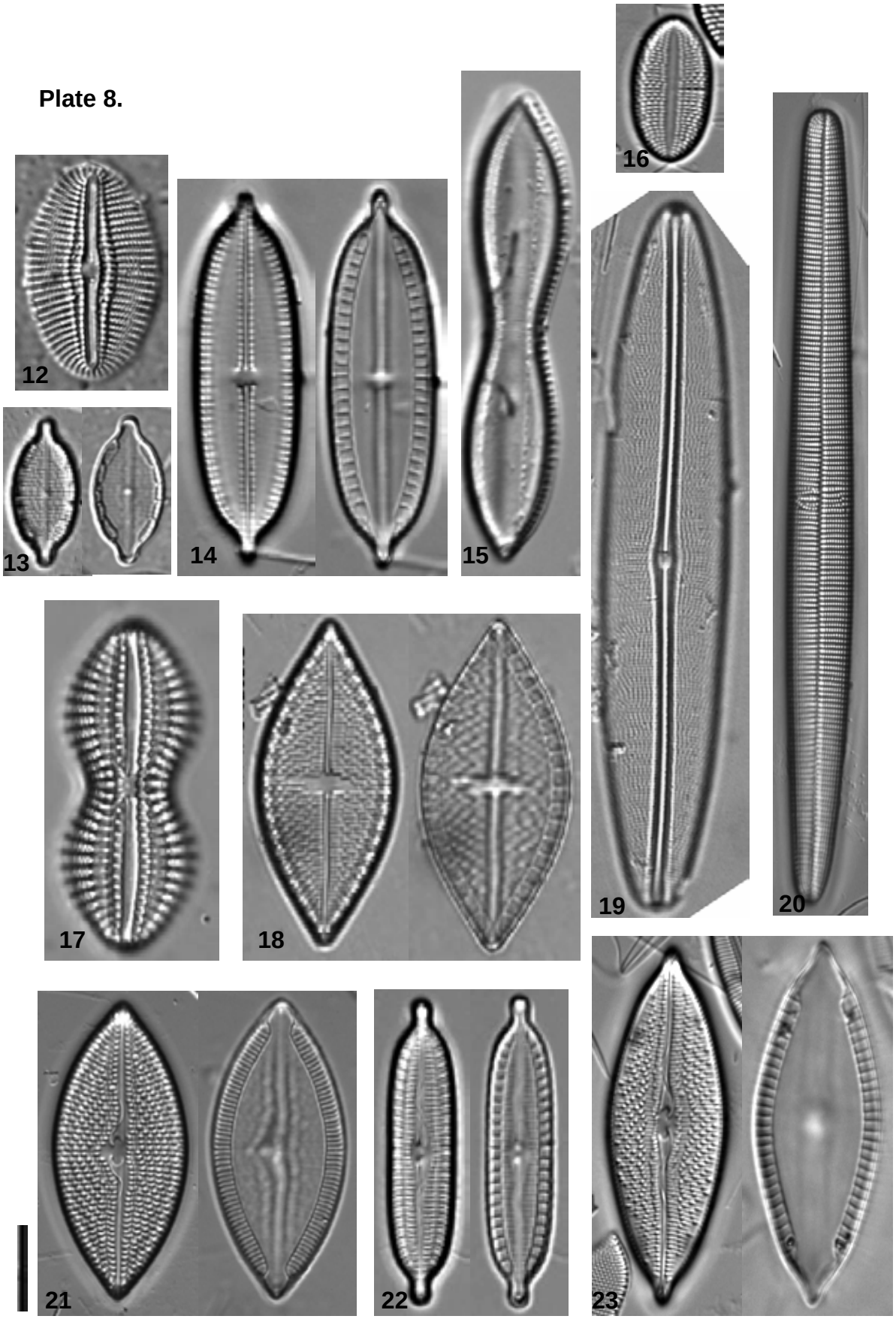


Plate 9.

