PROJECT TITLE: A MULTI-METRIC SITE EVALUATION TOOL FOR RESTORATION OF NEW JERSEY'S TIDALLY INFLUENCED WETLANDS

GRANTEE ORGANIZATION NAME: NJ DEPARTMENT OF ENVIRONMENTAL PROTECTION

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Abstract:

Wetland restoration is a complex science that attempts to facilitate positive changes in ecologic function via changes in integrated physical and biologic structure. Although wetland ecology is driven by a suite of interactive factors, frequently, a single parameter or metric is used to determine the restoration goals and measures of a project. Additionally, restoration and/or mitigation targets may be set and evaluated without a complete understanding of appropriate reference conditions the project is proposing to duplicate. As interest in adaptive restoration (focusing on resilience to sea level rise and storm impacts) grows, it is vital to provide information to correctly characterize baseline and changing conditions of the wetland being manipulated relative toa relevant natural or reference condition for greater resilience. Precise evaluation of condition, function, and structure will allow for greater refinement in project design, effective monitoring plan development, and adaptive management strategies to achieve the target goals and objectives. The goals of this effort were to: 1) fill gaps in tidal wetland reference data in New Jersey, and 2) increase the accessibility of monitoring data to the public. This was accomplished by: 1) developing the NJ Reference Wetland Tool database; 2) filling data gaps on tidal wetland hydrology and water quality; 3) adding a long-term monitoring site in the Raritan River; and 3) developing tools that will assist standardized data collection in the future.

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Overview of Need

New Jersey has led the nation in the protection of wetlands through identification, acquisition, and regulation. Examples include the delineation of tidal wetlands in the 1970s, coastal wetland regulations (1970), freshwater wetland regulations (1986), and the acquisition of wetlands through federal, state, and local programs. More recently, additional effort has been applied to long-term monitoring and the collection of data and information on reference conditions. In 2007 New Jersey released its report *Valuing New Jersey's Natural Capital: An Assessment of the Economic Value of the State's Natural Resources* which brought further attention to the ecosystem value of wetlands from a monetary perspective. While New Jersey has invested in wetlands restoration it has been through a relatively small number of projects and usually where there was an egregious environmental assault. While New Jersey's coastal wetlands are protected from outright destruction through regulation, they are not immune to the impacts of sea level rise, subsidence, and human impacts (ditching, dredging, diking, OMWM, erosion). Hurricane Sandy was momentous in focusing attention on a) the value of wetlands in protecting coastal development and b) the declining condition of wetlands. These realizations prompted greater attention on restoration opportunities in addition to protection (through acquisition and regulation). Protected wetlands were now being looked at as the staging area for restoration activities rather than being left in their 'natural condition'. Hurricane Sandy also ushered in federal funding and the opportunity to explore new restoration techniques focused on climate adaptation. While the federal funds and interest were a boon for restoration, there was limited timing to fully characterize the wetlands being restored and the techniques applied. The work being conducted by the state, federal and NGO partners in collecting data on various wetland parameters/metrics were not readily accessible to be used in determining the right approach (technique) or target for the restoration project. This project looked to provide a multi-metric tool (The NJ Reference Wetland Tool) that allows restoration practitioners the ability to identify the appropriate reference conditions (based on reference data), and targets on which to base their restoration project.

Project Goals & Tasks

This project's focus was on filling reference data gaps from tidal wetlands in New Jersey and making monitoring data more accessible to the public. This was accomplished by: 1) developing the NJ Reference Wetland Tool; 2) filling data gaps on tidal wetland hydrology and water quality; 3) adding a long-term monitoring site in the Raritan River; and 4) developing tools that will assist standardized data collection in the future.

Task 1: Adding New Jersey Reference Wetlands to a Regional Interactive Data Base

Reference Wetland Tool

NJDEP partnered with Riparia and the Center for Environmental Informatics (CEI) at Penn State to develop a multi-metric Reference Wetland Tool for tidal wetlands in New Jersey. The use of reference sites has become increasingly more common as scientists and resource managers search for reasonable and scientifically based methods to measure and describe the inherent variability in natural aquatic systems (e.g., Hughes et al. 1986[1]; Brooks and Hughes 1988[2], Kentula et al. 1992[3], Brooks et al. 2002[4]). The term reference wetlands is used to connote naturally occurring sites composed of wetland, stream, and riparian components that span a gradient of anthropogenic/human disturbance. The primary reasons to include reference sites in regional assessments and restoration efforts are the need to compare impacted or degraded sites to a least-impaired set of attributes or benchmarks, and to provide appropriate design and to inform the development of performance criteria for mitigation and restoration projects. The primary criterion for selecting reference sites involves identifying locations that represent ideal, relatively natural conditions (I.e., least disturbed), which is common for stream assessments (Karr and Chu 1999[5]). Sites can be chosen to represent the best attainable conditions for a particular region even though they may not be pristine (Smith et al. 1995[6]).

The Center for Environmental Informatics (CEI) at Penn State has pioneered advanced web approaches for a wide range of environmental and agricultural decision support tools. The tools combine interactive, feature-rich user interfaces with the underlying geospatial capability of web map server technology.

For this project, reference wetland data (biological and chemical) specific to New Jersey and collected through the NWCA, MACWA, and other initiatives were integrated into this Regional Interactive Tool.

a. Link to Tool: https://tools.cei.psu.edu/wetlands/njdep/
b. Link to User Guide: https://storymaps.arcgis.com/stories/caae4374e6ef48fe965efabec299c47e

The full report on the project developed by Penn State can be found in Appendix 1.

Evaluating Wetland Condition Using the Ecological Integrity Assessment (EIA) Method

Supplemental Funding was provided for a two-day training course, "Evaluating Wetland Condition Using the Ecological Integrity Assessment (EIA) Method." The field portion was not conducted due to complications arising from the COVID-19 pandemic restricting in-person attendance. Content for the EIA training was compiled in a "Field Manual for Applying Rapid Ecological Integrity Assessments in Wetlands and Riparian

[1] Hughes RM, Larsen DP, Omernik JM (1986) Regional reference sites: a method for assessing stream potentials. Environ Manage 10(5):629–635.
[2] Brooks, RP and RM Hughes. 1988. Guidelines for assessing the biotic communities of freshwater wetlands. Pages 276-282 in Proc. Nat. Wetland Mitigation Symp.: Mitigation of Impacts and Losses. Assoc. State Wetland Managers Tech. Rep. 3. 460pp.
[3] Kentula ME, Brooks RP, Gwin SE, Holland CC, Sherman AD, Sifneos JC (1992) Wetlands. An approach to improving decision making in wetland restoration and creation. Island Press, Washington, DC, 151pp.
[4] Brooks, RP, DH Wardrop, CA Cole, and KR Reisinger. 2002. Using reference wetlands for integrating wetland inventory, assessment, and restoration for watersheds. Pages 9-15 in RW Tiner (compiler). Watershed-based wetland planning and evaluation. A collection of papers from the Wetland Millennium Event, 6-12 August 2000, Quebec City, Quebec, Canada. Distrib. by Assoc. State Wetland Managers, Inc., Berne, NY. 141pp.
[5] Karr JR, Chu EW (1999) Restoring life in running waters. Better biological monitoring. Island Press, Washington, DC, 149pp.
[6] Smith RD, Ammann A, Bartoldus C, Brinson MM (1995) An approach for assessing wetland functions using hydrogeomorphic classification, reference wetlands, and functional indices. Wetlands research program technical report WRP-DE-9. U.S. Army Corps of Engineers, Waterways Experiment Station, Washington, DC, 79pp.

Areas in New Jersey", including field forms and a "New Jersey Wetland Ecological Integrity Assessment Calculator." Both products were adopted from the Washington Department of Natural Resources, Natural Heritage Program with permission from the authors. Kathleen Walz (NJ) and Joe Rocchio (WA) co-authored the 2016 EIA protocol (Faber-Langendoen et al. 2016 v2.08), and both developed EIA field forms and instructions for their respective states. Of note, the WA manual included updates to metrics and ratings that were more accurate to the most recent version of the EIA protocol. Upon review of the excellent WA field manual, and discussion with NatureServe and the WA Natural Heritage Program, a decision was made to simply modify the WA version for New Jersey. The EIA field manual, field forms, metric rating descriptions, and calculator – all of which form the basis for EIA training – are now available for use by practitioners conducting ecological integrity assessments of wetlands in New Jersey.

Citation for EIA Field Manual:

Rocchio, F. Joseph, Rex C. Crawford, Tynan Ramm-Granberg, and Kathleen S. Walz. 2022. Field Manual for Applying Rapid Ecological Integrity Assessments in Wetlands and Riparian Areas in New Jersey. "This manual is adopted from the Washington Department of Natural Resources, Natural Heritage Program EIA manual Version 1.2. Only minor changes were made to make the manual geographically relevant." New Jersey Department of Environmental Protection, Office of Natural Lands Management, New Jersey Natural Heritage Program, Trenton, NJ. 92 p.

https://hdl.handle.net/10929/106999

Citation for EIA Calculator:

Rocchio, F. J., T. Ramm-Granberg, I. J. Weber, K.S. Walz and J. Hafstad. 2022. New Jersey Wetland Ecological Integrity Assessment Calculator [Adapted from Ecological Integrity Assessment Calculator (Macro-Enabled Excel Spreadsheet). Washington Natural Heritage Program, Department of Natural Resources, Olympia, WA.], New Jersey Natural Heritage Program, NJ Department of Environmental Protection, Trenton, NJ.

https://hdl.handle.net/10929/107449

Citation for NatureServe EIA Protocol:

Faber-Langendoen, D., W. Nichols, K. Walz, J. Rocchio, J. Lemly, and L. Gilligan, 2016. NatureServe Ecological Integrity Assessment: Protocols for Rapid Field Assessment of Wetlands. v2.08. NatureServe, Arlington, VA.

https://hdl.handle.net/10929/107450

Task 2: New Jersey Reference Wetland Network

Reference Standard Site Monitoring

The original grant application indicated that 50 additional wetland reference standard sites would be monitored to augment existing reference gradient wetland sites identified and sampled during the statewide wetland condition assessment probabilistic study (EPA-R2-WPDG-CD97225809-0). Because data gaps that are critical for setting appropriate goals and developing designs for restoration projects were identified during a meeting with experts, monitoring reference standard wetland sites using EIA protocols was replaced with a

GIS-based assessment of hydrogeomorphology at NJ Tidal Wetland Monitoring Network sites across the state. **These data were incorporated in the Reference Wetland Tool. The final report on this work entitled, "New Jersey Tidal Marsh Morphology Study," can be found Appendix 2.**

In addition, supplemental funding was provided to conduct hydrologic monitoring at a select set of reference standard sites. Due to travel restrictions during the pandemic and supply chain issues, we were not able to install the tide gauges during the grant. However, three permanent tide gauges were purchased toward the end of the grant. These will be installed as part of the New Jersey Tidal Wetland Monitoring Network.

Collect algae/diatom specimens from coastal wetland reference standard sites

Tidal wetland characteristics were compared in natural and sediment-enhanced tidal wetlands using diatom inferences. **The final report, entitled "Cape May peninsula and Delaware Bay wetland characteristics based on diatom inferences: a comparison of TLP (thin layer placement) and control sites located in Fortescue, Avalon, and Ring Island salt marshes," can be found in the appendix 3.** Samples collected by the National Wetland Conditions Assessment were not recounted because combined samples from across a wetland could not be used to calculate inferences.

Additional funding was received from EPA to create the "Diatom Flora of the New Jersey Coastal Wetlands". In 2012-2017 the New Jersey Department of Environmental Protection sponsored several research projects aimed at evaluating the potential use of diatoms for characterizing present and inferring past environmental conditions in New Jersey coastal wetlands. The goal of this report was to document the most common diatom taxa from studied wetlands, with high-resolution light and electron microscopy images. The images of 499 taxa found in the sub-, inter-, and supratidal habitats and sediment core samples are presented. Genera with the most species are Navicula (148), Fallacia (34), Nitzschia (21), and Parlibellus (16). Some taxa could not be identified to species level and are listed under provisional names. Voucher slides are deposited in the Diatom Herbarium of the Academy of Natural Sciences of Drexel University.

This report is publicly available at https://hdl.handle.net/10929/68423 and a Appendix 4.

Task 3: Installation and Monitoring of a Site-Specific Intensive Monitoring Station – Urban Raritan Bay

The Mid-Atlantic Coastal Wetland Assessment (MACWA) led by Partnership for the Delaware Estuary and the Barnegat Bay Partnership, evaluates coastal wetland health states and trajectories in two estuaries in the Mid-Atlantic US through the implementation of Site-Specific Intensive Monitoring (SSIM) protocols. At the time the proposal for this grant was written, there were 14 SSIM stations (each with three Surface Elevation Tables (SETs)) in New Jersey and two in Pennsylvania (within the Delaware Watershed). The northernmost

SSIM in New Jersey is located in the Barnegat Bay Watershed. This task filled the geographic gap between the monitoring stations in the Meadowlands and the MACWA SSIM sites in Ocean County south by extending the SSIM network to the Raritan Bay wetland system. A new SSIM station was installed and monitored for two years by Rutgers University. The site and associated data have been incorporated into MACWA and the New Jersey Tidal Wetlands Monitoring Network.

The final report from Rutgers University can be found in Appendix 5.

Task 4: Developing additional tools that will assist standardized data collection in the future.

Task 4a: Statistical Analyses of Biological and Chemical Parameters included in Restoration Metrics

The Statistical Analyses of Biological and Chemical Parameters included in Restoration Metrics were accomplished through task 1 and task 4c. Task 1, the development of the Reference Wetland Tool, statistically analyzed reference data, comparing reference standard sites to reference sites across an alteration gradient. Task 4c compared data collected at restored tidal wetlands to data in the Reference Wetland Tool. It was determined that many of the parameters that are frequently collected as part of wetland conditions are too qualitative and based on disturbance to be used to assess restoration projects, at least in the short term. **See Appendices 1 and 6 for more information.**

Task 4b: Convene Panel of Restoration Scientists (Peer Review Team) – Recommendation for Multi-Metric Matrix

A panel of restoration scientists and monitoring practitioners with representatives from academic, non-profit, consulting, and federal sectors were convened several times to aid in the development of the Reference Wetland Tool (Task 1). **See the Penn State report in Appendix 1 for more information.**

Task 4c: Application of Reference Wetland Tool to 3 to 5 ongoing restoration projects in NJ's tidally influenced (coastal specific) wetlands

The Reference Wetland Tool (Task 1) was applied to three restoration projects in New Jersey's coastal wetlands. The purpose of this exercise was to pilot the Interactive Tool on restoration projects, provide data for adaptive management of ongoing projects, and inform future projects in the same geographic region and/or utilizing the same restoration techniques. Lessons learned from testing the Reference Wetland Tool on restoration sites were used to improve the Tool.

The report on Task 6, entitled “Applicability of a Rapid Assessment Method for Evaluating Restoration Sites Using the New Jersey Reference Wetland Tool,” can be found in Appendix 6.

Project-wide Summary and Conclusions and Future Work

The New Jersey Reference Wetland Tool provides easy public access to ecological condition assessment metrics and site scores for a broad cross-section of coastal wetlands in New Jersey. This tool provides stakeholders with valuable information about the condition of wetland resources and emphasizes the potential for improved ecological conditions by highlighting Reference Standard Wetlands along the coastline and across varied tidal and salinity ranges.

Throughout the project, stakeholder feedback was collected and incorporated in the Tool and User Guide. Not all suggestions received by the project team during agency and stakeholder workshops could be incorporated in the 2021 version of the Web Tool, but these additions can potentially be included in future updates. The feedback received during stakeholder workshops points to several potential opportunities. Of potential value to stakeholders interested in tidal wetland restoration is an addition to the site type drop-down menu to expand the user-defined choices to include restored wetlands. This option could provide users with data-driven ecological condition goals for wetland restoration efforts based on similar locations in the same watershed or landscape position. Another potential future addition is a suite of outputs dedicated to a specific program or decision support tool/model. This output could curate metrics necessary for a specific program or tool and provide output options readymade for use in these other management tools.

Currently, the Web Tool includes data from tidal wetlands, but we anticipate data from non-tidal wetlands in future updates. Data gaps can be easily identified through specific combinations of drop-down menu selections, so we anticipate targeted efforts to fill these gaps during future field seasons. Groups interested in partnering with the current data providers can request information from Riparia at Penn State. Existing data partner organizations should submit ecological condition assessment data to Riparia at Penn State after the completion of field seasons and after internal data quality assurance checks have been completed.

Acknowledgments

This project has been funded wholly or in part by the United States Environmental Protection Agency under assistance agreement CD96284315 to the NJ Department of Environmental Protection.

Please see individual reports for a full list of acknowledgments.

A review of the final report was provided by Joshua Moody and Nicholas A. Procopio, both of NJ DEP Division of Science and Research.

Appendix 1

A Multi-Metric Site Evaluation Tool for Restoration of New Jersey's Tidally Influenced Wetlands

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Final Report - EPA Agreement Number: CD 96284315

EPA Region 2 Wetlands Program Development Grant: 2015-2017

Federal Award Identification Number: CD-962843-15

Grant Identifier: SR16-012

PSU Proposal: EM150398

Principal Investigators: Metthea Yepsen[1], Robert Brooks[2], and Michael Nassry[2]

Additional Authors: Stephan Crawford[3], Hannah Ingram[2], Kirk Raper[1], and Kathleen Walz[1]

1. New Jersey Department of Environmental Protection
2. Riparia at Penn State
3. Penn State Center for Environmental Informatics

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Funding for this project was provided by an EPA Region 2 Wetland Program Development Grant and completed by a partnership between the New Jersey Department of Environmental Protection Division of Science and Research and Office of Natural Lands Management, Riparia at Penn State, and the Penn State Center for Environmental Informatics.

Technical assistance, data analysis, and quality assurance checks were provided by Don Morrison of the New Jersey Department of Environmental Protection.

Assessment demonstrations, site tours, and additional reviews of metrics selected for the Web Tool were provided by LeeAnn Haff and The Partnership for the Delaware Estuary.

The User Guide was developed by Christian Cooke, Nelson Huffaker, and Melody Sipe through the Penn State Department of Geography Undergraduate Research Opportunities Connection program in the College of Earth and Mineral Sciences.

The New Jersey Reference Wetland Tool is an extension of the regional Riparia Reference Wetland Database created by Dr. Robert Brooks, his graduate students, and undergraduate interns during his 38-year career advancing wetland and water science.

The New Jersey Reference Wetland Database data were a result of the collective efforts of dedicated field crews, laboratory staff, data management and quality control staff, analysts, and many others from organizations in New Jersey. Please contact dsr.wetlands@dep.nj.gov with any questions.

Suggested Citation:

Penn State and The New Jersey Department of Environmental Protection. 2022. New Jersey Reference Wetland Database (data and metadata files). Available from: https://tools.cei.psu.edu/wetlands/njdep/. Date accessed: YYYY-MM-DD.

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Executive Summary

Wetland ecological condition data can provide insight into wetland structure and function across an area of interest, as well as a better understanding of ecosystem service provisioning, landscape stressors, and changes over time to aquatic resources. The development of a reference wetland database targeting specific geographic regions, landscapes with similar land use patterns, and wetlands with varying structure across the spectrum of functional conditions can inform stakeholders ranging from landowners to field technicians to policy makers. This report describes the development and contents of the New Jersey Reference Wetland Database and Web Tool, a collaboration between the New Jersey Department of Environmental Protection (DEP) and Riparia at Penn State.

The New Jersey DEP identified data partners and stakeholder feedback was collected throughout the project, including four workshops targeting New Jersey DEP personnel, data partners, and the public from 2019 to 2021. Over the course of this project, focus was shifted from all wetlands to focus on coastal wetlands spanning the spectrum of tidal ranges and salinity regimes present along the New Jersey coastline. A data sharing agreement was developed and agreed upon by the data partners, ensuring potentially sensitive location data was not made available via the public facing Web Tool.

The New Jersey Reference Wetland Database comprises of (1) A public-facing Web Tool, (2) A PostgreSQL database, and (3) A publicly accessible User Guide. The Web Tool provides summary statistics for a priority group of metrics describing wetland structure, function, and condition, provides graphical displays of metric distribution, and allows users to select and view specific regions, site conditions, or site types out of the larger pool of reference wetlands. Selection options currently available on the Web Tool include HUC-8 watersheds, New Jersey Watershed Management Areas (WMAs), salinity, tidal range, and site type (all vs. reference standard sites). The priority list of metrics displayed on the Web Tool are group in 4 categories: Condition, Hydrology & Water Quality, Soil & Topography, and Vegetation. Data downloads are available for the public-facing summary data, and original condition assessment data including location information is available for data partners by contacting the New Jersey DEP data steward via the email provided on the Web Tool.

The database was developed using PostgreSQL ("postgres"), an open-source relational database management system, and includes PostGIS, a library of geographic functions. The original condition data are represented as tables in the database, and are then filtered, aggregated, and spatially joined to create the database views—virtual tables—that are published as web services that power the Web Tool and data download.

A User Guide is provided through a link on the Web Tool, and contains background information on the tool and database, descriptions of the Web Tool selection options, and contact information for data partners. The User Guide is presented on an ESRI Story Map platform and was developed by students working in the Penn State Geography Undergraduate Research Opportunity Connection program.

The 2022 database, Web Tool, and User Guide are the first iterations of a growing resource, that will update on an annual basis with new data, and potentially additional sites and metrics. We anticipate data gaps will be identified and filled during subsequent field seasons to provide more robust coverage across the state and tidal/salinity ranges. Additional features, such as the inclusion of restored wetlands as a user-defined sub-set of sites, may also be included in future database and Web Tool updates.

Introduction

Ecological condition assessments performed across a range of geographic locations and landscapes are useful for evaluating ecosystem structure and function, designing restoration projects, and managing natural resources and ecosystem services. Here, we explore the application of this concept to wetland systems and the aquatic and terrestrial resources they encompass. While individual site evaluations can be useful when assessing a single system, property, or small area of interest, a larger collection of site assessments and wetland data is necessary to understand conditions at a watershed, state, or regional scale. The Riparia Reference Wetland Database serves this purpose and contains ecological condition assessment data for freshwater wetlands throughout the Mid-Atlantic region.