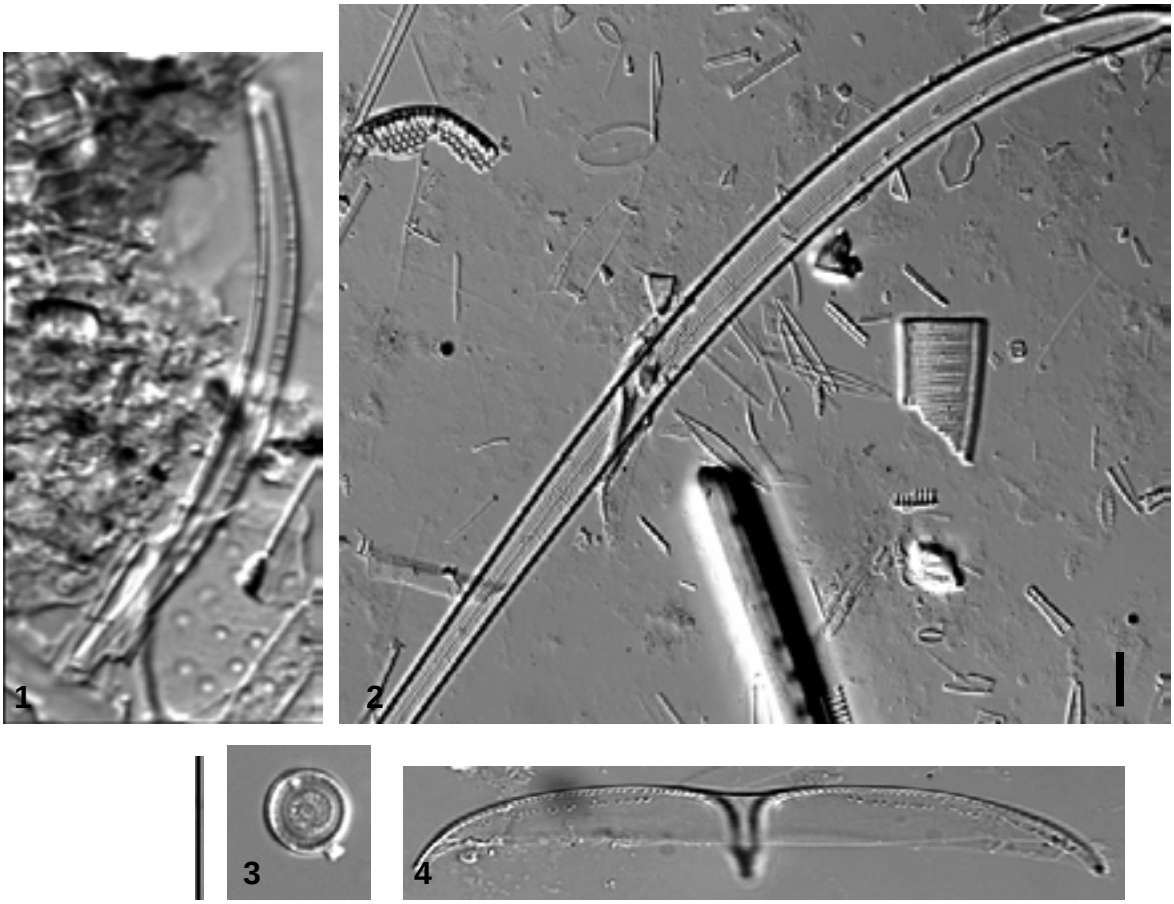
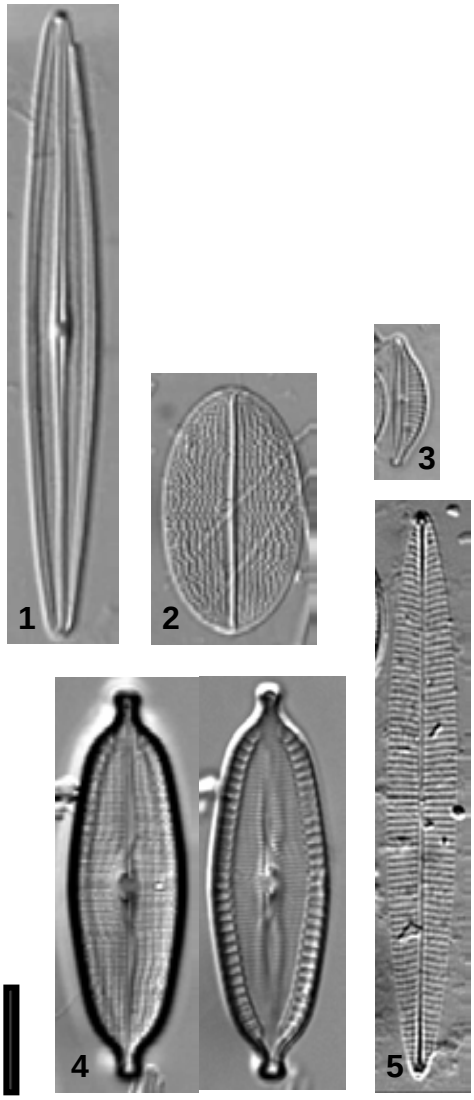


Plate 10.



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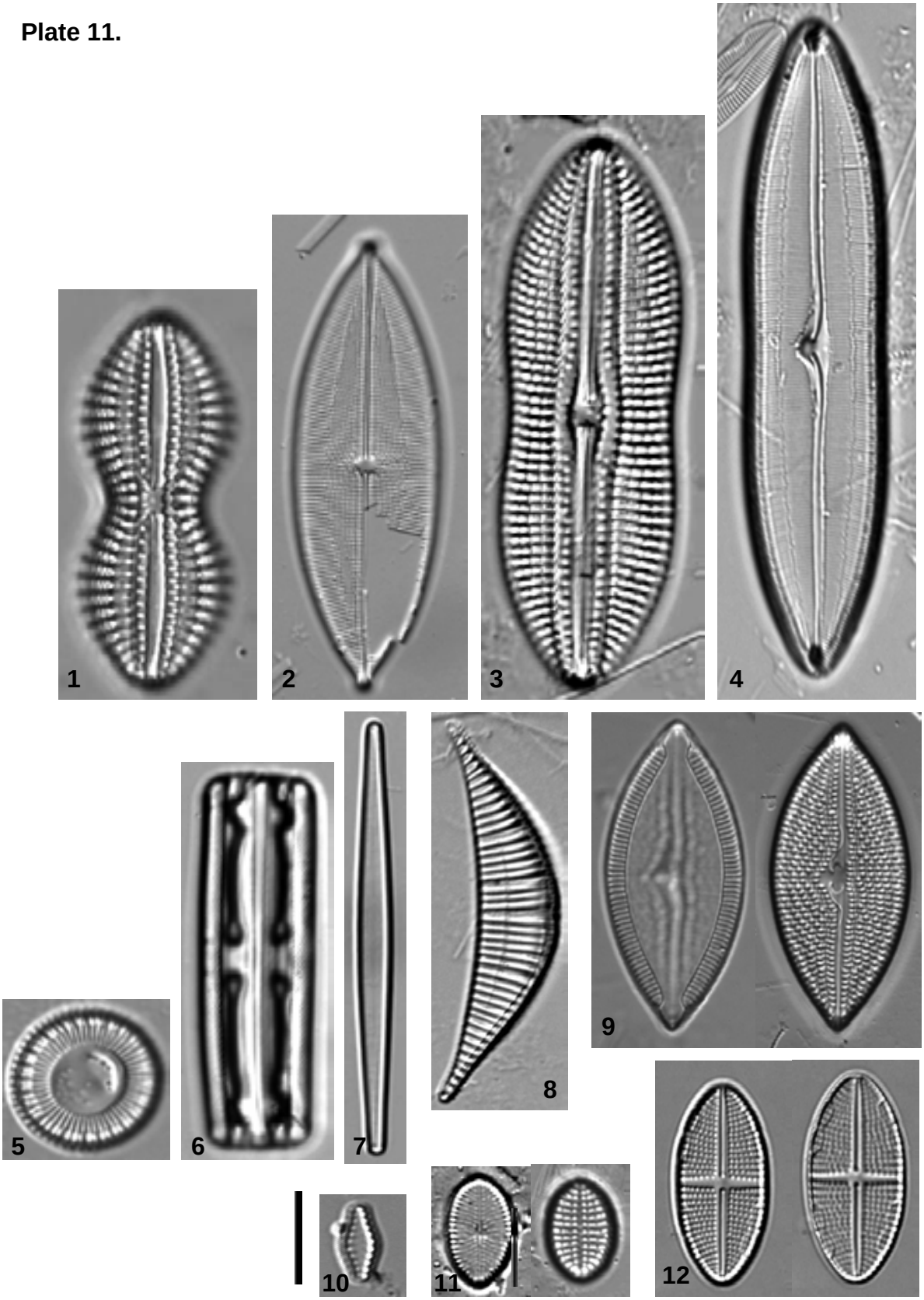