Riparia, formerly the Penn State Cooperative Wetland Center (CWC), is a research center in the Department of Geography at Penn State with a focus on science that informs policy and practice in wetland ecology, landscape hydrology, and watershed management. The Riparia Reference Wetland Database was built through several funded and unfunded research initiatives dating back to 1993. This 222-site publicly accessible database allows users to view wetland ecological condition data distributions and select sub-sets of sites by state, ecoregion, wetland hydrogeomorphic (HGM) class, and site condition. This living database continues to grow, and sites are scheduled for re-assessment every 10 years to identify condition changes at individual sites and broader trends driven by increased development and landscape fragmentation, climate change, or conservation practices that can differentially impact wetland resources across the Mid-Atlantic region. An additional feature allows users to compare a sub-set of wetlands to high quality sites, referred to as Reference Standard Wetlands. This feature has possible applications and recently was used to better understand the potential function and condition of forested riparian buffer projects created through the USDA's Conservation Reserve Enhancement Program (CREP) in agricultural landscapes across Pennsylvania, Maryland, and Virginia.

An EPA Region 2 Wetland Program Development Grant (WPDG) was awarded to the New Jersey Department of Environmental Protection (NJ DEP) to facilitate the addition of the state's wetland condition assessment data into the regional Riparia Reference Wetland Database, making the site assessment data available to regional partners and the public. This project originally set out to incorporate New Jersey freshwater wetlands directly into the existing Riparia database using a set of pre-determined metrics describing landscape position and ecological condition. Through conversations with stakeholders, the focus of the initial database site pool was shifted to center around coastal wetlands and inform current efforts to manage, restore, and protect these resources. This shift was driven by the need to better understand, protect, and enhance the critical ecosystem services these wetlands provide including habitat for terrestrial wildlife and fisheries, shoreline stabilization, and flood mitigation during storm events.

Because coastal wetlands are best described using a different set of categorical descriptors and condition metrics, a new database was created for these sites outside of the existing Riparia database. Although the metrics used for the coastal sites changed, the Riparia Reference Wetland Database has several key features that and functions that were carried over to the new database. One of the key design features is a series of drop-down menus allowing users to select sub-sets of sites specific to a location, condition, or landscape position of a wetland (Figure 1).

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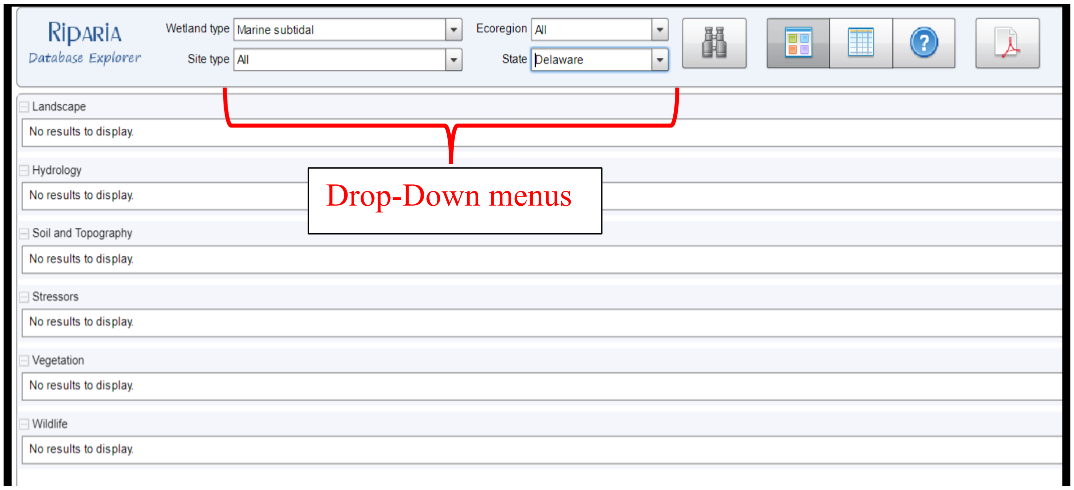


Figure 1: Riparia Reference Wetland Database Home Page with drop-down menus and data download options across the top, and ecological condition metric categories below.

After selections indicating state, HGM type, ecoregion, and condition are made, data distribution charts with short metric descriptions and site counts are displayed (Figure 2).

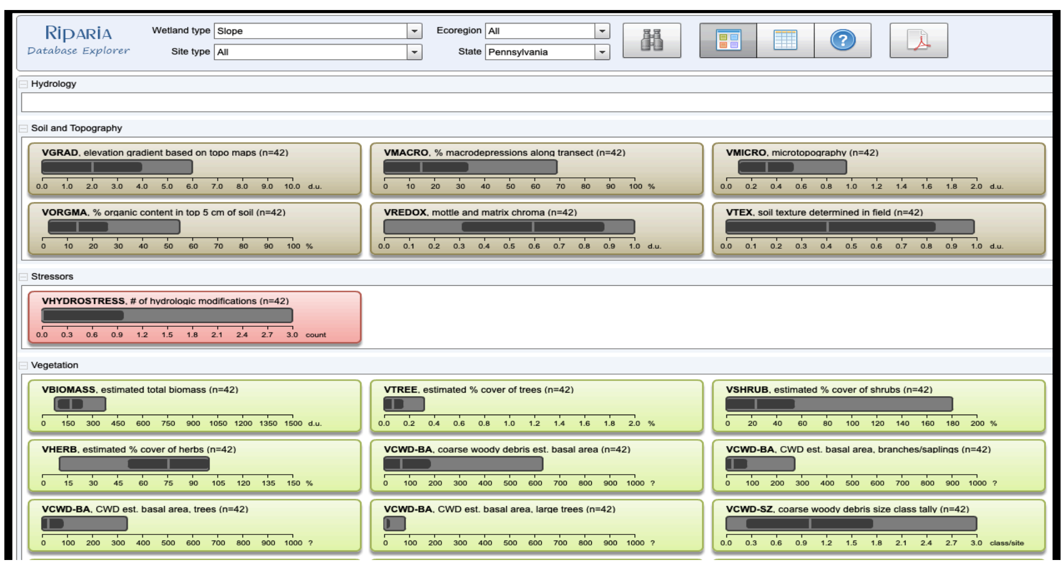
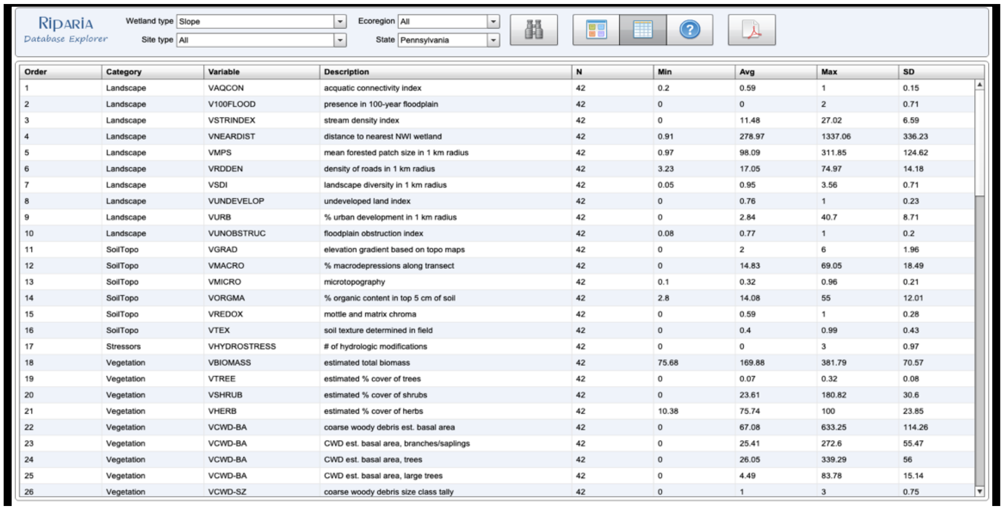


Figure 2: Riparia Reference Wetland Database with user-defined options displaying slope wetlands in Pennsylvania and graphic displays reflecting the score distribution of select metrics.

Users also have the option of viewing and downloading condition metric distribution summary statistics with the same category, description, and site count information displayed on the data distribution charts (Figure 3).

App1



Order	Category	Variable	Description	N	Min	Avg	Max	SD
1	Landscape	VAQCON	acquatic connectivity index	42	0.2	0.59	1	0.15
2	Landscape	V100FLOOD	presence in 100-year floodplain	42	0	0	2	0.71
3	Landscape	VSTRINDEX	stream density index	42	0	11.48	27.02	6.59
4	Landscape	VNEARDIST	distance to nearest NWI wetland	42	0.91	278.97	1337.06	336.23
5	Landscape	VMPS	mean forested patch size in 1 km radius	42	0.97	98.09	311.85	124.62
6	Landscape	VRDDEN	density of roads in 1 km radius	42	3.23	17.05	74.97	14.18
7	Landscape	VSDI	landscape diversity in 1 km radius	42	0.05	0.95	3.56	0.71
8	Landscape	VUNDEVELOP	undeveloped land index	42	0	0.76	1	0.23
9	Landscape	VURB	% urban development in 1 km radius	42	0	2.84	40.7	8.71
10	Landscape	VUNOBSTRUC	floodplain obstruction index	42	0.08	0.77	1	0.2
11	SoilTopo	VGRAD	elevation gradient based on topo maps	42	0	2	6	1.96
12	SoilTopo	VMACRO	% macrodepressions along transect	42	0	14.83	69.05	18.49
13	SoilTopo	VMICRO	microtopography	42	0.1	0.32	0.96	0.21
14	SoilTopo	VORGMA	% organic content in top 5 cm of soil	42	2.8	14.08	55	12.01
15	SoilTopo	VREDOX	mottle and matrix chroma	42	0	0.59	1	0.28
16	SoilTopo	VTEX	soil texture determined in field	42	0	0.4	0.99	0.43
17	Stressors	VHYDROSTRESS	# of hydrologic modifications	42	0	0	3	0.97
18	Vegetation	VBIOMASS	estimated total biomass	42	75.68	169.88	381.79	70.57
19	Vegetation	VTREE	estimated % cover of trees	42	0	0.07	0.32	0.08
20	Vegetation	VSHRUB	estimated % cover of shrubs	42	0	23.61	180.82	30.6
21	Vegetation	VHERB	estimated % cover of herbs	42	10.38	75.74	100	23.85
22	Vegetation	VCWD-BA	coarse woody debris est. basal area	42	0	67.08	633.25	114.26
23	Vegetation	VCWD-BA	CWD est. basal area, branches/saplings	42	0	25.41	272.6	55.47
24	Vegetation	VCWD-BA	CWD est. basal area, trees	42	0	26.05	339.29	56
25	Vegetation	VCWD-BA	CWD est. basal area, large trees	42	0	4.49	83.78	15.14
26	Vegetation	VCWD-SZ	coarse woody debris size class tally	42	0	1	3	0.75

Figure 3: Riparia Reference Wetland Database numeric summary statistic display showing site count, average value, maximum value, minimum value, and standard deviation for user-defined sites (slope wetlands located in Pennsylvania).

Of specific interest to stakeholders in New Jersey, was the ability of the Riparia Wetland database to group and display summary statistics in both numeric and graphical form comparing all sites in a user-defined subset to high quality, Reference Standard Wetlands (Figure 4).

Figure 4: Riparia Reference Wetland Database showing a graphical data distribution comparison of all sites and reference standard sites in the user-defined categories.

This comparative display was a desirable feature for inclusion in the New Jersey Reference Wetland Database because it provides relevant data-driven guidance when setting realistic goals for improvements at both existing sites and during the creation of new wetlands in specific regions or with specific landscape characteristics. An up-to-date reference wetland database containing condition assessment data alleviates much of the need for time consuming and expensive assessments on a project-by-project basis.

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Project Design and Methods

Metric data and condition scores from extensive wetland monitoring and assessment efforts conducted within New Jersey, including the National Wetland Condition Assessment, Mid-Atlantic Coastal Wetland Assessment, Ecological Integrity Assessment, and other research were included in a PostgreSQL database, aggregated, and summarized in the publicly accessible tool. Through stakeholder feedback collected during workshops and individual communications with the project team, metrics critical to understanding tidal wetland condition were included in the Web Tool, when data was available, to provide ecologically relevant condition information to practitioners.

Monitoring data from partner organizations was compiled by The New Jersey DEP from:

1. Mid-Atlantic Coastal Wetland Assessment (MACWA) through a data sharing agreement
    a. Partnership for the Delaware Estuary
    b. Barnegat Bay Partnership
    c. The Academy of Natural Sciences at Rutgers University

2. The National Wetland Condition Assessment (NWCA), which is publicly available
    a. NJ DEP
    b. US Environmental Protection Agency

3. Control sites from salt marsh restoration projects
    a. NJ DEP
    b. The Natural Conservancy
    c. Rutgers University
    d. The Wetlands Institute
    e. GreenVest
    f. Princeton Hydro

4. The Ecological Integrity Assessment
    a. NJ DEP
    b. Nature Serve

5. The Natural Heritage Program
    a. NJ DEP
    b. VegBank

Data Partner Organizations, DEP staff, and restoration practitioners were invited to several workshops held throughout this project to solicit feedback on the approach, data input / output process, and features of the database and Web Tool. The first workshop was held at the Assunpink Wildlife Conservation Center located at 1 Eldrige Road, Allentown, NJ 08501 on May13, 2019. The 34 participants provided feedback related to prioritized metrics to display in the Web Tool, and how they would potentially use the Web Tool for their organizations. Travel restrictions and social distancing policies required the remaining workshops to be held virtually. A workshop showcasing the draft Web Tool for New Jersey DEP personnel was held on January

13, 2021, with 17 participants, followed by a workshop for data partners and the public on January 20, 2021, with 44 participants. A final workshop was held on June 17, 2021 for 45 participants to gather feedback on the final draft of the Web Tool, demonstrate example queries and downloads, and gather final comments for updates to the both the Web Tool and User Guide.

A select list of workshop feedback and comments is listed below:

- Data contributors are sensitive to site location on the public facing Web Tool
- Data contributors would like to see the addition of new metrics included in future sampling protocols added to the database and Web Tool
- An option to compare metrics and condition scores between natural and restored sites is desirable, as 50% of stakeholders collect data at restored sites
- The definition of Reference Standard Wetlands must be clearly defined
- Stakeholders would like the database and Web Tool to assist in identifying and filling data gaps
- Stakeholders would like to see a GIS interface feature as well as user-defined time range constraining data statistics and chart displays to specific years or seasons.
- The longevity of data, archiving, and security were mentioned as general database concerns

Some of these comments and questions were addressed immediately and included in the 2021 Database and Web Tool, while others were noted for potential future database updates.

Sites included in the database came from several sources, including programs administered by the New Jersey DEP, MACWA and NWCA. Because final review and quality assurance approval has not been completed for the 2016 NWCA, metrics and scores from this program reflect final values associated with the 2011 NWCA field effort. Table 1 includes a list of data sources and site counts for wetlands appearing in the Web Tool with a final site condition score. Some overlap among sites occurred where some of the SSIM sites also had the RAM protocol conducted and therefore have a condition score (n=14).

Table 1: Site count for Web Tool data with final condition score listed by source.

Data Source	Number of Tidal Sites Included in Web Tool
MACWA	200
EIA	17
NWCA	14
DEP	176

When overall site condition scores were included as part of an assessment methodology or the product of several or all the individual metric scores, a designation of Reference Standard Wetland given to the highest quality sites. These sites are sometimes referred to as “The Best of The Best”, typically have minimal stressors, and represent what is possible given the wetland location and position in the landscape. These designations and data points are useful when setting restoration goals, as they represent real word site conditions in locations relevant to sites of interest rather than an ideal wetland or theoretical numeric standard. Threshold scores used for the Reference Standard Wetland designation in this database and Web Tool are listed in Table 2.

Table 2: Reference Standard Wetland designation threshold score by source.

Data Source	Reference Standard Threshold
RAM	>81
NJWET	>74
NWCA	>74

A database populated with coastal wetlands required a different organizational approach to select sub-sets of data relevant to sites of concern, as well as a different set of metrics to provide information relevant to site condition. The priority metrics identified through stakeholder feedback and displayed on the Web Tool include summary statistics for data relevant to the physical, chemical, and biological characteristics of wetlands along the coast. Data processing of original files and spreadsheets was needed to include of several of these metrics in the database and Web Tool. A few examples are provided below in Figure 5, detailing how naming conventions for sites and metrics required standardization for database queries.

SSIM Site Location	
Object-ID	SET
ReedyCreek1	1
ReedyCreek2	2
ReedyCreek3	3
IslandBeach1	1
IslandBeach2	2
IslandBeach3	3

→

SSIM Site Location (revised)
set_id
RDY_01
RDY_02
RDY_03
ISL_01
ISL_02
ISL_03

SSIM soil data	
site	set
RC	1
RC	3
IB	1
IB	3

→

SSIM soil data (revised)
set_id
RDY_01
RDY_03
ISL_01
ISL_03

Figure 5: Example data processing needs required to make original datasets ready for upload and accessible for database queries. Merging location and set values to create unique identification marker (left); Merging location abbreviation and soil layer maker to create unique identification marker (right).

Because some metrics included several individual data points at the site or plot scale, an average value or sub-set of the original field data was included in the Web Tool. For example, vegetation cover metrics were averaged across all plots within a site, and soil chemistry and texture values were an average of field observations recorded for the top 2 soil layers to display information relevant to the top 30cm of soil. Metrics with these data modifications are noted in the Data Dictionary available on the Web Tool.

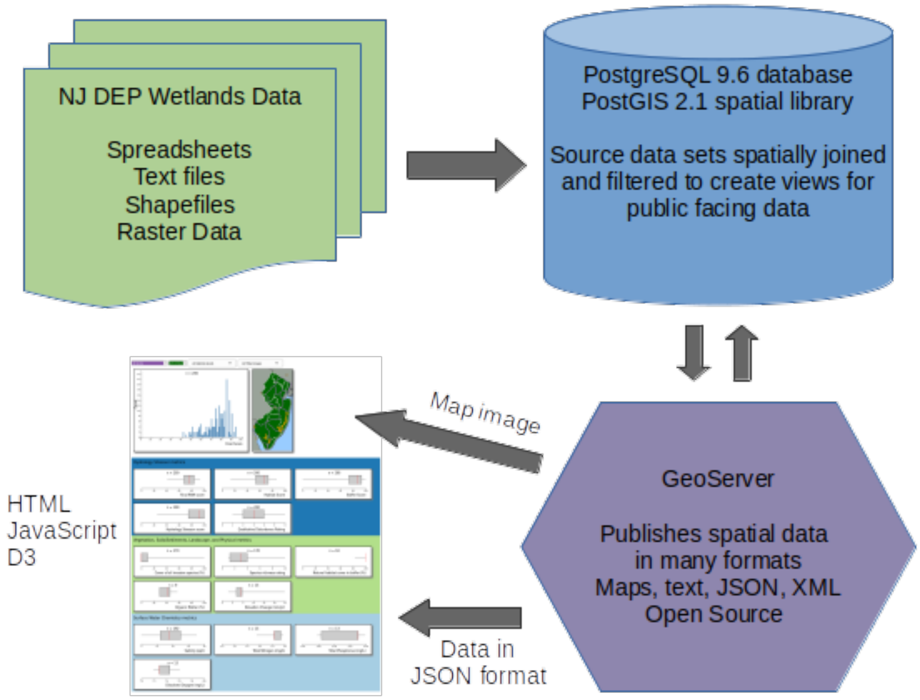

Figure 6: Database and web tool software architecture.

Geographic functions within the database were used to "spatially join" the assessment site point locations to area-wide data sets to assign codes representing salinity levels and tidal ranges to each location. Spatial joins were similarly used to determine each site's HUC-8 watershed and WMA. These tables of location were then joined to other assessment data sets on common IDs to create database views, which represent the data to the tool user and for download.

Our system uses a geographic data server software (Geoserver) to connect the private, secure database to the public Web Tool. Geoserver can serve data in many formats. Here it is used to generate the .png image for the map the web tool; to return the metrics data to the tool in the JSON format to draw the graphs; and to provide the .csv file for data download.

The Web Tool is programmed in simple HTML and Javascript, which includes the d3 library of functions for drawing data-driven graphs and charts. The heavy-lifting for the system is done with the database and the Geoserver middleware.

A User Guide was created to inform data providers and the public of the features in the newly created New Jersey Reference Wetland Tool and database including the upload/download process, how to select and filter data, and link users to data partners for additional inquiries. The User Guide was developed on an ESRI Story Map platform through Penn State's ESRI academic account. The Story Map is designed with static navigation tabs along the top which allows users to easily locate topics of interest. This Story Map was first created by undergraduate students through the Penn State Geography Undergraduate Research Opportunity Connections program during the Spring 2021 semester. The Penn State University GIS Librarian has administrative ownership of the User Guide, and the Director of Riparia at Penn State is a Co-Owner of the site.

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Quality Assurance

Several strategies were used to ensure accurate data in database, Web Tool, and User Guide. Data acquired from partner organizations was uploaded into the database only after it was approved through each organizations internal quality assurance processes and protocols. Preliminary data was not included from any source including the New Jersey DEP and National Wetland Condition Assessment, even though other approved datasets from these sources were included in the database. Methodology and results were shared with data partners through the process, including during 4 workshops. Feedback, such as watershed display name and site count discrepancies were identified in draft outputs through feedback from these workshops.
The structure of the database and constraints on certain data fields also prevents errors from incorrectly formatted data to appear in metric summary statistics. Future data uploads will require partner organizations to pre-format metrics for direct upload to the database to minimize potential future errors from personnel without direct knowledge of data collection procedures.

Results and Discussion

The New Jersey Reference Wetland Tool displays metric summary statistics for user-defined wetland condition, location, salinity, and tidal ranges.

The New Jersey Reference Wetland Tool can be accessed using the following link:
https://tools.cei.psu.edu/wetlands/njdep/

The User Guide can be accessed using the following link:
https://storymaps.arcgis.com/stories/caae4374e6ef48fe965efabec299c47e

To maintain landowner privacy, wetland locations and site-specific data are not displayed on the tool, but requests for detailed site information can be made to data partners. A histogram of final site condition scores and an adjacent map displaying coarse wetland locations will update as selections are made on the drop-down menus (Figure 7).

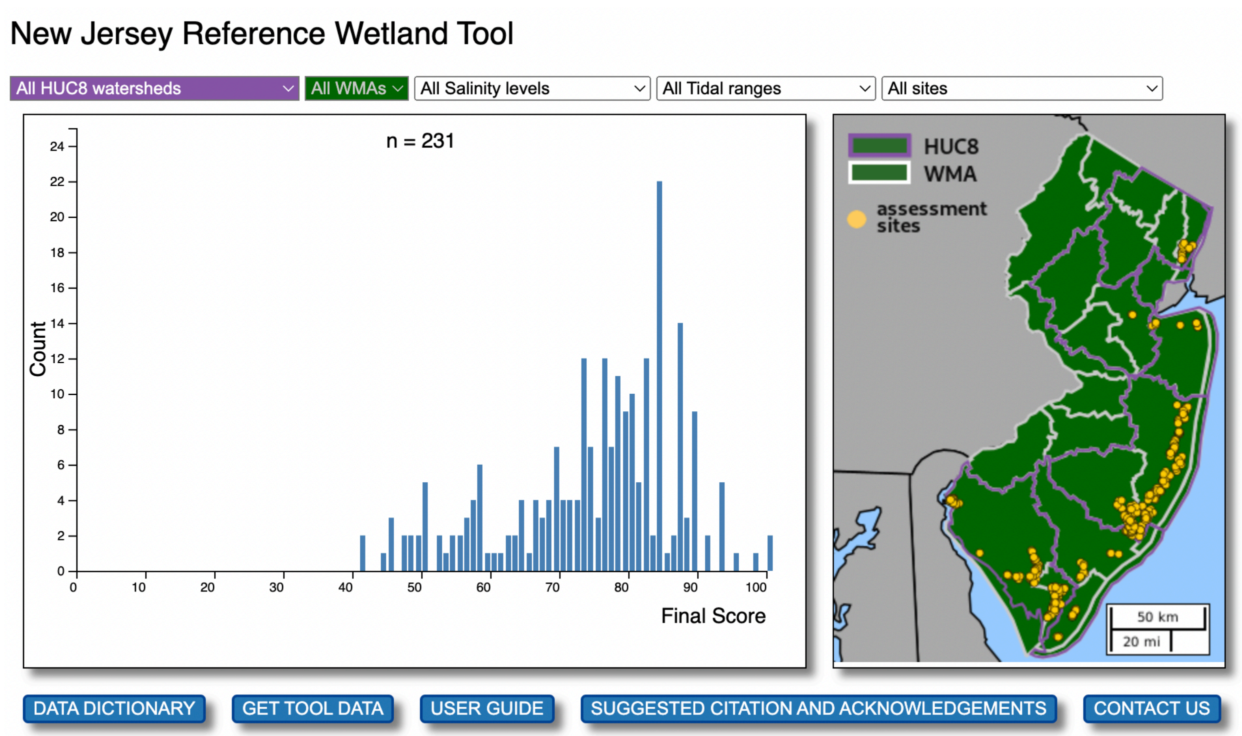

Figure 7: The New Jersey Reference Wetland Tool features drop-down menus (Top), Final Score histogram (Left), Map indicating coarse site locations (Right), and additional linked resources (Bottom).

Drop-down menus located across the top of the tool allow users to select subsets of wetlands and display metric summary data representative of specific locations and/or conditions of interest (Figure 8). The Get Tool Data feature allows users to download a file containing the numerical summary values displayed in the metric distribution charts and will reflect the user-defined selections on the drop-down menus. Users from partner organizations can request original data and metrics not displayed on the public facing tool by using the email provided in the Contact Us feature – dsr.wetlands@dep.nj.gov.

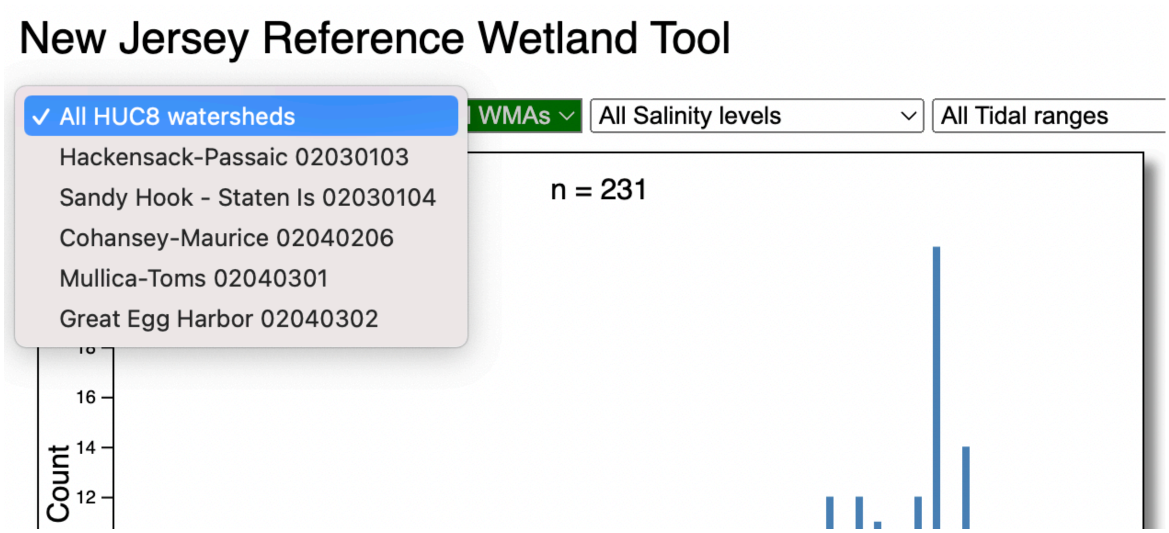

Figure 8 Example of Drop-Down menu highlighting user options for selecting HUC-8 watersheds of interest

Site counts will vary according to selections, and not every combination of selection options will have data available for display. The drop-down menus included in the Web Tool allow users to make the following selections:

<u>HUC-8 Watersheds</u>

Rondout (02020007)*
Lower Hudson (02030101)*
Hackensack-Passaic (02030103)
Sandy Hook-Staten Island (02030104)
Raritan (02030105)*
Middle Delaware-Mongaup-Brodhead (02040104)*
Middle Delaware-Musconetcong (02040105)*
Crosswicks-Neshaminy (02040201)*
Lower Delaware (02040202)*
Cohansey-Maurice (02040206)
Mullica-Toms (02040301)
Great Egg Harbor (02040302)

<u>Watershed Management Area (WMA)</u>

1. Upper Delaware*
2. Wallkill*
3. Pompton, Pequannock, Wanaque, Ramapo*
4. Lower Passaic and Saddle*
5. Hackensack, Hudson and Pascack
6. Upper and Mid-Passaic, Whippany, and Rockaway*
7. Arthur Kill*

8. North and South Branch Raritan*
9. Lower Raritan, South River, and Lawerence*
10. Millstone*
11. Central Delaware*
12. Monmouth
13. Barnegat Bay
14. Mullica
15. Great Egg Harbor
16. Cape May
17. Maurice, Salem, and Cohansey
18. Lower Delaware*
19. Rancocas*
20. Assiscunk, Crosswicks, and Doctors*

Salinity

Tidal Freshwater (< 0.5 ppt)
Oligohaline (0.5 - 5 ppt)
Mesohaline (5 - 18 ppt)
Polyhaline (18 - 33 ppt)

Tidal Range

Microtidal (< 1m)
Low-Mesotidal (1 – 2m)
High-Mesotidal (2 – 3.5m)
Low-Macrotidal (3.5 – 5m)
Macrotidal (> 5m)

Site Type

All Sites
Reference Standard Sites
All vs. Reference Standard Sites

• Indicates data not displayed in 2022 edition of New Jersey Reference Wetland Tool

Metrics are organized in Condition, Hydrology & Water Quality, Soil & Topography, and Vegetation categories on the tool display, and represent a prioritized subset of the wetland condition data collected by partner organizations. Charts displaying metric value distribution also update as drop-down menu selections are made and include the number of sites represented in the chart and the organization providing the data (Figure 9)

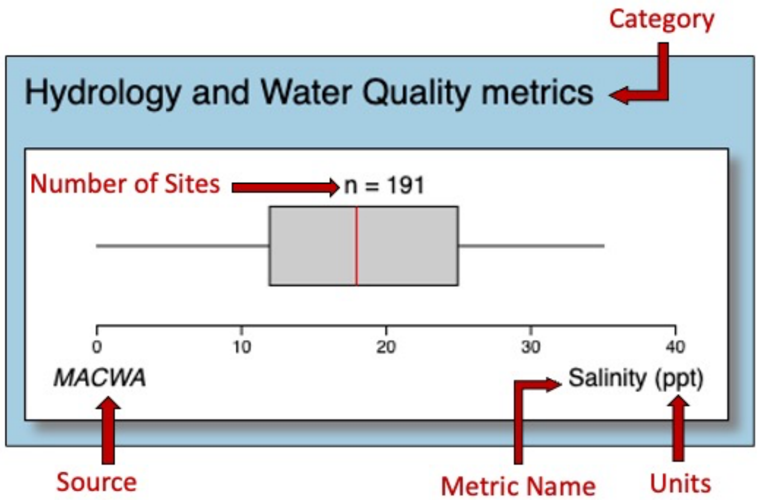

Figure 9: Example metric value distribution chart including metric category, number of sites, source, and units.

The final database structure includes the original source site assessment data as database tables. Some of these tables needed to be joined by common IDs to have consistent coordinates (lon/lat) for all metrics. Then all tables with location were spatially joined to polygon and raster date to produce views for each data set that include codes representing categories for Tidal Range, Salinity, and to which HUC-8 Watershed and Watershed Management Area each site belongs. These views where then joined to create the full public view ("toolsites") of the data. The "toolsites" view is pulled from the database by the Geoserver software, where it is available to be consumed by the Web Tool as map, as data in the JSON format for the tool plots, and as the data table in .csv format for download. Each of these products can be filtered thought the dropdown selections on the web tool.

Tables have been established as placeholders for both future metrics which have not been collected, and for updates of metrics already in the database. Templates will be provided to allow easy upload of data into the tables, which in turn will be added to the "toolsites" view.

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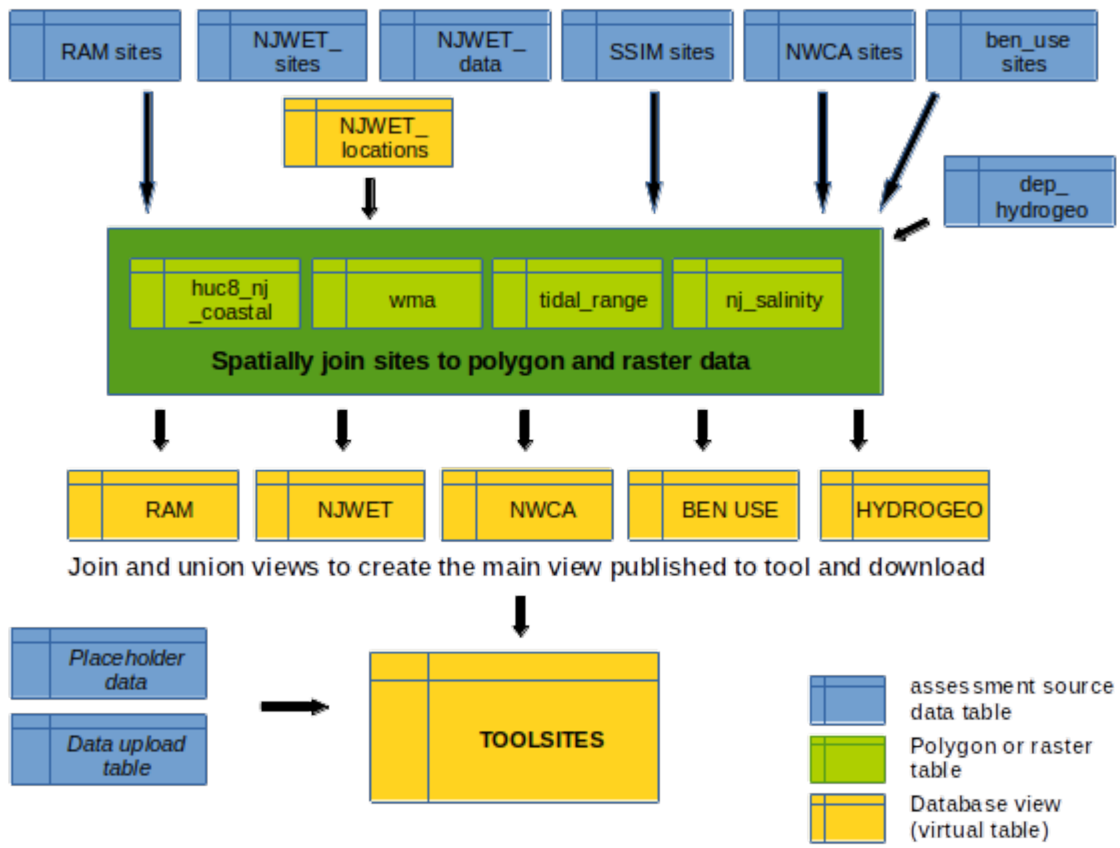

Figure 10: Database structure

The final published version of the User Guide has 9 sections: Background, Using the Web Tool, Site Type, HUC-8 Watersheds, Watershed Management Areas, Tidal Range, Salinity, Partner Organizations, and Acknowledgements (Figure 9). The User Guide provides links to the Web Tool and the following partners and sources: Riparia at Penn State, New Jersey Department of Environmental Protection, Partnership for the Delaware Estuary, The Nature Conservancy, Barnegat Bay Partnership, EPA - National Wetland Condition Assessment, and NatureServe – Ecological Integrity Assessment. The guide contains interactive map components as seen below on the right side of Figure 11, but this feature has been disabled to prevent zooming to fine scales revealing potentially sensitive site location information.

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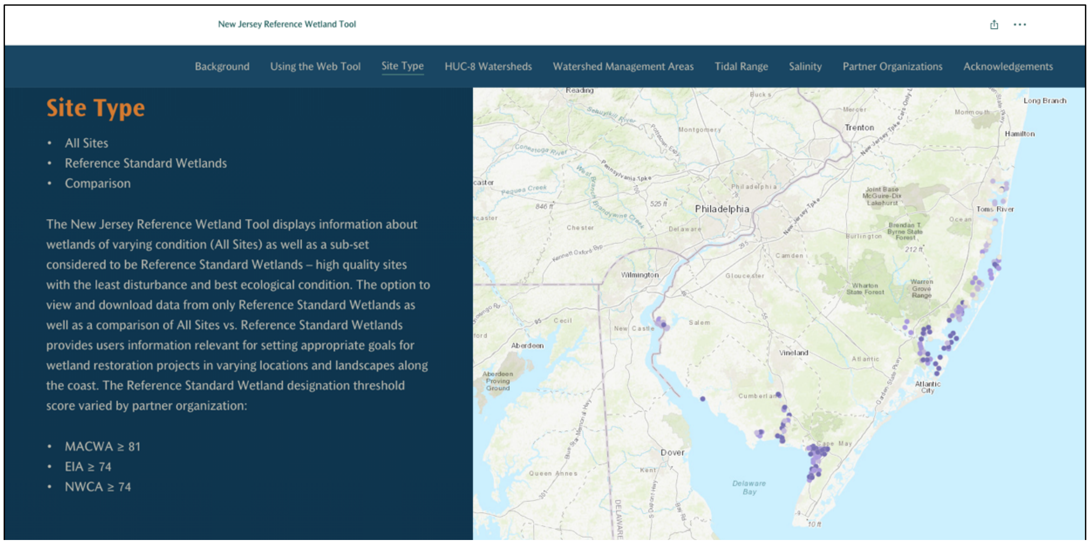

Figure 11: User Guide for the New Jersey Reference Wetland Web Tool. The Site Type section displayed above provides background information on the differences between the All Sites and the Reference Standard Sites selection options.

Conclusions and Recommendations for Future Work

The New Jersey Reference Wetland Tool provides easy public access to ecological condition assessment metrics and site scores for a broad cross-section of coastal wetlands in New Jersey. This tool provides stakeholders with valuable information about the condition of wetland resources and emphasizes the potential for improved ecological condition by highlighting Reference Standard Wetlands along the coastline and across varied tidal and salinity ranges.

Throughout the project, stakeholder feedback was collected and incorporated in the Web Tool and User Guide. Not all suggestions received by the project team during agency and stakeholder workshops could be incorporated in the 2021 version of the Web Tool, but these additions can potentially be included in future updates. The feedback received during stakeholder workshops point to several potential future Web Tool feature update opportunities. Of potential value to stakeholders interested in wetland restoration is an addition to the site type drop down menu to expand the user-defined choices to include restored wetlands. This option could provide users with data-driven ecological condition goals for wetland restoration efforts based on similar locations in the same watershed or landscape position. Another potential future addition is a suite of outputs dedicated to a specific program or decision support tool / model. This output could curate metrics necessary for a specific program or tool and provide output options readymade for use in these other management tools.

Currently, the Web Tool includes data from tidal wetlands, but we anticipate data from non-tidal wetlands in future updates. Data gaps can be easily identified through specific combinations of drop-down menu selections, so we anticipate targeted efforts to fill these gaps during future field seasons. Groups interested in partnering with the current data providers can request information from Riparia at Penn State. Existing data partner organizations should submit ecological condition assessment data to Riparia at Penn State after the completion of field seasons and after internal data quality assurance checks have been completed.

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Recommendations and Application and Use by the New Jersey DEP

Because it is often time and cost prohibitive to collect ecological condition assessment data at local reference sites as part of a restoration project, the New Jersey Reference Wetland Tool and Database, developed by the New Jersey DEP and Riparia at Penn State, provides data relevant to local and state-level stakeholders. The information provided by this tool can be used to inform restoration efforts by setting performance goals appropriate to a geographic location or landscape position. These criteria can also be used for community outreach to showcase the potential for properties and point to local high-quality sites to be used as benchmarks.

Additional potential uses are to incorporate information relevant to specific ecosystem services such as habitat for species valuable to the commercial or recreational fishery industry, sites suitable for protection or restoration to support the needs of threatened and endangered species, or to inform local communities and statewide efforts on climate change resiliency efforts. A better understanding of the distribution of site conditions within a watershed or management area can facilitate a better understanding of overall wetland condition to inform future planning and resource allocation.

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Relevant References and Background Material

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Kentula ME, Brooks RP, Gwin SE, Holland CC, Sherman AD, Sifneos JC (1992) Wetlands. An approach to Improving decision making in wetland restoration and creation. Island Press, Washington, DC, 151pp.

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Riparia Wetland Sampling Protocol and Variables 2004 (Level 3 -Intensive Assessment Protocol for ·Reference Wetlands; Wardrop et al. 2004 Wetlands, II.B.3.a, from Brooks 2004 Monitoring and Assessing Pennsylvania, Final Report to U.S. EPA). Review-describes source and sampling approach for all variables in database.

Smith RD, Ammann A, Bartoldus C, Brinson MM (1995) An approach for assessing wetland functions using hydrogeomorphic classification, reference wetlands, and functional Indices. Wetlands research program technical report WRP-DE-9. U.S. Army Corps of Engineers, Waterways Experiment Station, Washington, DC, 79pp.

Data Partner Links and Contact Information - 2021

Riparia at Penn State
Trevor Birkenholtz (Director)
Phone: 814-863-1596
Email: trevbirk@psu.edu
https://riparia.psu.edu/

New Jersey Department of Environmental Protection
Metthea Yepsen
Phone: (609) 940-4027
Email: Metthea.Yepsen@dep.nj.gov
https://www.nj.gov/dep/dsr/

Partnership for the Delaware Estuary
Kathy Klein (Executive Director)
Phone: (302) 655-4990
Email: kklein@delawareestuary.org
https://delawareestuary.org/science-and-research/wetlands/macwa-homepage/

The Nature Conservancy
Patricia Doerr (New Jersey Chapter Director of Coastal and Marine Programs)
Phone: 609-861-4123
Email: pdoerr@tnc.org
https://www.nature.org/en-us/

Barnegat Bay Partnership
https://www.barnegatbaypartnership.org/

National Wetland Condition Assessment
https://www.epa.gov/national-aquatic-resource-surveys/nwca

Ecological Integrity Assessment
https://www.natureserve.org/products/ecological-integrity-assessment

Appendix 2

New Jersey Tidal Marsh Morphology Study

Don Morrison July 2020

Background:

Tidal wetlands are the sites of complex interactions between terrestrial and aquatic systems. These areas have values that far outweigh their relative size in the larger ecosystem. They are exceptionally important habitat for a wide variety of organisms, those living primarily on land, others in the water, and a few that are found only in the intertidal zone between land and water. Tidal wetland systems provide important ecosystem services including water filtration capacity, storm surge abatement, and carbon sequestration. They are uniquely valued by humans not only for the recreational and ecological services they provide but also as a buffer to sea level rise and storm surge impacts to adjacent development. Tidal wetlands can be classified as a natural buffer to these impacts.