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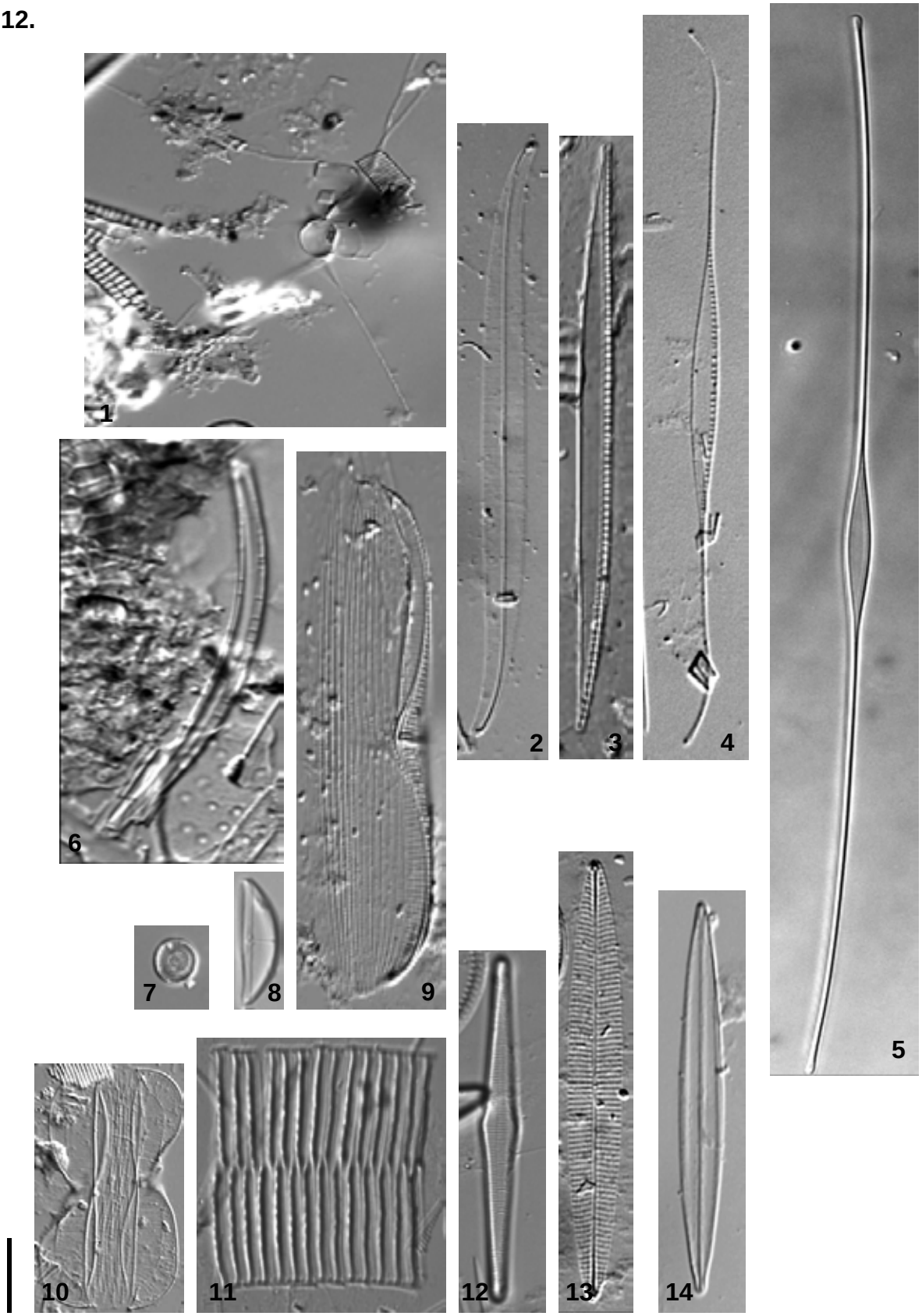

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