With the current trend towards adaption restoration (focusing on resilience to sea level rise and storm impacts) it is even more important to design wetland enhancement projects to achieve a state most like the natural or reference condition displayed by resilient natural marshes. Central to this characterization is the role of tidal marsh channels. The stability of these channels is dependent on the balance between sedimentary processes and hydrodynamics (Coco et al., 2013). Tidal channels provide a path for the tide to propagate and are a primary control on the sedimentation and ecology of the marsh environment (Hughes 2012). "Tidal courses are an essential part of coastal wetlands as they play a major role in water and nutrient exchange" (Perillo 2009). "The tidal creek influence, species richness of the vegetation, and the identities of the species assemblages have all been shown to vary with channel size and distance from the channel bank in Petaluma Marsh, CA, USA" (Sanderson et al., 2000). "Similar sequences of species were shown to occur with distance from both smaller and larger channels but displaced farther away from the larger channels. Although the ecological mechanisms behind these patterns are not well understood, these patterns suggest that channel size and distance to the bank are fundamental factors in determining species distributions" (Chapman 1960, Adam 1990, Sanderson et al., 2000).

The legacy of pervasive grid ditching and diking in the tidal wetlands of New Jersey are pervasive. These activities and the more modern method of mosquito management, Open Marsh Water Management (OMWM) changed marsh hydrology across the state. Grid ditching changed marsh hydrology from sinuous shallow creeks into deeper, straight lines that were effective at draining the marsh.

A better understanding of the structure of natural and manmade tidal channels will allow more refinement in the restoration project design. Tidal channel structure can be combined with other metrics to better understand how tidal channel structure relates to tidal wetland functions, such as elevation change, primary production, carbon storage, and fish production.

Problem Statement:

In order to understand how the marsh platform is affected by the hydrodynamics of tidal marsh creek morphology, we first need to classify the structure of tidal creeks. What are the commonalities in the structure of healthy creek networks? How do tidal creeks differ across a reference gradient? How do man made channels, like mosquito ditches and Open Marsh Water Management (OMWM), differ from natural channels?

Establishing Metrics:

The tidal creek network is the transport system for the marsh landscape. Water, sediment, nutrients, and waste are transported to and from the marsh by this network. The size, shape, and distribution of the channel network will influence sedimentation and erosion processes, distribution and variety of vegetation, and habitat for fish and other aquatic life.

Metrics Identified:

- **Channel Order**
  - Useful for characterizing the volume of water flowing in a given portion of a channel network
  - Used as a proxy for channel width
- **Cumulative Inverse Squared Distance**
  - Identified as a useful metric in the literature review
  - Models influence of tidal channels on the marsh platform
- **Sinuosity**
  - The Sinuosity Index describes how curvy a stream channel is as a ratio of its flow distance to its straight- line distance from starting to ending points. Straight channels have an index of one. Indexes up to 1.5 are considered sinuous. Indexes greater than 1.5 are considered meandering. Sinuosity increases the flow distance of the channel, generally have a slower flow speed and lower sediment load. This has the effect of lowering flow velocities and increasing edge habitat.
- **Bifurcation Ratio**
  - Bifurcation Ratio is the ratio of the number of streams in one order and its next highest order. It is a dimensionless number that indicates the likelihood of flooding. The more branches in the higher order, the more likely the surrounding area is to flood.
- **Drainage Density/Channel Density**
  - Drainage Density is the total length of channels divided by the marsh area being drained.
  - We need to define the drainage area. Since the marsh area is essentially flat, a normal watershed analysis from a digital elevation model doesn't work.
- **Channel Length Ratio**
  - Calculate length of 1st order channels vs 2nd order channels
  - Calculate length of 2nd order channels vs 3rd order channels
  - Scales
    - 500m SET buffers
    - HUC 14
- **Marsh to open water ratio**
  - Ratio of marsh platform to tidal channels
  - Restricted to NJ LU15 "Wetland" categories to exclude bay/estuary area in calculations
- **Marsh Surface Ponding**
  - Data from Rutgers Center for Remote Sensing and Spatial Analysis used to determine

presence or absence of OMWM

Study Areas:

Our analysis uses Surface Elevation Table (SET) locations within long-term tidal wetland monitoring sites in NJ.

For each SET location we calculated metrics for the 500m radii used in the CISD analysis and for NHD SPARROW Modeler catchment areas. The SPARROW catchment areas represent drainage areas that are a sub-division of HUC 14 sub-watersheds. This gives an area to use for calculating drainage density and gives us a higher resolution than the HUC 14.

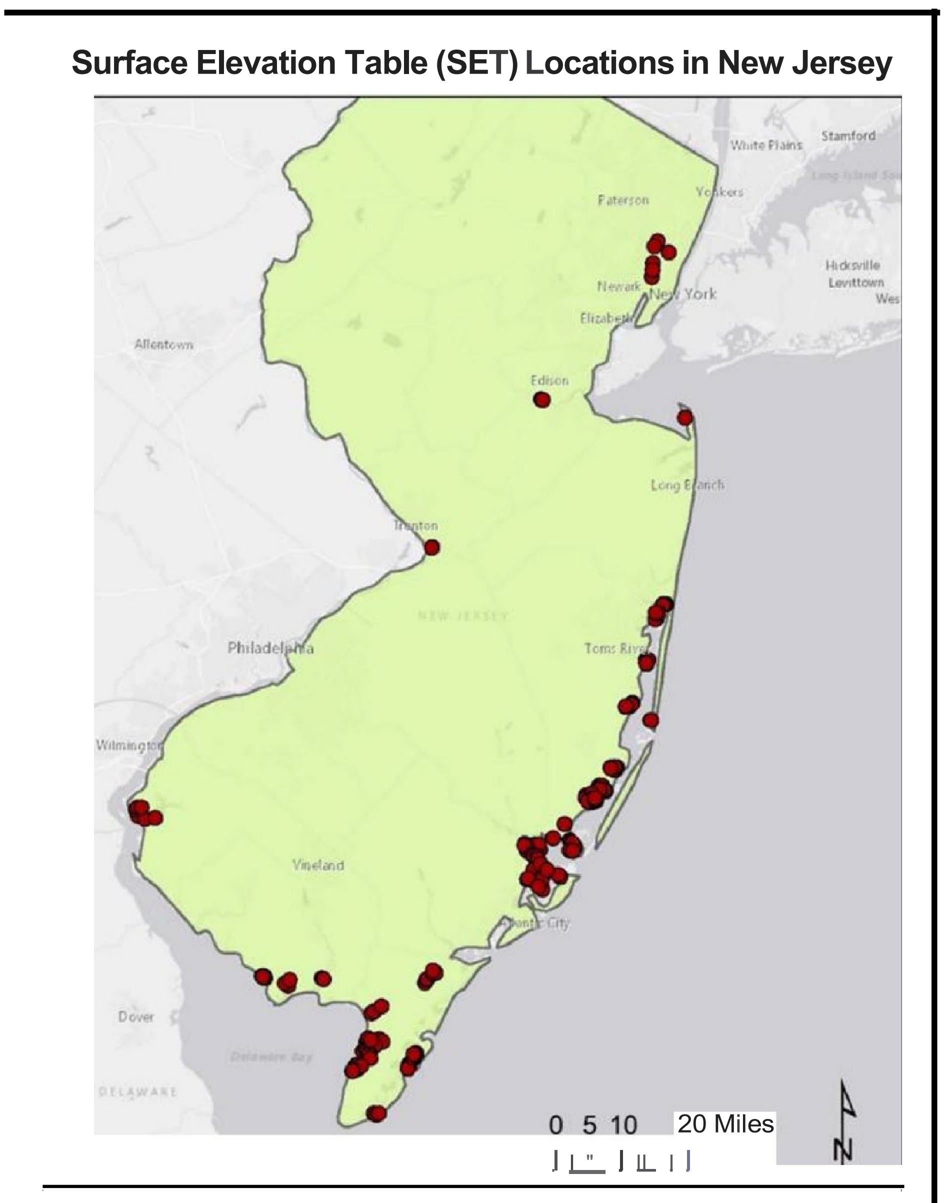


figure 1 Surface Elevation Table (SET) locations in New Jersey

Data Evaluated for Use:

Data Used:

- Vector Data
  - National Hydrography Dataset (NHD+ High Resolution)
    - Stream Channels
    - Channel Order
    - Channel Length
    - Some differentiation between natural and constructed channels
    - Missing considerable amount of channels in tidal areas
      - Ditching is represented to varying degrees
        - The way some ditches are drawn (90 degree angles) will affect accuracy of sinuosity index
      - Channel lines sometimes approximate actual channel centerlines
      - Stream order is not consistent in scale
    - Dataset is incomplete/approximated, especially in tidal wetland areas. It is useful as a starting point, but needs a considerable amount of work to accurately depict the reality of tidal marsh channels
  - 2015 New Jersey Land Use
    - Used to restrict MOWR calculations to coastal wetland categories
    - Eliminated "Bay/Estuary" from MOWR calculation
- Raster Imagery Data
  - NJ 2012 1ft imagery
    - Consistent imagery of the entire state
    - Imagery taken at high tide (3 hour window)
      - Easier to see and compare width of channels filled with water
    - Scale of data makes it difficult to identify the smallest channels which were the goal of this project

Data considered but not used:

  - NJ 2015 1ft imagery
    - Consistent imagery of entire state
    - Imagery taken at mean tide
      - Not easy to see and compare width of channels
    - Scale of date makes it difficult to identify the smallest channels which were the goal of this project
  - NearMap
    - High resolution imagery with greater frequency (2-3 times per year over past 5 years)
    - Unknown when in tidal period imagery was taken
    - Varying resolution (inches to feet)

        - Incomplete coverage of wetland areas (missing Delaware coast and several other wetland areas)
    - EagleView
        - Better coverage than Near Map
        - Unknown age of imagery
        - Unknown when in tidal period imagery was taken
    - LIDAR
        - Newest high resolution coastal LIDAR was not ready in time to be used for this project
        - Resolution of available 2017 NOAA topobathymetric LIDAR not high enough to identify/delineate all channels

Methods Considered:

We wanted to identify hydrogeomorphic metrics that were meaningful indicators of function. We accomplished this with a literature review of tidal morphology and methods used to construct metrics and consulting with local researchers with expertise in tidal wetland morphology and GIS. An automated process using existing data and tools was preferred.

Hydrological analysis of tidal areas is complicated by bi-directional flow. While fluvial streams form through drainage and erosion, tidal channels form through a combination of deposition and erosion as the tidal prism flows inland and retreats on the ebb. Channel width does not scale with channel order as it does in fluvial stream networks. *Hughes, 2012* Additionally, a larger percentage of New Jersey's tidal wetland have been modified with anthropogenic ditches and mosquito control ponds. The traditional methods of performing a hydrologic analysis do not work in these conditions.

Various methods using imagery and elevation data were tested to identify and delineate tidal channels:

> A Normalized Difference Vegetation Index (NDVI) was tested on multispectral imagery of a wetland area. This process compares the amount of reflected red light versus near- infrared light. The result is an index with values between -1 and 1 representing the amount of chlorophyll. Water absorbs near infrared light. Using this method, it was possible to isolate most areas of water. An attempt was made to use Arc Scan to automate the tracing of the centerlines of these areas of water. The results were not acceptable and would have required extensive manual editing to create a useable network of tidal channels.
>
> 2017 LIDAR data from NOAA was used to attempt to isolate channels by elevation. The idea was to use the Slope tool in Arc GIS Spatial Analyst to detect the bank edge of the channels which could then be used to clip the channels from the surrounding imagery.

The resolution of the imagery was not sufficient to identify smaller channels. Each pixel was 3 meters square and most channels were not wide enough to be detected. If that process had been successful, there was still the same issue of automating the delineation of channel centerlines we faced with the NDVI approach.

These trials led us to select the National Hydrography dataset as our source for flowline data. There are issues with channel ordering and small channels that are missing, but it is a more complete representation of channel centerlines than we could have generated by any other method. Accepting the limitations of the dataset, we felt that we could construct useful tidal channel morphology metrics and by choosing to use surface elevation table locations as our study areas, we would have a means to compare the results with field observations. If those field observations validate our metrics, our methodology could be applied to tidal marsh areas statewide.

Assessment of Methods and Process Development:

- **Automated processes**
  - Several ideas were tried to automate a workflow to identify tidal channels from imagery
    - Normalized Difference Vegetation Index (NDVI)
      - Thresholding to isolate water from land
        - Attempts to auto-trace resulting areas of water did not work well
        - Needed an additional method to restrict "water" areas to channel boundaries
          .
        - Would have required manually tracing/editing
        - Would have been equivalent to re-creating the NHD from scratch
    - LIDAR
      - Attempted to identify channels by elevation
        - Need to find low spots within tidal range
        - Tidal range varies somewhat
        - Too much of an unknown to isolate channels
      - Attempted to identify channels by slope
        - Rate of change in elevation should identify channel banks
        - Resolution not high enough to capture bank slope

- **Manual process (for CISD analysis)**
  - A manual process to edit channels using NHD flowlines as a starting point was chosen as the only option with available datasets
  - Focused on SET location buffers and CISD analysis
  - Used NHD flowlines as a starting point
  - An attempt was made to normalize the scale of stream order across all set locations

        - Though effort was taken to treat each area equally, there was no way to completely eliminate bias in the manual editing process
        - Judgement calls needed to be made
        - Available time was a factor
    - In many areas, NHD flowlines were a rough approximation of channels visible in imagery
        - These were corrected to channel centerlines visible in imagery as they were found
    - NJ 2012 imagery was used because of uniformity and high tide conditions
    - Smallest tributaries were not identifiable/able to be delineated from this data
    - CISD channels were identified and processed
        - CISD results were completed for 219 NJ SET locations
        - Several problems were found and corrected
            - Multiple layers of stream channels were created where SET buffers overlapped.
                - These extra layers were removed so that they didn't artificially inflate the CISD scores
            - Some SET locations had reduced decimal precision resulting in locations that were up to 500' away from their actual location.
                - Locations for 60+ SETs were updated to coordinates with higher decimal precision
    - Many channels were added within the 500m SET buffers
        - These channels were assigned a stream order attribute
        - Stream length can be calculated for these streams
        - These streams do not have the rest of the attributes that existing NHD flowlines have.
        - They do not have an attribute differentiating between natural and constructed ditches though an attempt will be made to add this attribute
    - Channels less than 1ft were not delineated
        - These channels were difficult to identify
        - These channels were far too numerous to attempt to delineate across 219 500m SET buffer areas in the time available
    - The extent of how much editing was required to correct existing NHD flowlines in coastal wetlands was not easy to assess until it was happening.
    - Sinuosity Index scores can be calculated for the NJ SET 500m buffer areas using the edited channels.
        - Ditches should end up having a sinuosity index of 1.
            - An attempt can be made to look over these channels and classify them as ditches
        - Sinuosity scores at the HUC 14 scale will use the existing NHD flowlines
        - NHD SPARROW model contains sinuosity index score for catchment areas
            - Not all catchment areas have scores
            - I intersected these with NJ SET locations, a good

number are missing

- Bifurcation Ratio will not be able to represent the smallest tributaries
  - 1st order streams would be >= 1 ft in width
- Stream length ratio would also not be able to represent channels < 1ft in width
- Marsh to open water ratio would have to rely on the existing NHD data for channel area as there is no way to calculate area for the channels that were added.
  - Need to decide what dataset identifies "marsh"
    - 2015 NJ Land use?
  - Need to determine sources for "open water"
    - Existing NHD flowlines
    - 2015 NJ land use
    - OMWM shapefile from Drexel University
  - Settled on SHARP wetlands classiffication raster dataset for MOWR calculations
- Channel type (dead end vs through flowing)
  - Basically the 1st order channels are dead end and the higher order channels are through flowing
  - This gets more complicated in ditched areas where 2nd and 3rd order channels dead end
- Asymmetric flow is beyond the scope of what we can do with existing data/tools
- Bank angle is not possible without higher resolution LIDAR
- Drainage density would have to rely on NHD catchment areas as the drainage area to divide the channel segment it relates to. This means we could only calculate drainage density using existing NHD data.
- Open Marsh Water Management
  - Beyond what is delineated in existing datasets (NHD waterbody, 2015 NJ Land Use, and OMWM shapefile from Drexel University) there is not a practical way to identify and delineate surface ponding quickly
  - Used data from Rutgers Center for Remote Sensing and Spatial Analysis to classify study areas by presence or absence of OMWM.
- Number of first order rivulets was not attainable with the current state of existing data.
  - They are below the resolution of the contiguous imagery that we have available
  - This should become easier in the future when the high-resolution coastal LIDAR becomes available
  - Over time, the NHD flowlines will be updated and improved but, realistically this is years away

Methodology Selected and Employed for this Project:

Channel Order is useful for characterizing the volume of water flowing in a given portion of a network. Generally, a change in stream order represents an order-of-magnitude change in flow volume. It also is an indicator of a channel segments distance from the ocean and tidal forces. As such, it can inform both connectivity (supply of water, sediment, and nutrients) and isolation (protection from predation for spawning fish).

Stream order in a fluvial system has a relationship to the total drainage area and therefor represents magnitude. In tidal course networks, this relationship is not so clear-cut. It is important to understand that channels in tidal areas have significant differences from fluvial streams in their scaling with size (Perillo 2009). Fluvial streams are formed by drainage. Tidal channels are formed through bi- directional flow (*Huges 2012*) We identified the National Hydrography Dataset as the best available source for constructing our channel metrics. Constructing metrics for SET locations in New Jersey allows for the results to be tested against field observations. Using the NHD data, these metrics could be constructed for any location in the state.

> *"Preliminary studies. Especially those related to drainage networks (Pethick, 1992, Pye and French, 1993) have considered fluvial terminology to describe tidal course networks although there are clear differences related to hydraulic and geomorphic considerations" (Perillo 2009).*

The Strahler (top down) method of stream ordering describes a one-way (fluvial) drainage network, increasing in order from the tributaries to the estuary. This type of system is formed by erosion. A tidal channel network is the result of erosion and deposition as the tide flows in and out.

> *"Watershed delineation for a tidal channel has theoretical and practical difficulties. First of all, ebbing and flooding phases preclude the definition of a divide as a time independent locus of points in space" (Perillo 2009).*

Channel Order:

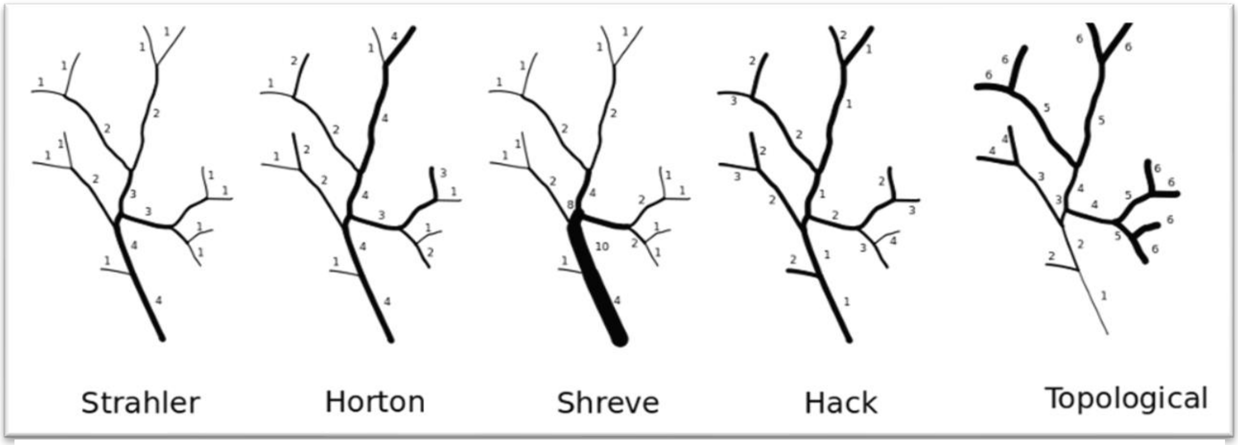


Figure 2 Examples of stream ordering methods. The NHD uses Strahler stream ordering

Flowline data from the National Hydrography dataset was used to determine channel order for our analysis. The specific version used is the August 25th, 2010 extract hosted by NJDEP Bureau of GIS which includes some corrections to the USGS hosted version of the NHD flowlines. Even so, many of the flowlines and channel order values in tidal marsh areas don't represent all existing channels or work well as a proxy for width. With the exception of the CISD analysis, all NHD flowline and channel order data was used as is with the understanding that, while not perfect, is the best available model of the channel network. For the CISD analysis, the flowlines were edited with each SET location 500m radius. This was done to add small channels that were not included in the NHD flowlines and normalize channel orders by channel width, which was necessary for the CISD analysis. This was done from the 2012 NJ 1ft imagery. The 2012 imagery was chosen because it was taken within a 3 hour window of high tide, which made it easier to identify small channels visually. While care was taken to treat each area equally, we expect some amount of error was introduced during the manual editing process. Taking this into consideration, at the 500m radius level, we did the analysis with both the original, un-edited NHD flowlines and the edited flowlines. At the SPARROW catchment level, only the original NHD flowlines were used. Due to the resolution of the imagery used (1ft pixels), it wasn't possible to digitize the smallest rivulets and channels less than 1ft in width.

Figure 3 NHD Flowlines showing channel order

With the exception of the CISD analysis, all NHD flowline and channel order data was used as is with the understanding that, while not perfect, is the best available model of the channel network. For the CISD analysis, the flowlines were edited with each SET location 500m radius. This was done to add small channels that were not included in the NHD flowlines and normalize channel orders by channel width, which was necessary for the CISD analysis. This was done from the 2012 NJ 1ft imagery. The 2012 imagery was chosen because it was taken within a 3 hour window of high tide, which made it easier to identify small channels visually. While care was taken to treat each area equally, we expect some amount of error was introduced during the manual editing process. Taking this into consideration, at the 500m radius level, we did the analysis with both the original, un-edited NHD flowlines and the edited flowlines. At the SPARROW catchment level, only the original NHD flowlines were used. Due to the resolution of the imagery used (1ft pixels), it wasn't possible to digitize the smallest rivulets and channels less than 1ft in width.

Edited and original NHD flowlines were clipped the 500m SET study areas. The original NHD flowlines were additionally clipped to the NHD SPARROW Modeler catchment areas that intersect with SET locations. Sparrow catchment areas don not have a 1:1 relationship with SET locations. In many cases, there are multiple SET locations in each selected catchment area. However, the flowlines were clipped to individual shapefiles for each SET location, so that each SET would have the flowlines within its respective study area. Each flowline shapefile was given the name of the SET location shapefile used as the clip feature using an iterator within Arc GIS model builder on the Clip tool. An inline variable passes the clip feature filename to the output filename.

Once clipped, the flow lengths were recalculated in feet. A field was added to include the SET name for each flow line. A Python script was used to populate this field with the filename. This assigned the SET name to each flowline in the shapefile. These individual shapefiles of flowlines were written to a folder. All flowline shapefiles in that folder were then merged into one shapefile. The added field with the SET location name allowed us to later summarize the flowlines by SET location. This process solved the problem of flowlines that needed to be counted for multiple SET locations within the same study area. This merged shapefile of flowlines was then joined with the NHD Value Added Attributes (VAA) table. The VAA tables provide additional information about each flowline, including channel order and whether it is a natural channel or ditch. NJ spans 3 regions. Both the flowlines and the VAA tables were merged into single files that included all 3 regions (202, 203, and 204). When the flowlines were merged with the VAA tables, only the matching results were kept. The NHD flowlines include coastlines as polyline features. These coastline polylines were removed as we were only concerned with channels.

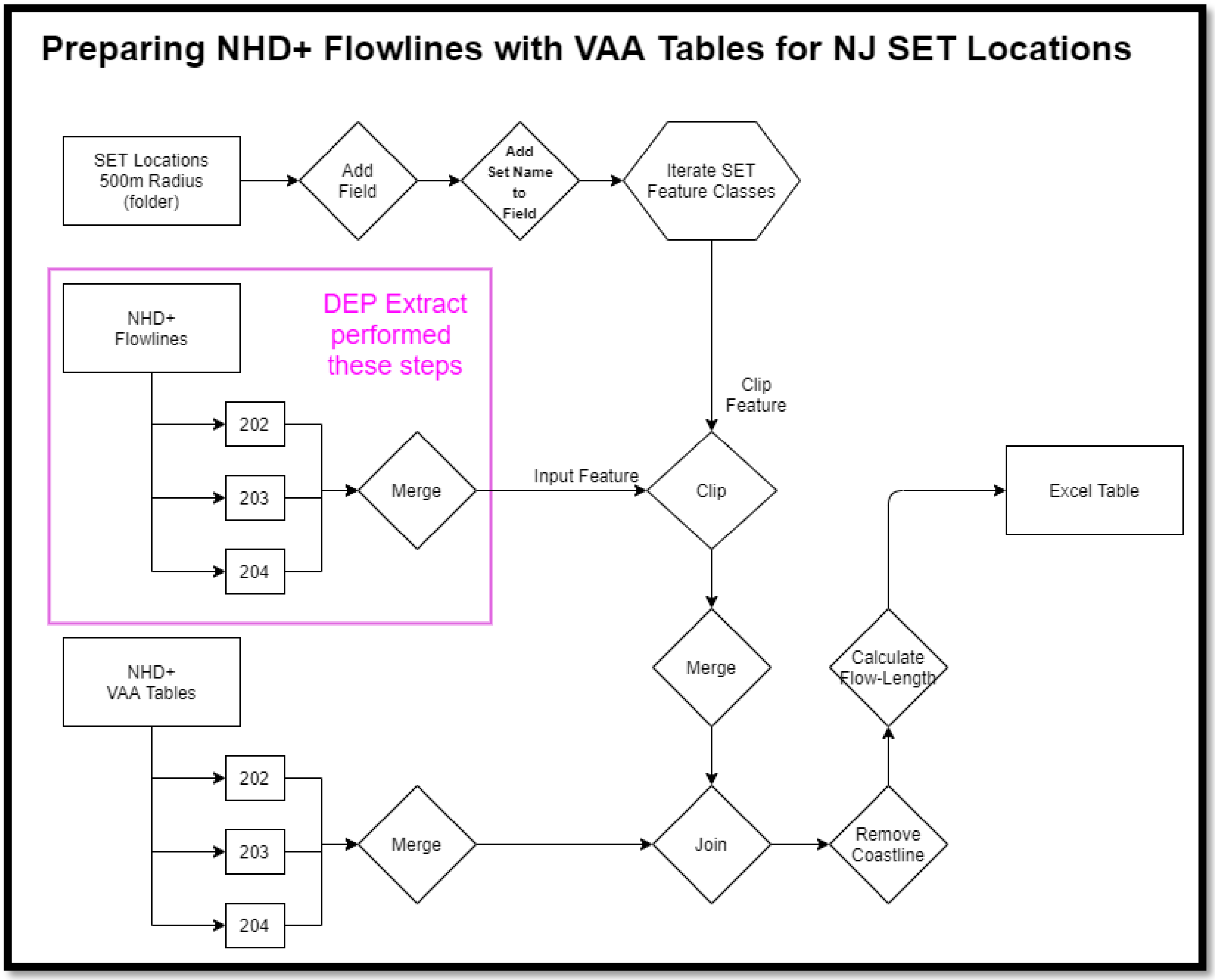


Figure 4 Arc GIS Workflow for preparing NHD flowlines for calculating SET metrics

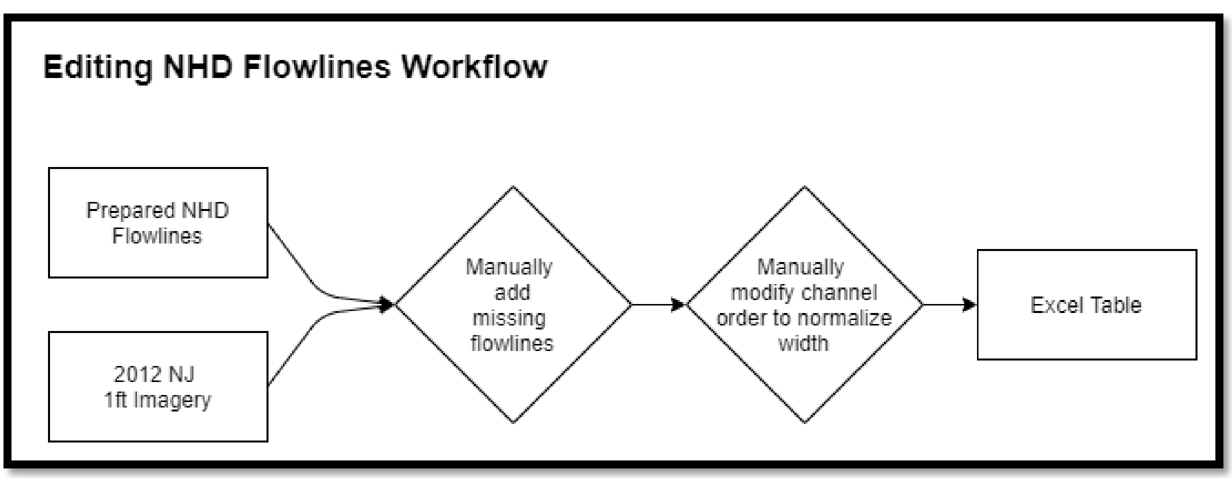


Figure 5 Arc GIS Workflow for adding channels and adjusting channel order

Cumulative Inverse Squared Distance (CISD)

We based our Cumulative Inverse Squared Distance analysis on the method described in “A Simple Empirical Model of Salt Marsh Plant Spatial Distributions with Respect to a Tidal Channel Network”, Sanderson et. al. 2001. 1 We increased the radius of our study areas to 500m so that all SET location included channels.

This method uses points generated every half meter along the channel flowlines. Each point uses the channel order as its weight. We multiply the weight by the squared inverse of the point’s distance from the SET location. The final metric is the sum of these weighted inverse squared distances.

The method uses the first, closest channel in every direction from the SET location. Channels beyond those first channels are omitted. For this reason, increasing the size of the study area didn’t inflate the results, as using the

inverse squares of their distance adjusted for their reduced influence on the SET location.

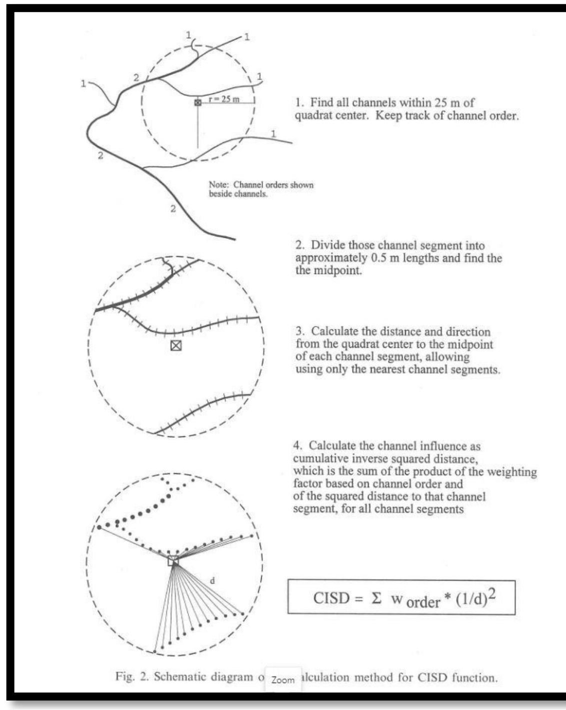


Figure 5 CISD methodology from Sanderson et. al. 2001

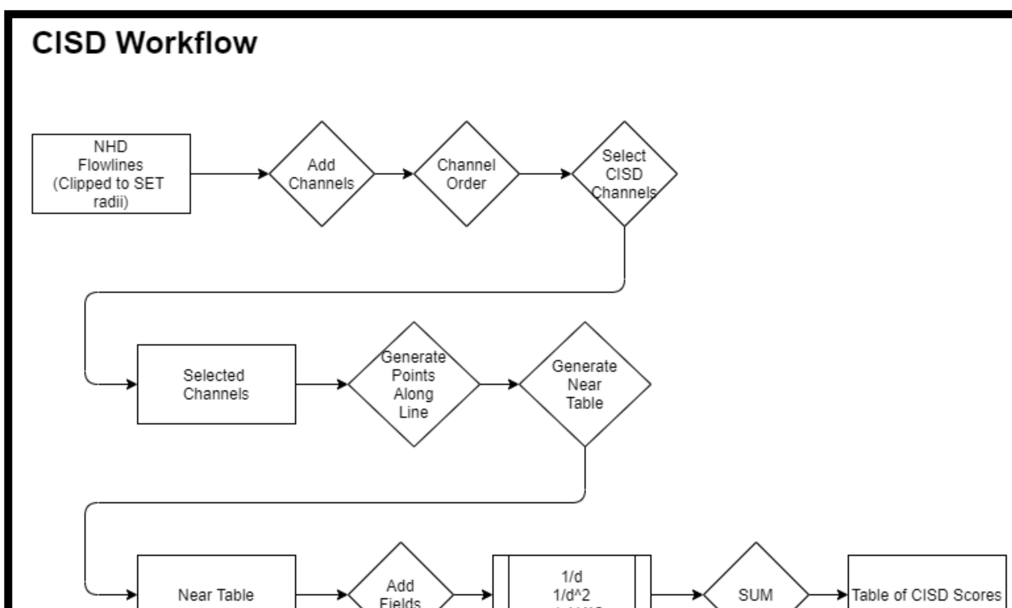


Figure 6 Arc GIS Workflow for CISD analysis of SET locations

Cumulative Inverse Squared Distance Analysis Results:

Our scores ranged from 0.4803 to 10.2771 with a mean score of 5.1236. This represents the influence the tidal channels have on the 211 SET locations in NJ. The Sanderson et. al. study took the process further and created a continuous raster layer which they could use to predict the presence of certain plant species. They performed a logarithmic transform on their raw CISD scores to scale with pre- existing data for their study area. While we did not have the same end goal, we wanted to be able to compare our values to the original study. We performed their transform on our raw CISD values. Our transformed values ranged from 11.8 to 20.99 with a mean value of 18.63. These values are near the center of the distribution of values shown in the Sanderson study's graph of plant distribution probabilities. (figure 8)

	SET CISD Score	**Transformed CISD Score**
min	0.4803	11.8
max	10.2771	20.99
mean	5.1236	18.63
std. dev.	1.9371	1.3711

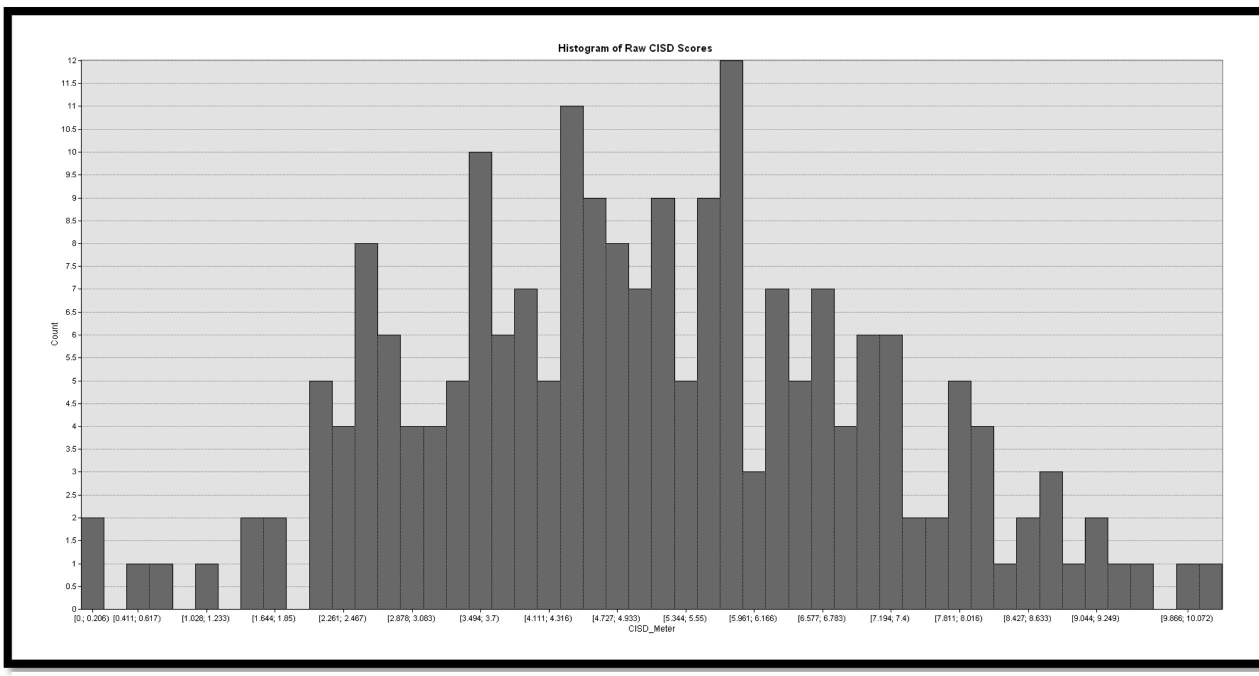


Figure 7 Distribution of CISD scores from our analysis

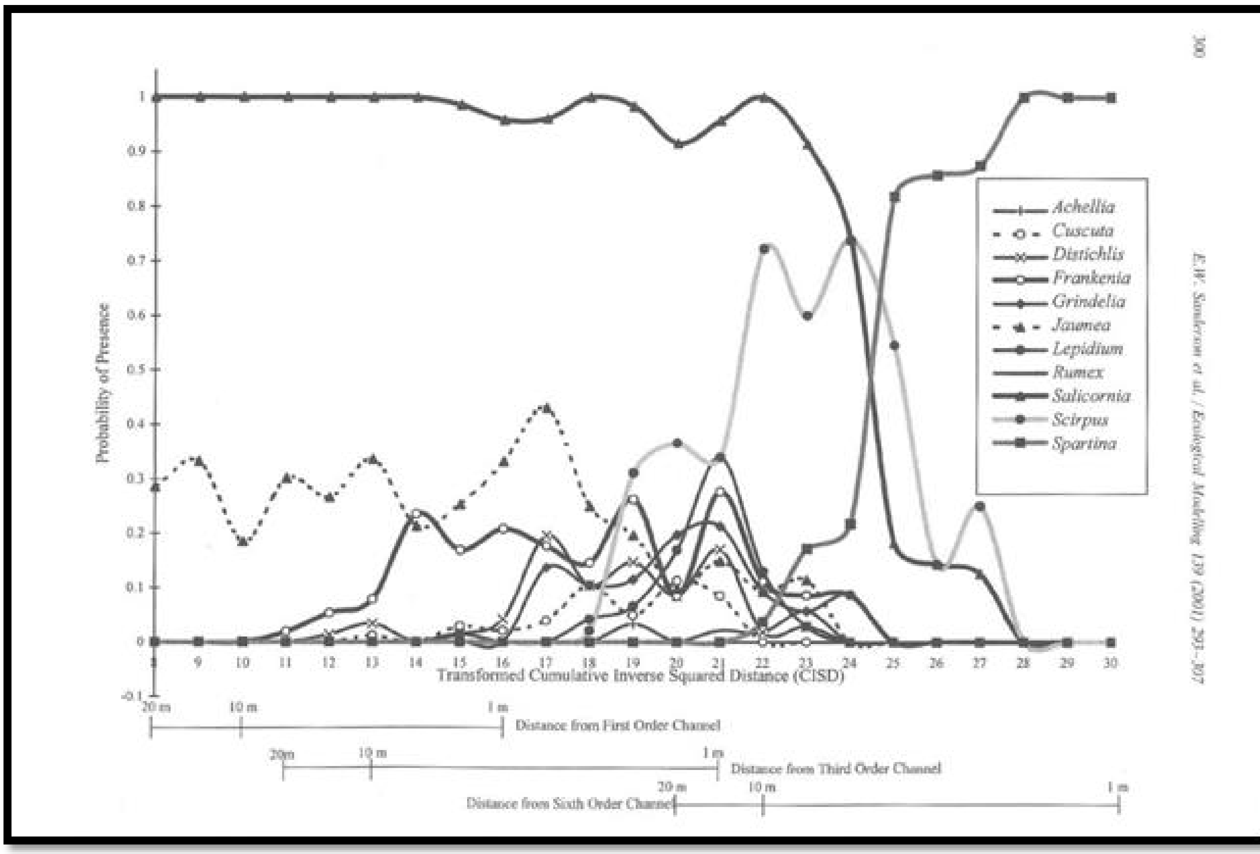
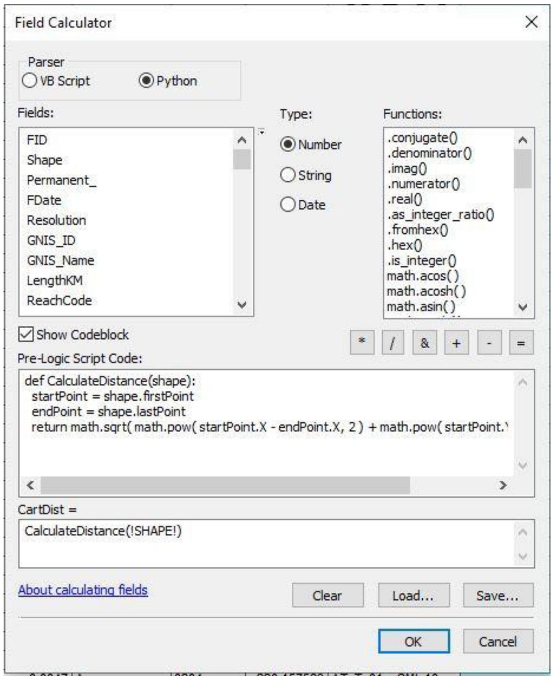


Figure 8 Graph from Sanderson et. al. showing range of transformed CISD values

Sinuosity Index:

The sinuosity index is the ratio of the flow length to the cartesian distance between the start and end of each stream segment. To calculate the cartesian distance, we used Python scripting within Field Calculator in Arc GIS to retrieve the starting and ending (x,y) coordinates of each flowline from the Shape object. A field was added for CartDist and the cartesian distance formula was used to populate that field with the line of sight distance of those starting and ending points. Field Calculator was then used to divide the flow length by the cartesian distance to populate the SinIndex field. These values were summarized by 500m radius and catchment area to create an average sinuosity index value for each SET location.



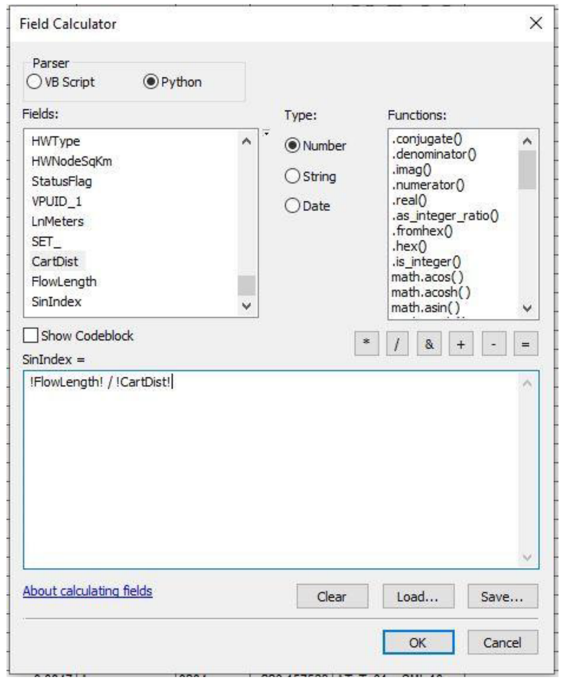


Figure 10 Python script to obtain cartesian distance of channel segment end points from SHAPE object in ArcGIS
Figure 9 Calculating sinuosity index in ArcGIS Field Calculator

There were several situations present in the NHD flowlines that complicated the sinuosity index calculations. In some cases, the way that the flowlines were drawn resulted in extremely short cartesian distances and long, straight flow lengths. In other cases, the start and end vertices are not properly placed at the beginning and end of the flowline. These issues had a negligible influence on the final sinuosity index values. Clipping flowlines to study areas, in some cases ended up splitting flowlines into two or more segments. This resulted in long cartesian distances with much shorter flow lengths and a sinuosity score less than 0. There were approximately 40 – 50 of these across all study areas, so they were manually measured (snapping to vertices) with the ruler tool in Arc GIS and corrected in the table. Another situation where there were long flow lengths with short cartesian distances were diversions along meandering channels.