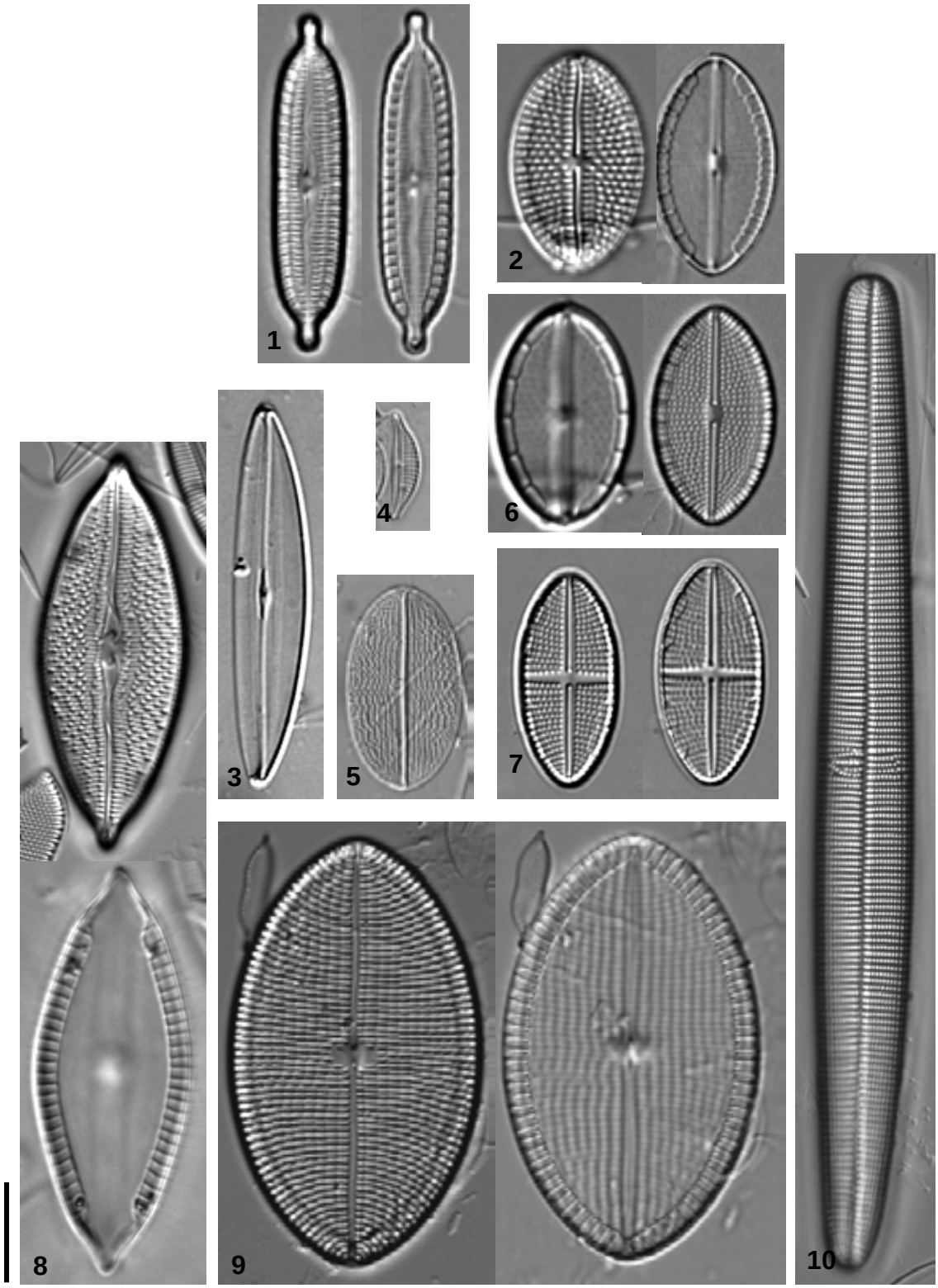

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