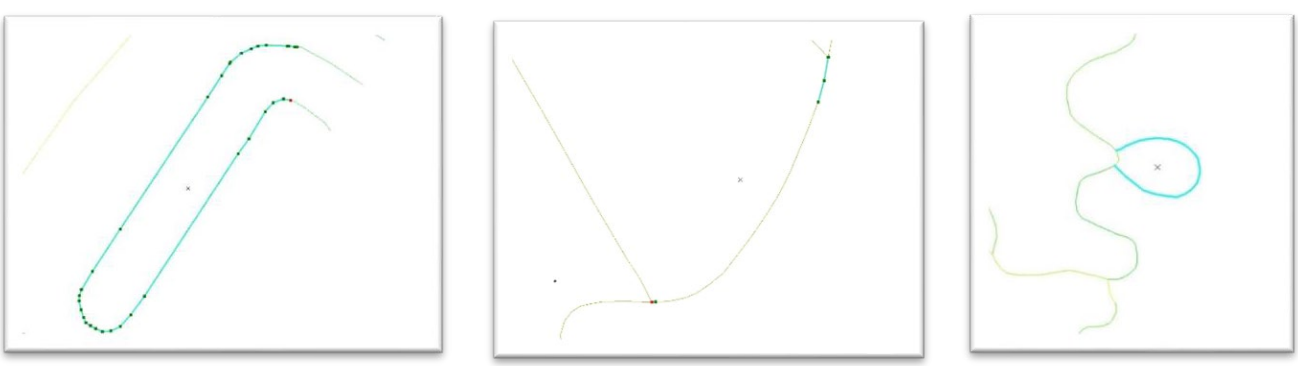


Figure 11 Various issues affecting cartesian distance derived from NHD flowlines

Sinuosity Index Results:

Our sinuosity index scores are summarized by SET 500m radii and catchment areas. A score of 1 indicates perfectly straight channels and would suggest that the primary channel type is anthropomorphic ditching. Higher values indicate increasing degrees of curviness and indicate a higher presence of naturally formed tidal channels.

	SET 500m Radii	**Catchment Area**
min	1.00	1.00
max	14.82	3.12
mean	1.32	1.11
std. dev	1.19	0.21

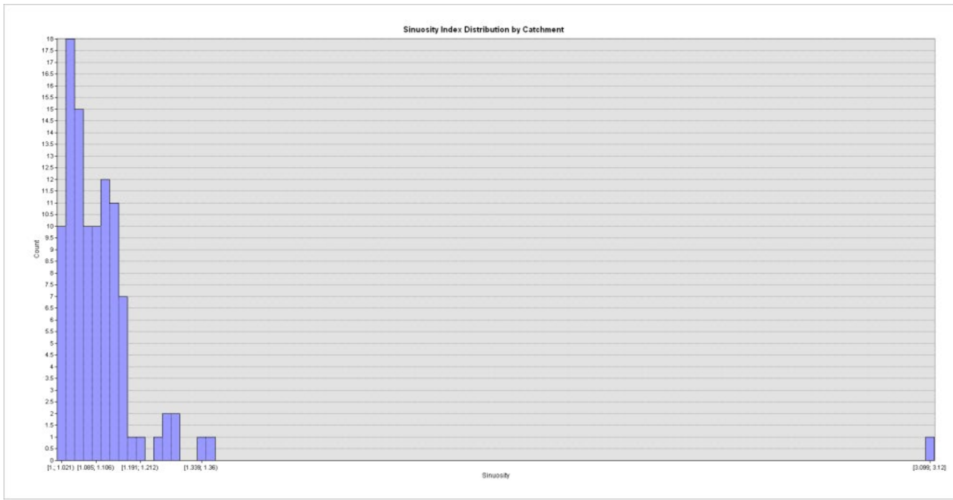


Figure 12 Distribution of sinuosity index scores summarized by catchment area

Figure 13 Distribution of sinuosity scores summarized by 500m SET radii using NHD flowlines

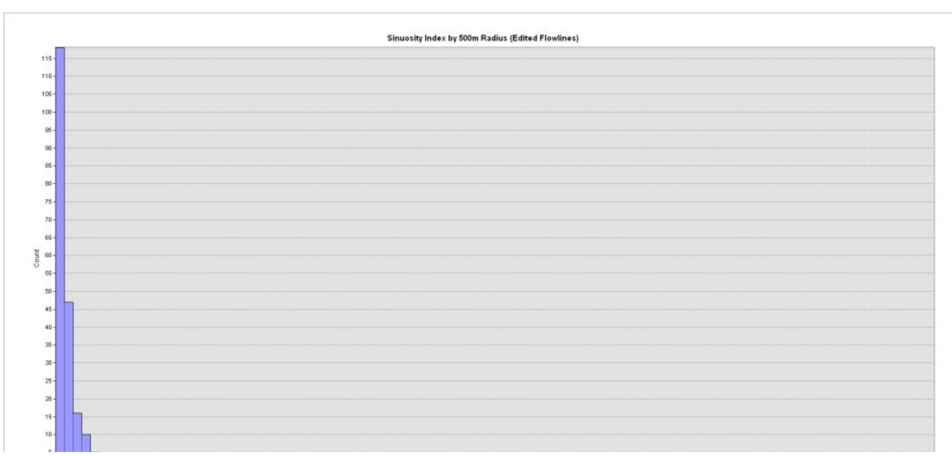


Figure 14 Distribution of sinuosity scores summarized by 500m SET radii using NHD flowlines edited for the CISD analysis

Bifurcation Ratio:

This is the ratio of the count of 1st order channels to the count of 2nd order channels. It is a dimensionless metric that describes how much branching there is in the channel network. At the 500m radius level, this was calculated with both the original and edited NHD flowlines. At the catchment level, only the original NHD flowlines were used.

Channels were clipped in Arc Maps and summarized for the 500m buffer around SETs and catchment areas of SETsby study area at both scales in Excel using pivot tables. The count of 1st order channels was divided by the count of 2nd order channels. Bifurcation ratio describes the degree of branching in the channel network.

Results were in a range from 0-8. Values of 0 indicate there were no 1st order channels. Values of 9999 indicate there were no 2nd order channels. These 2 cases occurred primarily in areas that were ditched, however there are situations where 1st order channels had not been delineated in the NHD flowlines.

Drainage Density/Channel Density:

For the 500m radii, there is no drainage relationship between the channels and the study area. It's an arbitrary circle drawn around the SET location. For this reason, we are using the term "Channel Density" to report the total length of channels within the study area. At the catchment level, there is a drainage relationship between the catchment area and the channels they contain.

Channels were clipped in Arc Maps and summarized for the 500m buffer around SETs and catchment areas of SETs by study area at both scales in Excel using pivot tables. The length of all channel orders within each study area in feet was divided by the square footage of the study area.

At the catchment level, there is a drainage relationship between the catchment area and the channels. At the 500m radius, the study area is arbitrary to the channels, therefore there is no drainage relationship. At the 500m scale we are calling this metric "Channel Density" to clarify the lack of drainage relationship.

Values ranged between 0 and 0.009

Channel Length Ratio:

This is the ratio of 1st order channels to 2nd order channels within each study area. Reported for 500m radii and catchment areas.

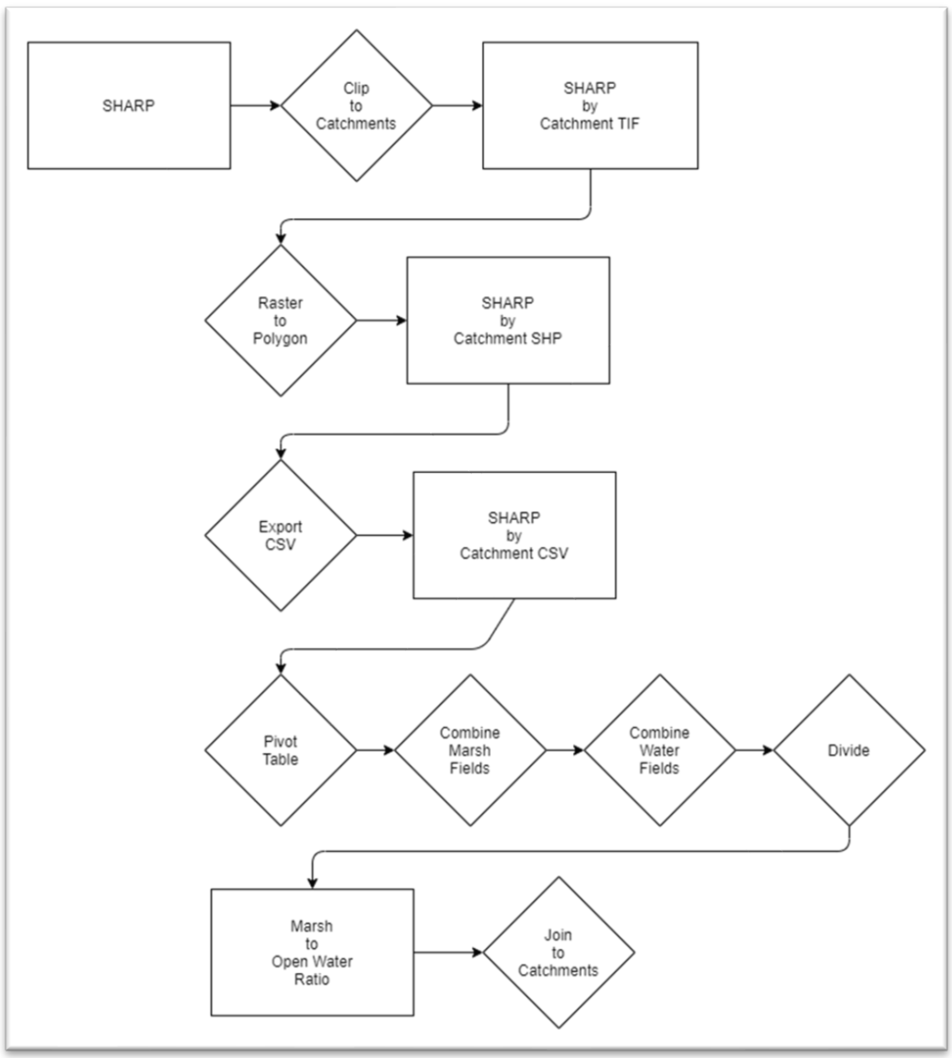
Channels were clipped and summarized for the 500m buffer around SETs and catchment areas of SETs by study area at both scales in Excel using pivot tables. The length of 1st order channels in feet was divided by the length of 2nd order channels in feet.

Values ranged from 0 –15.48. 0 indicates that there were no 1st order channels. 9999 indicates there were no 2nd order channels. These 2 cases occurred primarily in areas that were ditched, however there are situations where 1st order channels had not been delineated in the NHD flowlines.

Marsh to Open Water Ratio:

This metric was derived from the Saltmarsh Habitat and Avian Research Program's habitat zonation map. Marsh areas were classified as "High Marsh", "Low Marsh", "Mudflat", "Phragmites", "Terrestrial Border", "Upland", "Pool/Panne", and "Stream/Open Water". "High Marsh", "Low Marsh", and "Phragmites" were combined as vegetated marsh area. "Mudflat", "Pool/Panne", and "Stream/Open Water" were combined as non-vegetated open water area. "Terrestrial Border" and "Upland" were excluded. Our Marsh to Open Water ratio represents vegetated marshland / non-vegetated open water for each study area.

Tidal Marsh classifications were clipped for the 500m buffer around SETs and catchment areas of SETs by study area from the SHARP habitat zone raster layer. "High Marsh", "Low Marsh", and "Phragmites" zones were combined into "Vegetated Marsh". "Mudflat", "Pool/Panne", and "Stream/Open Water" zones were combined into "Non-Vegetated Open Water". "Terrestrial Border" and "Upland" zones were excluded. "Vegetated Marsh" was divided by "Non-Vegetated Open Water".



Results ranged from 0.28 to 77.19. 7 out of the 211 SET locations did not have SHARP data that intersected. These 7 SET locations have a value of 'null'.

Corrections to the Marsh to Open Water Ratio:

Upon review of the data, we determined that the Marsh to Open Water data included large areas of bays for some study areas. We wanted our MOWR metric to more show the relationship between the marsh platform and the tidal channels. To do this, we re-ran the MOWR process with the SET 500m radii and catchments clipped to "Wetland" categories from the 2015 New Jersey Land Use dataset. "Bay/Estuary" and "Large Tidal Rivers" were grouped together in that dataset. We were not able to isolate large tidal rivers from bay/estuary. We decided to calculate the new Marsh to Open Water Ratio without the large tidal rivers. We feel that this more closely quantifies the relationship between the lower order tidal channels and the marsh platform.

Open Marsh Water Management:

This metric represents Open Marsh Water Management ponds as either present or absent in each study area.

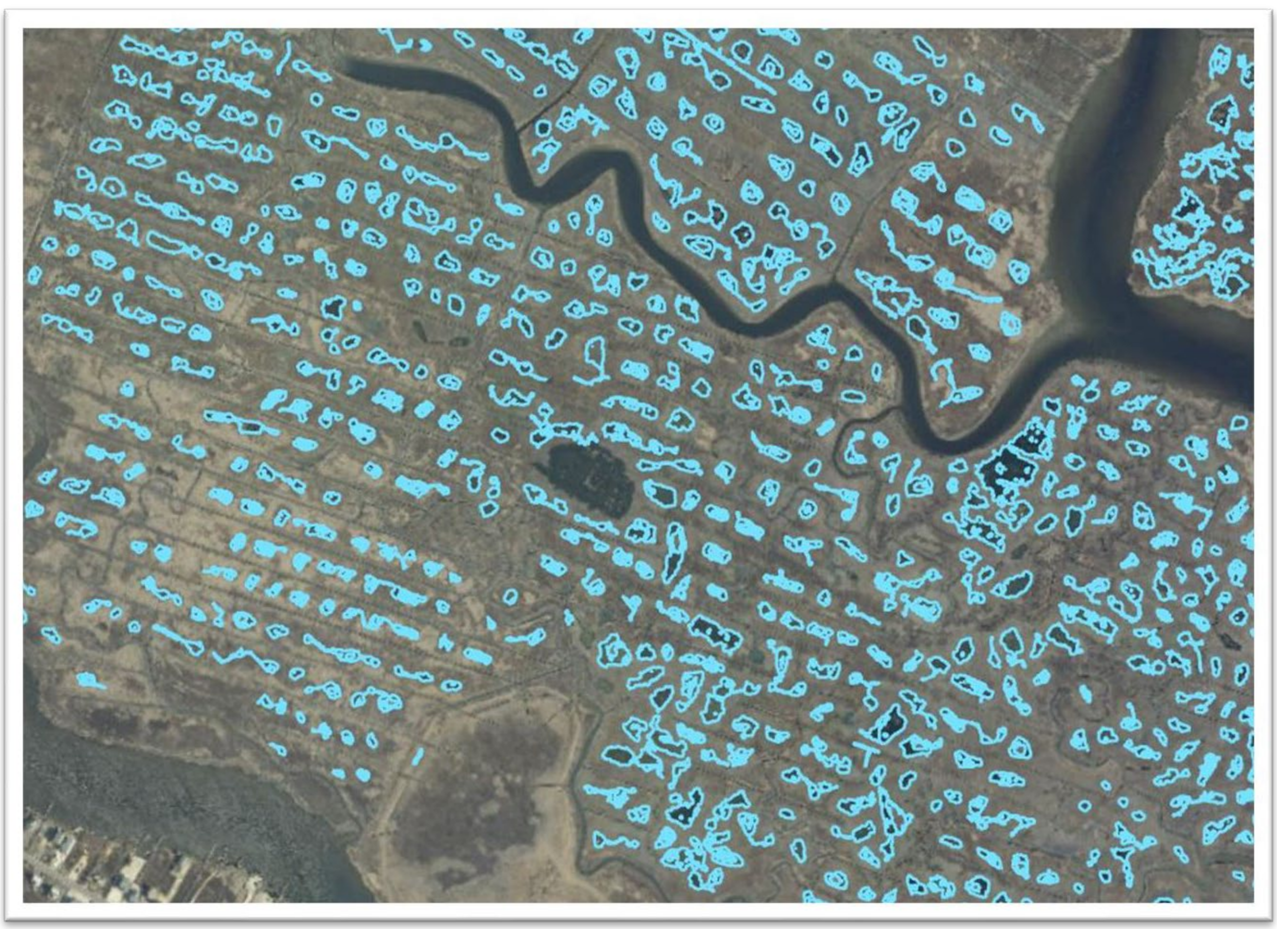


Figure 15 Open Marsh Water Management (OMWM) ponds highlighted in blue.

Data from the Rutgers Center for Remote Sensing and Spatial Analysis classified New Jersey land Use coastal wetlands areas by "Absence", "Limited", "Partial", and "Complete" coverage by Open Marsh Water Management ponds. These land use areas were clipped for the 500m buffer around SETs and catchment areas of SETs by our study areas, resulting in most study areas containing multiple

classifications of OMWM presence. Study areas that contained exclusively “Absence” classifications were marked “A”. Study areas that contained any combination of multiple classifications was marked “P”. Additional vector data from Elizabeth Watson at Drexel University was added to provide area calculations from OMWM delineations for tidal marsh areas in Barnegate Bay. We are not including this data with the metrics sent to Penn State, but it will be retained in the files stored at NJDEP.
Upon review of the data, we identified 3 study areas where the OMWM presence/absence result was incorrect. All study areas were visually checked and corrected for the presence or absence of OMWM.

References

Journal Articles:

- Perillo, G.M., 2009. Tidal courses: classification, origin and functionality. Coastal Wetlands: An Integrated Ecosystem Approach. Elsevier, pp.185-209.Hughes, Z.J. 2012.
- Hughes, Z.J., 2012. Tidal channels on tidal flats and marshes. Principles of tidal sedimentology, pp.269-300.
- Sanderson, E.W., Foin, T.C. and Ustin, S.L., 2001. A simple empirical model of salt marsh plant spatial distributions with respect to a tidal channel network. Ecological Modelling, 139(2-3), pp.293-307.Data Sets:

Data Sets:

- National Hydrography Dataset
    - https://www.nj.gov/dep/gis/digidownload/metadata/statewide/nhdstreams2002.htm
    - NJ 2012 1ft imagery
        - https://newjersey.maps.arcgis.com/home/item.html?id=153e2820ad454ffcbfddd9fda4ec3d7e
    - **Rutgers CRSSA**
        - http://adcrssa.rutgers.edu/data/projects/rsacatelli/Transfer_out/20150922
            - _Marshes_Levees_CRSSAdraft/MosquitoDitches_OMWM_UnalteredMarsh/_MosquitoDitch_OMWM_UnalteredMarshes.shp_(not publicly accessible)
    - **Drexel University (Elizabeth Watson) via DRYAD**
        - https://datadryad.org/stash/dataset/doi:10.5061/dryad.3j9kd51d2
    - **SHARP**
        - https://www.tidalmarshbirds.org/?page_id=2168

APPENDIX 3

Wetland characteristics based on diatom inferences: a comparison of TLP (thin layer placement) and control sites located in Cape May peninsula and Delaware Bay

Summary

Surface sediment samples were collected from wetlands located on the northern shore of Delaware Bay and Atlantic coast of Cape May peninsula and analyzed for diatom species composition. A total of twenty (20) samples were collected from sites located in the vicinity of existing surface elevation tables (SETs) from Fortescue, Avalon, Ring Island and Dias Headwaters salt marshes. Based on the New Jersey wetland diatom flora published on NJDEP website, more than 200 species were identified in the twenty study sites. Diatom-based models have been previously developed for inferring salinity, nitrogen sediment content, and tidal exposure in New Jersey (NJ) salt marshes by Desianti *et coll*. Based on the species composition and relative abundances, these models were used to infer nutrient (TN) sediment concentration, water salinity and wetland tidal exposure indices. The tidal exposure is represented by the Tidal Exposure and Standardized Water Level Indices – TEI and SWLI. TEI represents the portion of time a site is above the tide level where supratidal samples have a zero TEI value, the mean tidal level has a value of 50, and submerged sites have a TEI value of 100. SWLI estimates salt marsh elevation relative to tidal level; SWLI with the value 0 represents salt marsh elevation at mean lower low water and 1 at mean higher high water. Based upon these diatom-based inferences, a comparison was conducted to examine differences in wetland characteristics between sites that were located inside the thin layer placement (TLP) and outside the TLP (control) areas for the Fortescue, Avalon, and Ring Island salt marshes. The Dias Headwaters marshes didn't undergo a TLP. Fortescue sites were represented by both high and low marsh sites while Avalon and Ring Island sites were all located within low marsh areas.

Fortescue high marsh sites were represented by one (1) TLP and one control site only. Inferences for these sites revealed that the TLP site is characterized by higher sediment TN and SWLI, but lower salinity and TEI, particularly TEI was 50% lower than the control site. A slightly lower sediment TN, TEI and SWLI were found for the low marsh sites and higher salinity. Both TLP and control areas were represented by three (3) sites within each category. These inferences suggest that the TLP high marsh site is exhibiting increased marsh elevation and less impacts from tide activity compared to the control site, while the low marsh TLP sites did not produce a similar positive result.

Avalon sites were all low marsh with three (3) TLP and three control sites. The diatom-based inferences revealed slight increase in salinity and TEI, while SWLI and TN recorded slight decreases in TLP sites. These results appear to suggest the Avalon TLP sites are under higher tidal influence than control sites, and likely the TLP is not yet producing the expected protection from sea level rise (SLR) for these sites.

The Ring Island sites were also represented by three TLP and three control low marsh sites. The diatom-based inferences revealed even more pronounced differences between TLP and control sites, with the TLP sites experiencing increased SLR effects concretized in increased TEI and salinity and with lower TN and SWLI than the control sites. The differences observed in Ring Island were statistically significant suggesting higher exposure of TLP sites to tides and SLR, while the differences in inferred values for TLP and control sites in Fortescue and Avalon were not statistically significant. However, more sampling sites would be necessary for drawing a more accurate assessment of differences between the TLP and control marsh characteristics.

The Dias Headwater sites did not have a thin layer placement and exhibited similar species composition with variations in relative abundances between the two sites and also slight differences in the inferred TN, TEI, and salinity.

This investigation concludes that diatoms can provide an additional, independent tool with multiple possible applications in marsh condition assessment and monitoring.

Sampling sites and Sample collection

Samples comprising 10-cm square soil portions with a ~1-cm thickness were collected from wetland surface sediments located in the vicinity of existing surface elevation tables (SETs) (Figure 1). List of sampling sites is provided in Table 1. Fortescue and Dias Headwaters sites are located on the northern shore of Delaware Bay, while Avalon and Ring Island sites were located on the Atlantic Coast of Cape May peninsula. All samples were collected by The Nature Conservancy (TNC).

Table 1. List of sampling sites, geographic coordinates and habitat characteristics.

Sample code	Abbreviation	Lat	Long	Habitat	Vegetation
Fortescue FT-C-A-1	FT-C-A-1	39.24394	-75.17239	high marsh	S. alt, S. pat, Salicornia
Fortescue FT-C-B-17	FT-C-B-17	39.24797	-75.18142	low marsh	S. alterniflora
Fortescue FT-C-B-19	FT-C-B-19	39.24845	-75.18042	low marsh	S. alterniflora
Fortescue FT-P-1-44	FT-P-1-44	39.24693	-75.17788	low marsh	S. alterniflora
Fortescue FT-P-1-48	FT-P-1-48	39.24619	-75.17913	high marsh	Salicornia, S. alt (tall and short), Distichlis
Fortescue FT-P-2-37	FT-P-2-37	39.24864	-75.17554	low marsh	Salicornia, S. alt (tall and short)
Avalon AV-C-A-9	AV-C-A-9	39.07389	-74.75834	low marsh	S. alterniflora
Avalon AV-C-A-27	AV-C-A-27	39.07404	-74.76135	low marsh	S. alterniflora
Avalon AV-C-G-95	AV-C-G-95	39.08474	-74.7545	low marsh	S. alterniflora
Avalon AV-P-D-53	AV-P-D-53	39.08207	-74.7609	low marsh	Salicornia, Spa Alt
Avalon AV-P-E-72	AV-P-E-72	39.08143	-74.75674	low marsh	S. alterniflora
Avalon AV-P-F-88	AV-P-F-88	39.07886	-74.75484	low marsh	S. alterniflora
Ring Island RI-C-TLPC-4	RI-C-TLPC-4	39.05104	-74.77634	low marsh	S. alterniflora
Ring Island RI-C-TLPC-7	RI-C-TLPC-7	39.05076	-74.77654	low marsh	S. alterniflora
Ring Island RI-C-TLPC-15	RI-C-TLPC-15	39.05032	-74.7767	low marsh	S. alterniflora
Ring Island RI-P-TLP1-18	RI-P-TLP1-18	39.05362	-74.77312	low marsh	S. alterniflora
Ring Island RI-P-TLP2-6	RI-P-TLP2-6	39.05201	-74.77489	low marsh	S. alterniflora
Ring Island RI-P-TLP2-7	RI-P-TLP2-7	39.05186	-74.77515	low marsh	S. alterniflora
Dias Headwaters 2	DH-2	39.08100	-74.88400	low marsh	S.alt. , S.patens
Dias Headwaters 3	DH-3	39.07200	-74.88000	low marsh	S. alterniflora tall form

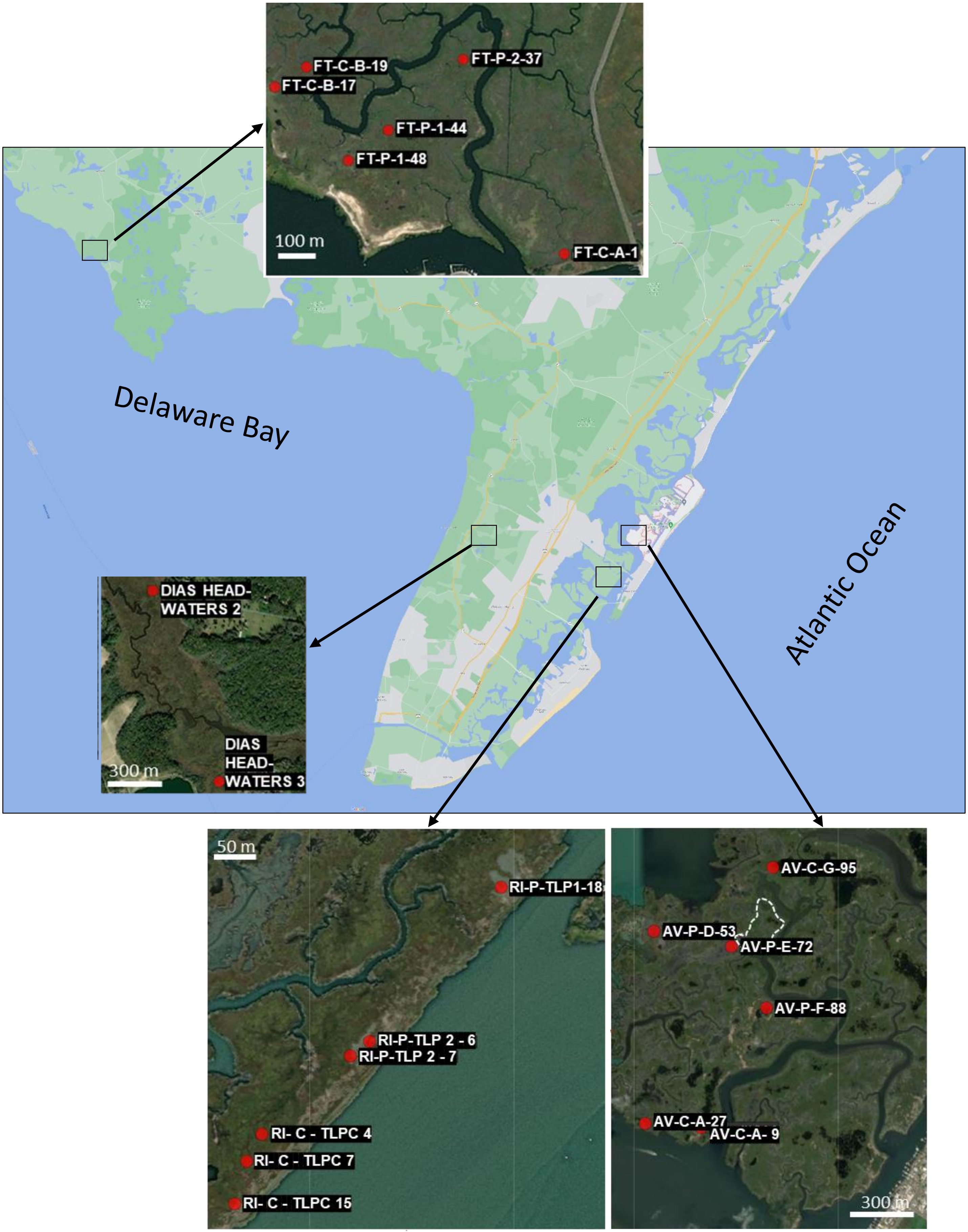


Figure 1. Location of sampling sites. Sites full names (codes) are provided in Table 1.

Diatom assemblages and inferences

Sediment samples were subsampled for ~1g wet sediment and digested in 70% nitric acid to remove organic matter content. Samples were then repeatedly rinsed with reverse osmosis (RO) water until near-neutral pH. Approximately 20 to 1000 µL of the cleaned sample containing diatom frustules were dripped onto coverslips and air-dried. Coverslips were then mounted on microscope slides using Naphrax™ mounting medium (Brunel Microscopes, U.K.). All diatom taxa identifications were made to species/variety level whenever possible using primarily the "Diatom Flora of the New Jersey Coastal Wetlands" identification guidebook (Desianti and Potapova 2019). Some small-celled taxa within the genera of *Chaetoceros* and *Minidiscus* could not be identified to species level under light microscopy and they were lumped in the "*Chaetoceros* spp.", and "*Minidiscus* spp." categories.

Diatom transfer functions, also named inference models were previously developed by Desianti et al. (2019) and were used in this study to calculate total nitrogen sediment content (TN, %dry weight), salinity, Standardized Water Level Index (SWLI), and Tidal Exposure Index (TEI) values. The values of salinity in the training dataset range from 0 to 32.1 practical salinity unit (psu), SWLI range from 0 to 1.6, TEI range from 1 to 100, and TN range from 0 to 2.32 (% DW) (Desianti et al. 2019). The SWLI model is used to estimate salt marsh elevation relative to tidal level. SWLI with a value of 0 represents salt marsh elevation at mean lower low water and 1 at mean higher high water (Kemp et al. 2013). TEI represents the portion of time a site is above the tide level where supratidal samples have a zero TEI value, samples at mean tidal level have a TEI value of 50 (Sawai et al. 2016) and samples submerged permanently have a value of 100.

More than 250 diatom species were identified in the 20 study sites (APPENDIX I). However, most of these species were present in low abundances or very rare. Only 35 species reached abundances more than 5% in at least one site. Across all sites, highest abundances were reached by *Navicula* sp. 63 (44%), *Denticula* subtilis (28%) and *Navicula* sp. 41 (26%). *Navicula* sp. 63, a species characteristic of high marsh habitat reached highest abundance in Fortescue FT-P-1-48, a high marsh TLP site. *Denticula subtilis*, a species related to lower tidal exposure reached highest abundances in Ring Island control sites RI-C-TLPC-4 and RI-C-TLPC-7. *Navicula* sp. 41 reached highest abundances in Ring Island TLP sites RI-P-TLP2-6 and RI-P-TLP2-7, associated with *Navicula salinicola* and other species attesting of lower elevation and/or higher tidal impacts. However, the Ring Island TLP sites had lower diatom abundances overall, likely due to higher tide/wave activity, possibly coarser substrates with poorer diatom population establishment after thin layer placement.

Diatom species composition and the inferred sediment TN, Salinity, TEI and SWLI in Fortescue TLP and control sites

Fortescue high marsh TLP and control sites were represented by one (1) sampling site each: Fortescue FT-C-A-1 and FT-P-1-48 (Fig. 1). The control site is characterized by a diverse diatom species composition, with highest abundances for *Navicula salinicola*, *Navicula* sp. 63 and *Planothidium* cf. *frequentissimum*, species that are typical of high marsh diatom associations previously found in Delaware Bay (Desianti et al. 2019). With lower abundances were also present *Denticula subtilis*, *Minidiscus proshkinae*, *Chamaepinnularia* aff. *begeri* (see Supplemental Material 1 for full count results; Fig. 2). The TLP high marsh site displays changes in species composition with highest increase in *Navicula* sp. 63 relative abundance from ~12% (in control site) to 44%. Navicula salinicola strongly declines, from ~12% to 2% relative abundance while *Halamphora aponina*, *Nitzschia scalpelliformis*, *Nitzschia sp. 25* reach moderate or higher abundances. These species composition changes, especially the high increase in *Navicula* sp. 63 abundance, are implicitly reflecting different conditions existing in the TLP high marsh site.

The diatom inferences for these sites revealed that the high marsh TLP site is characterized by higher sediment TN and SWLI, but lower salinity and TEI, particularly TEI was 50% lower than in the control site (Fig. 2). These changes could be related either to the pre-existing difference in the location and tide exposure of the two sites, or due to the effect of the TLP protection.

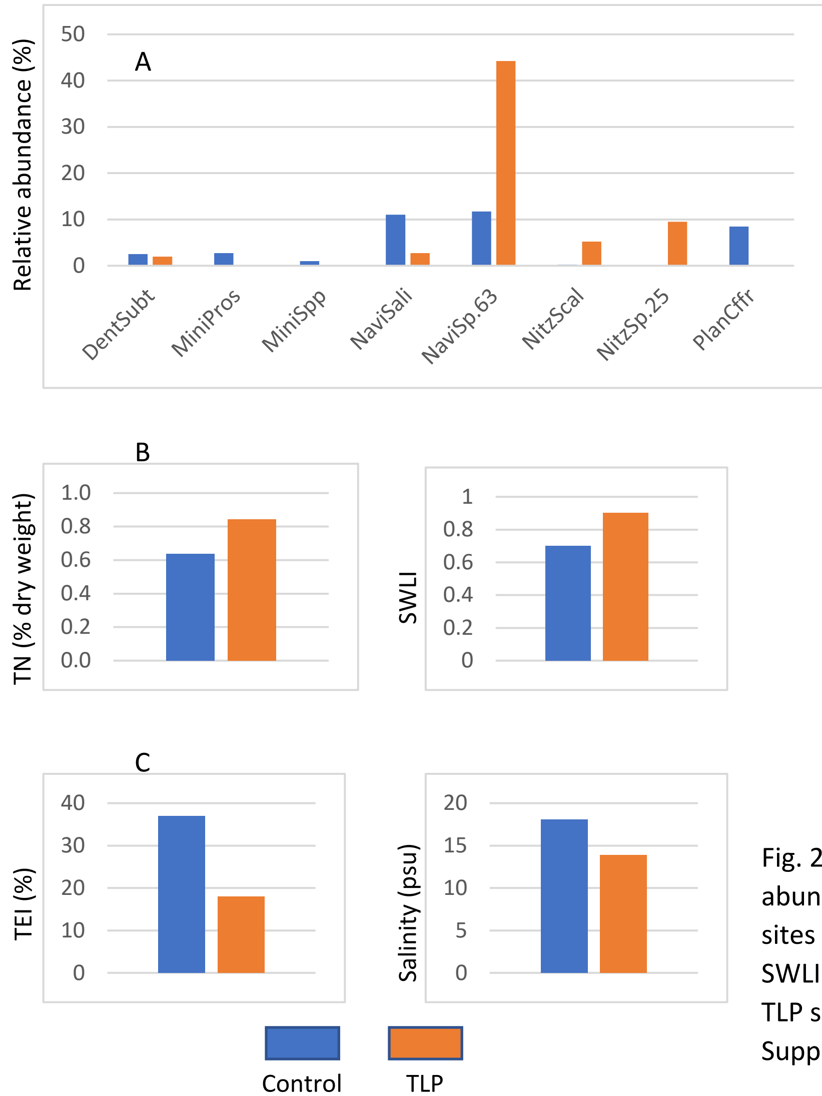


Fig. 2. Diatom species with relative abundances >5% in Fortescue high marsh sites (A); inferred TN sediment content and SWLI (B); TEI and salinity (C) in control and TLP sites. Full species names are found in Supplementary material I.

The Fortescue low marsh TLP and control sites were represented by 2 sites each: Fortescue FT-C-B-17, FT-C-B-19 for control sites and FT-P-1-44, FT-P-2-37 for the TLP sites (Fig. 1). The two control sites were represented by same species, although their abundances varied between the two sites. For example, most abundant species were *Denticula subtilis*, *Navicula* sp. 63, and *Planothidium* cf. *frequentissimum* (FT-C-B-19), and *Minidiscus proschkinae*, *Minidiscus* spp in FT-C-B-17; the above-mentioned FT-C-B-19 species are also present in FT-C-B-17 but with lower abundances. These differences in species relative abundance suggest that FT-C-B-17 receives more tidal input than the amont FT-C-B-19 site, although the two sites are close to each other (Fig. 1). These differences are also attesting the ability of New Jersey coastal diatoms to discriminate between microtidal marshes and their utility as indicators of relative sea level, as found in the previous study of New Jersey coastal diatoms by Desianti et al. (2019).

The TLP sites were represented by similar species composition, with *Navicula* sp. 63 and *Nitzschia* sp. 25 reaching highest abundances. Diatom-based inferences found a slightly lower sediment TN, TEI and SWLI suggesting that the TLP did not produce significant improvement in marsh elevation. However, the inferred differences between TLP and control sites were not statistically significant at $p<0.05$.

The averaged diatom species abundances, sediment TN, SWLI, salinity and TEI in Fortescue control and TLP low marsh sites are shown in Fig. 3.

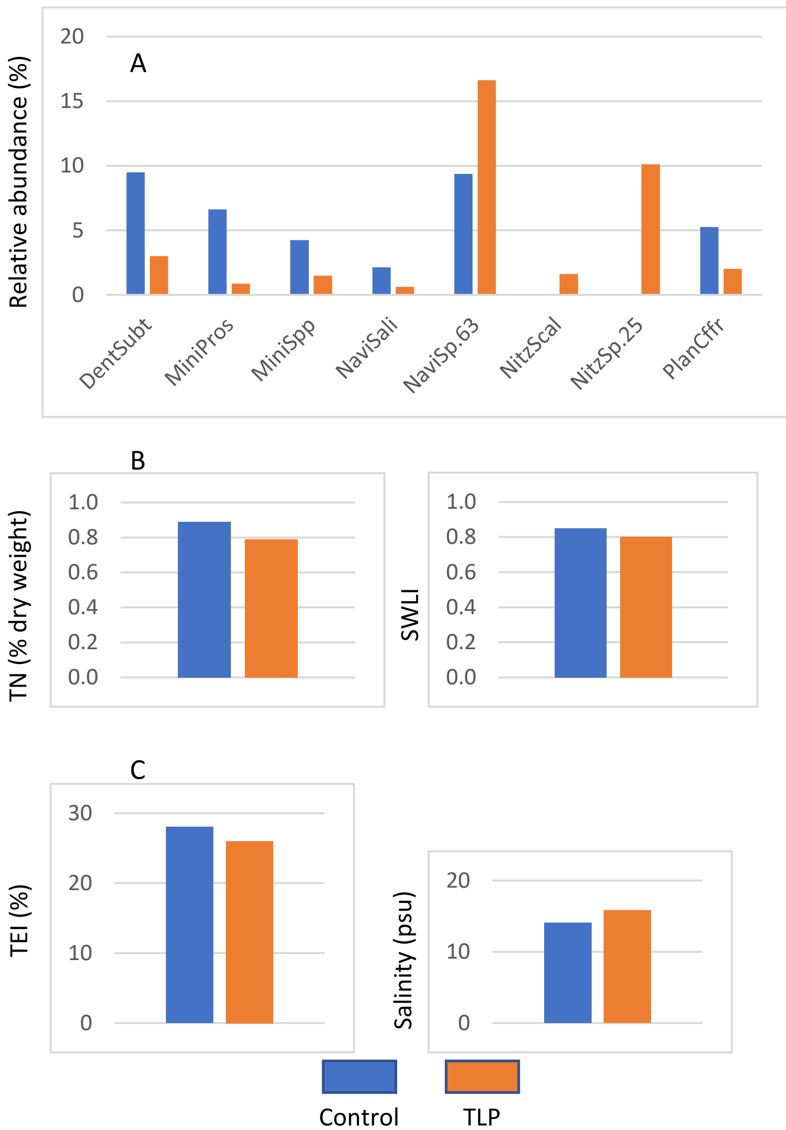


Fig. 3. Diatom species with relative abundances >5% in Fortescue low marsh sites (A); inferred TN sediment content and SWLI (B); TEI and salinity (C) in control and TLP sites. Full species names are found in Supplementary material I.

Diatom species composition and the inferred sediment TN, Salinity, TEI and SWLI in Avalon TLP and control sites

Avalon TLP and control sites were represented by low marsh sites only, three sites were sampled for each category: Avalon AV-C-A-9, AV-C-A-27, AV-C-G-95 (control sites) and Avalon AV-P-D-53, AV-P-E-72, AV-P-F-88 (TLP sites) (Fig. 1). The Avalon AV-C-A-9, AV-C-A-27 control sites had similar species composition with *Denticula subtilis* and *Navicula* sp. 63 dominance. AV-P-F-95 was represented by species attesting of higher tidal exposure, such as *Nitzschia scalpelliformis* and *Halamphora tenerrima*.

The Avalon TLP sites AV-P-E-72 and AV-P-F-88 shared similar abundances for *Cocconeis stauroneiformis* but with differences in the relative abundances of other species, such as *Pseudostaurosira perminuta*, found abundant only in AV-P-E-72. The Avalon AV-P-D-53 site has a species composition with higher abundances for *Denticula subtilis, Navicula* sp. 63, and *Planothidium* cf. *frequentissimum*, species which are attesting of a higher elevation and lower impact from tides.

Diatom inferences showed a lower inferred TN sediment content and SWLI, higher salinity and TEI for the TLP sites in average. These inferences suggest that the TLP sites receive higher impacts from tides activity and SLR in comparison to the control sites. However, these differences were not statistically significant at $p<0.05$.

The averaged diatom species abundances, sediment TN, SWLI, salinity and TEI in Avalon control and TLP low marsh sites are shown in Fig. 4.