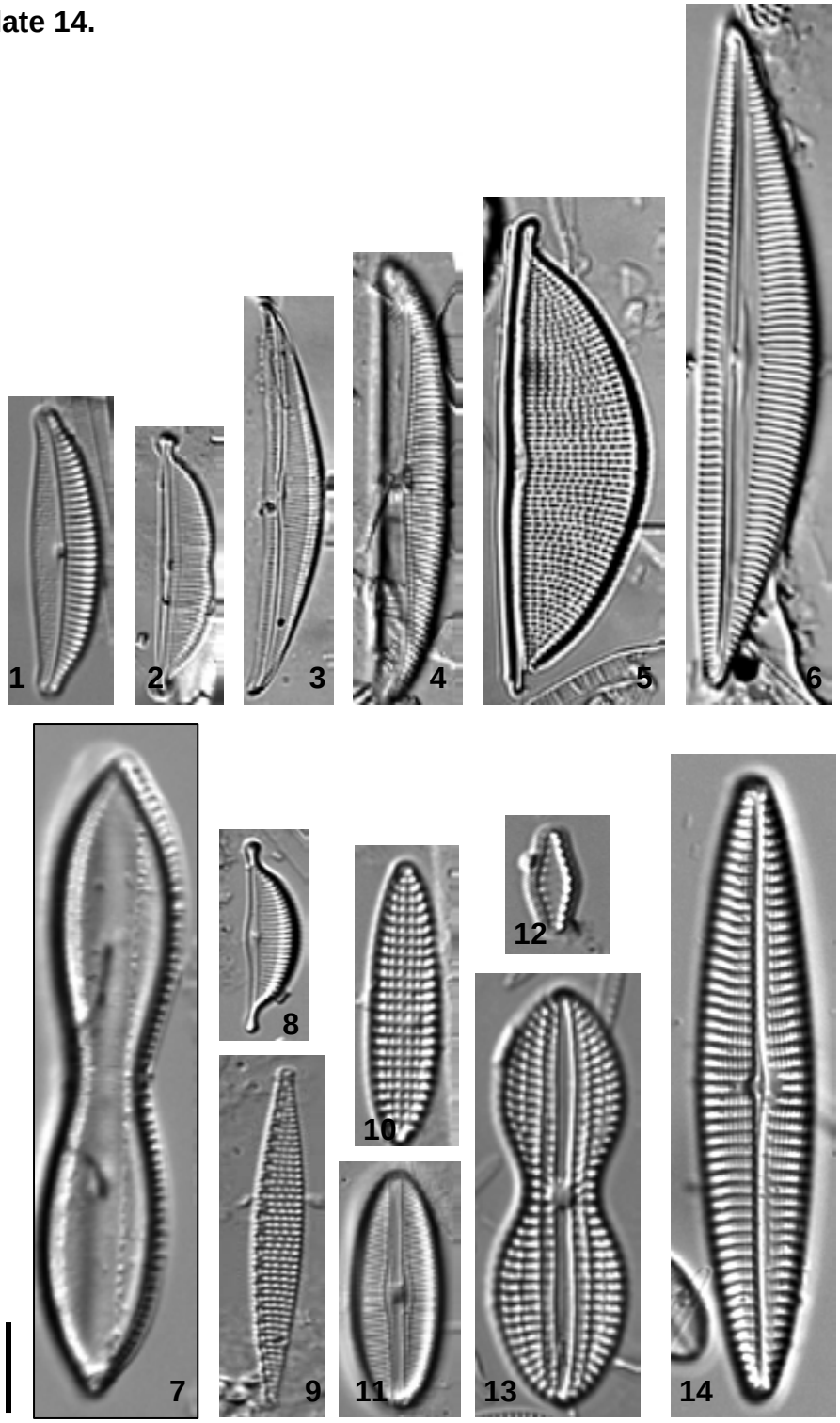
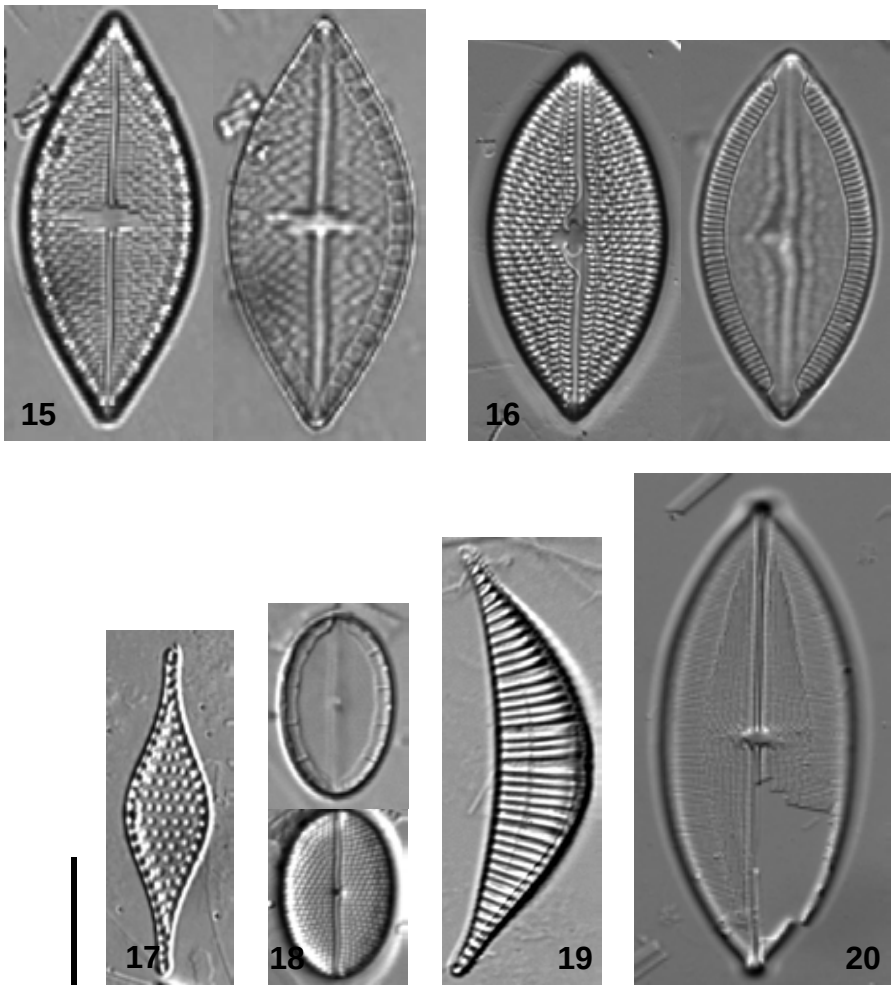


Plate 15.



XIII. APPENDIX 1

Literature used to identify diatoms in Biscayne Bay

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