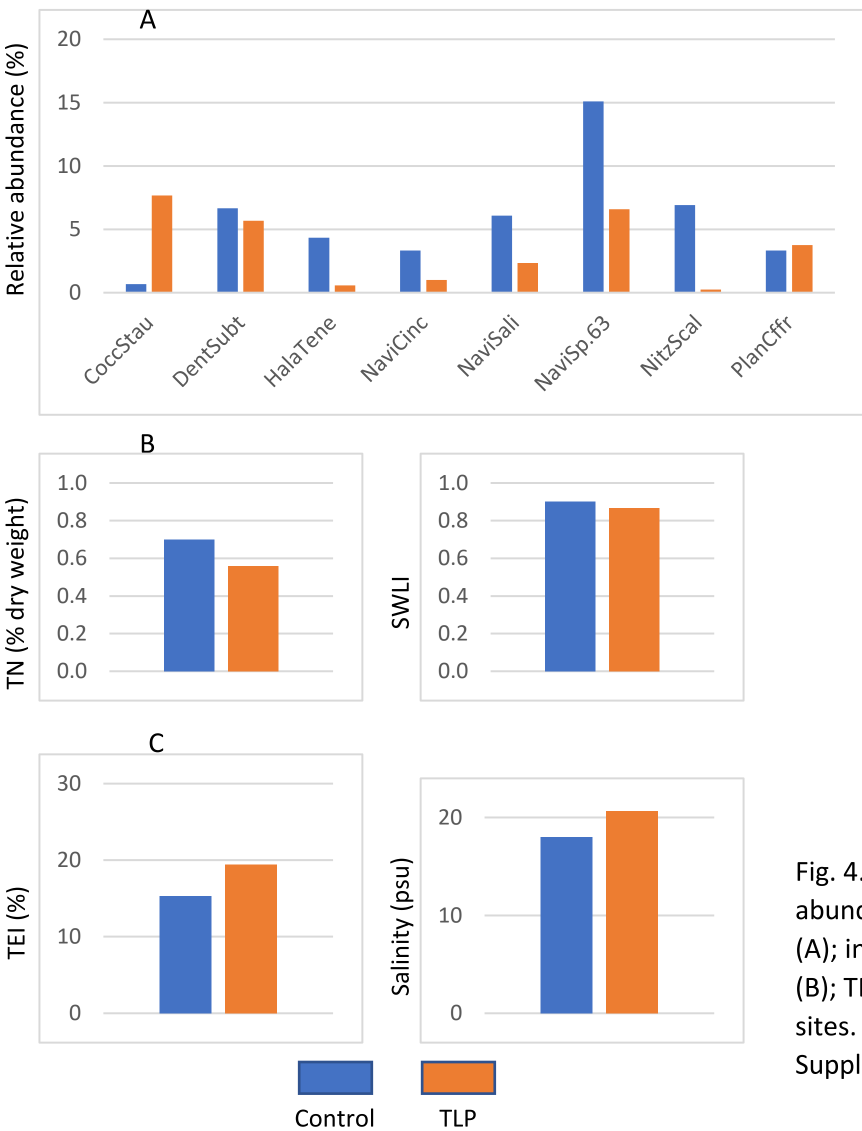


Fig. 4. Diatom species with relative abundances >5% in Avalon low marsh sites (A); inferred TN sediment content and SWLI (B); TEI and salinity (C) in control and TLP sites. Full species names are found in Supplementary material I.

Diatom species composition and the inferred sediment TN, Salinity, TEI and SWLI in Ring Island TLP and control sites

Ring Island TLP and control sites were represented by low marsh sites with three sites sampled for each category: Ring Island RI-C-TLPC-4, RI-C-TLPC-7, RI-C-TLPC-15 (control sites) and Ring Island RI-P-TLP1-18, RI-P-TLP2-6, RI-P-TLP2-7 (TLP sites) (Fig. 1). All Ring Island control sites had similar species composition with *Denticula subtilis* and *Navicula* sp. 63 dominant species, associated to lower abundances of *Planothidium* sp. 11 and *Planothidium delicatulum*. The TLP sites RI-P-TLP2-6 and RI-P-TLP2-7 had very similar species composition with *Navicula* sp. 41 the dominant species (up to 27%). The RI-P-TLP1-18 site had higher species diversity with *Navicula* sp. 63 and *Paralia sulcata* reaching slightly above 5% relative abundance (APPENDIX I).

Diatom inferences showed that TLP sites have on average significantly lower TN sediment content, lower SWLI, significantly higher salinity and TEI at $p<0.05$. These inferences suggest that the TLP sites receive higher impacts from tides activity and SLR in comparison to the control sites.

The averaged diatom species abundances, sediment TN, SWLI, salinity and TEI in Ring Island for control and TLP low marsh sites are shown in Fig. 5.

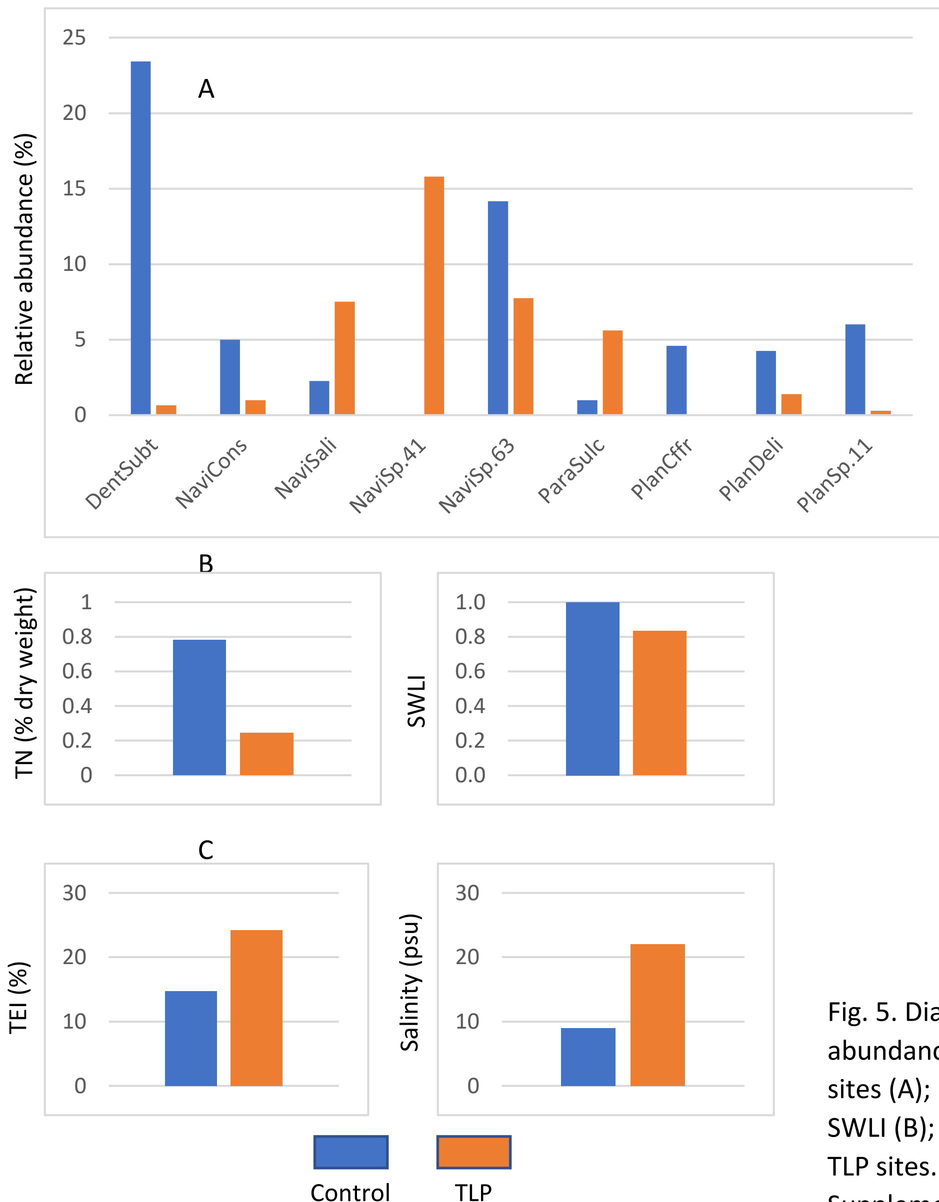


Fig. 5. Diatom species with relative abundances > ~5% in Ring Island low marsh sites (A); inferred TN sediment content and SWLI (B); TEI and salinity (C) in control and TLP sites. Full species names are found in Supplementary material I.

Diatom species composition and the inferred sediment TN, Salinity, TEI and SWLI in Dias Headwaters

Two sites (DH-2 and DH-3) were sampled from Dias Headwaters wetlands, situated approximately 1 mile distance from each other. Although with very similar species composition, the relative abundances of many of these species are different between the two sites (Fig. 6). Notably, DH-3 site has higher abundances of *Navicula* sp.63, *Denticula subtilis*, *Triblionella debilis*, etc. Although inferred SWLI is similar for both sites, DH-3 has slightly higher TN and lower salinity and TEI suggesting that this site is receiving lower influence from tides and SLR.

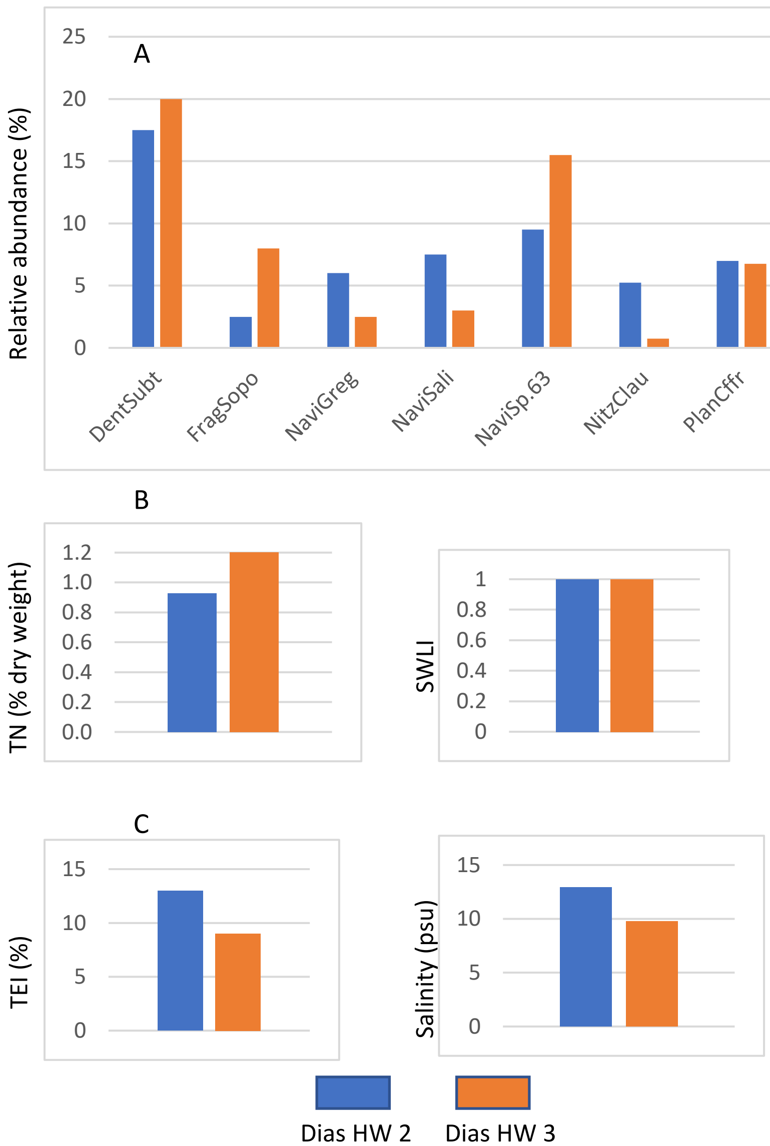


Fig. 6. Diatom species with relative abundances > 5% in Dias Headwaters sites (A); inferred TN sediment content and SWLI (B); TEI and salinity (C) in DH-2 and DH-3 sites. Full species names are found in Supplementary material I.

Conclusion

Diatom species identified in the 20 sampling sites from Delaware Bay and Cape May peninsula were used to compute inferences for wetlands TN sediment content, TEI, SWLI, and salinity. The diatom species composition and computed inferences were used to compare the characteristics of TLP and control wetland sites. This comparison revealed that the Fortescue TLP site is less impacted by tidal activity, while Avalon and especially Ring Island TLP sites appeared more disturbed by tidal activity than control site. Ring Island TLP sites had lower diatom abundances while presence of species attesting of increased tidal activity and SLR impacts compared to the control sites was found in both Avalon and Ring Island TLP sites. The differences found between TLP and control sites were significant ($p<0.05$) in Ring Island, but not in Fortescue and Avalon wetlands. However, wetland conditions prior to thin layer placement in control and TLP sites are unknown and the extent to which these inferred differences may be related to pre-TLP wetland conditions are not known. This investigation was based on a small number of sites. More sampling sites would be necessary for drawing a more accurate assessment of differences between TLP and control wetland condition.

The diatom-based inferences for tidal exposure, salinity and TN can provide an assessment tool to wetland managers for the identification of most vulnerable sites in need of protection. Due to their high sensitivity to New Jersey wetlands microtidal differences, diatom species can also be useful in evaluating and monitoring the rate of success of wetland restoration projects.

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Diatom Flora of the New Jersey Coastal Wetlands

FINAL REPORT

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Summary

In 2012-2017 the New Jersey Department of Environmental Protection sponsored several research projects aimed at evaluating the potential use of diatoms for monitoring present and inferring past environmental conditions in New Jersey coastal wetlands. The goal of this report is to document the most common diatom taxa from studied wetlands, with high-resolution light and electron microscopy images. The images of 499 taxa found in the sub-, inter- and supratidal habitats and in sediment core samples are presented. Genera with the most species are *Navicula* (148), *Fallacia* (34), *Nitzschia* (21), and *Parlibellus* (16). Some taxa could not be identified to species level and are listed under provisional names. Voucher slides are deposited in the Diatom Herbarium of the Academy of Natural Sciences of Drexel University.

List of diatom taxa

Division BACILLARIOPHYTA

Class *Coscinodiscophyceae* (CENTRIC DIATOMS)

Subclass *Chaetocerotophycidae*

Order *Leptocylindrales* Round & Crawford 1990

Family *Leptocylindraceae* Lebour 1930

Genus: ***Leptocylindrus* Cleve 1889, *Tenuicylindrus* Nanjappa & Zingone 2013**

***Leptocylindrus minimus*..Plate 1; Figs 1-5**

***Leptocylindrus danicus* ....Plate 1; Fig. 6**

***Tenuicylindrus belgicus* ....Plate 1; Fig. 7**

Order *Chaetocerotales* Round & Crawford 1990

Family *Chaetocerotaceae* Ralfs in Pritchard 1861

Genus: ***Chaetoceros* Ehrenberg 1844**

***Chaetoceros affinis*..Plate 2; Fig 1**

***Chaetoceros* sp. 1...Plate 2; Fig 2**

***Chaetoceros brevis*..Plate 3; Figs 1-5**

***Chaetoceros decipiens* ....Plate 4; Figs 1-7**

***Chaetoceros* cf. *elegans*..Plate 5; Figs 1-6**

***Chaetoceros tenuissimus*......................................Plate 6; Figs 1-10**

Order *Hemiaulales* Round & Crawford 1990

Family *Hemiaulaceae* Heiberg 1863

Genus: ***Hemialus* Ehrenberg 1844**

***Hemialus* sp. 1 ....Plate 7; Fig 1**

***Fragilariaforma* Williams & Round 1988*; Martyana ; Diatoma* de Candole 1805*; Meridion* Agardh 1824*; Synedra* Ehrenberg 1830*; Ctenophora* Williams & Round 1986*; Neosynedra* Williams & Round 1986, *Tabularia* Williams & Round 1986, *Martyana* Round 1990, *Opephora* Petit 1882, *Trachysphenia* Petit 1877, *Pteroncola* Holmes & Croll 1984, *Asterionellopsis* Round 1990**

Family *Eunotiaceae* Kützing 1844

Genus: ***Eunotia* Ehrenberg 1837**

Subclass *Bacillariophycidae*

Order *Lyrellales* Mann 1990

Family *Lyrellaceae* Mann 1990

Genera: ***Lyrella* Karayeva 1595, *Petroneis* Stickle & Mann 1990**

Suborder *Sellaphorineae* Mann 1990

Family *Sellaphoraceae* Mereschkowsky 1902

Genera: ***Sellaphora*** **Mereschkowsky 1902,** ***Fallacia*** **Stickle & Mann 1990**

Order *Rhopalodiales* Mann 1990

Family *Rhopalodiaceae* (Karsten) Topachevs'kyj & Oksiyuk 1960

Genera: ***Epithemia*** **Kützing 1844,** ***Rhopalodia*** **Müller 1895**

Plate 1 (Scale bars: Figs 1-3=10 μm; Figs 4-7=1 μm)

Figs 1-5: ***Leptocylindrus minimus*** Gran

Lit.: Gran 1915, p. 72; fig. 5; Hargraves 1990, p. 49, Figs 2-16, p. 51, Figs 17-23, p. 52, Figs 24-26.

Figs 1-5: Barnegat Bay, NJ.

Fig. 6: ***Leptocylindrus danicus*** Cleve

Lit.: Cleve 1889, p. 54, Nanjappa, Kooistra, & Zingone 2013, p. 925, Fig. 3.

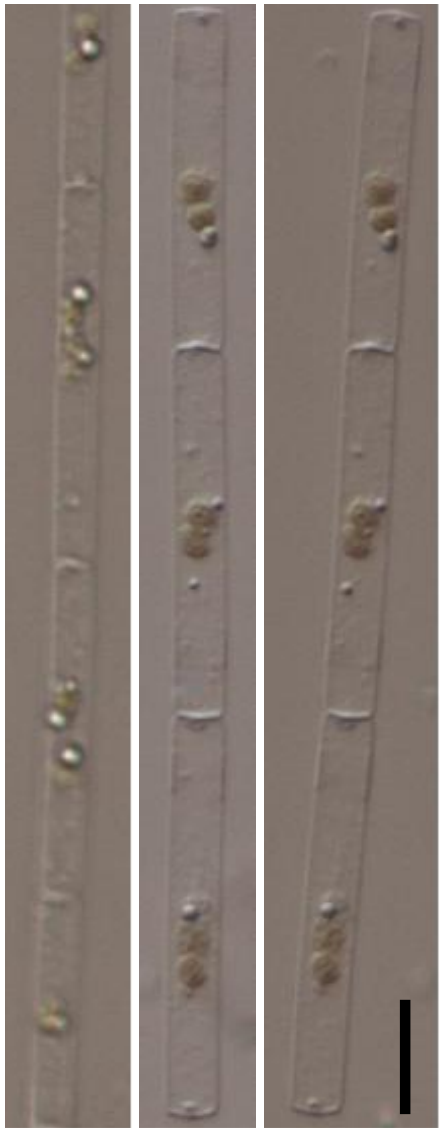
Fig. 6: Sample COAST096, Grassy Sound, NJ.

Fig. 7: ***Tenuicylindrus belgicus*** (Meunier) Nanjappa & Zingone

Lit.: Nanjappa, Kooistra, & Zingone 2013, p. 925, Fig. 7.

Basionym: *Leptocylindrus belgicus* Meunier 1915

Fig. 7: Sample COAST059, Barnegat Bay, NJ.



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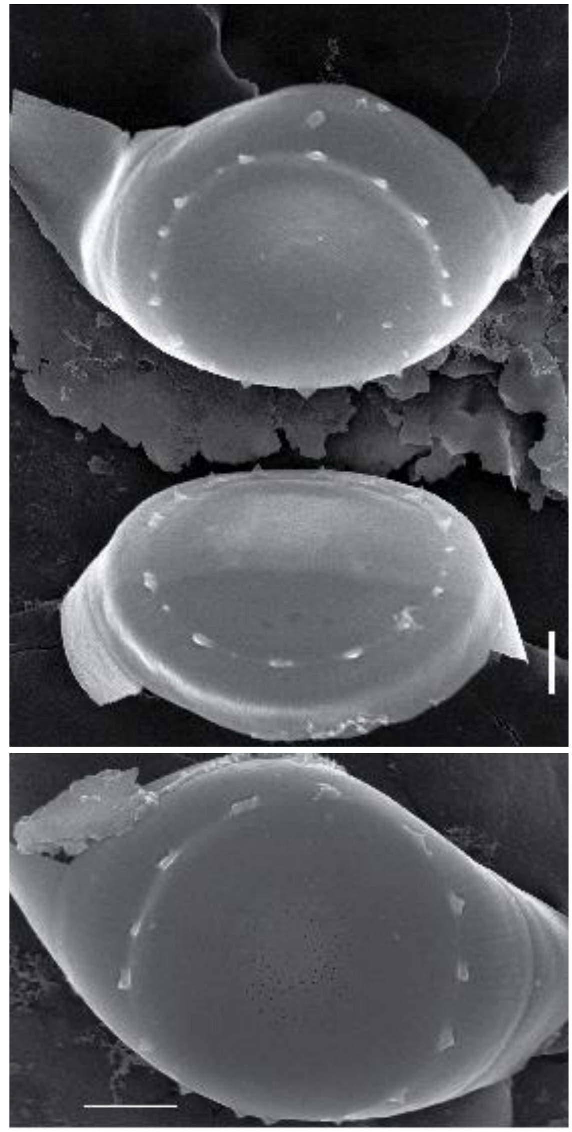

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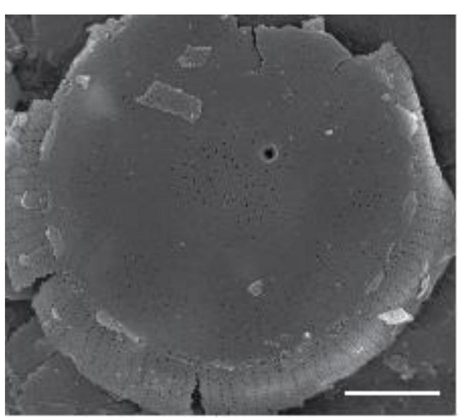

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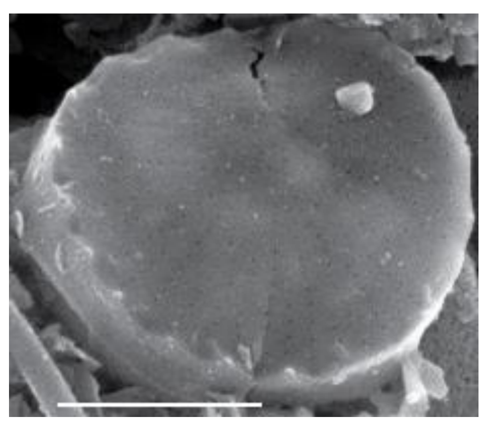

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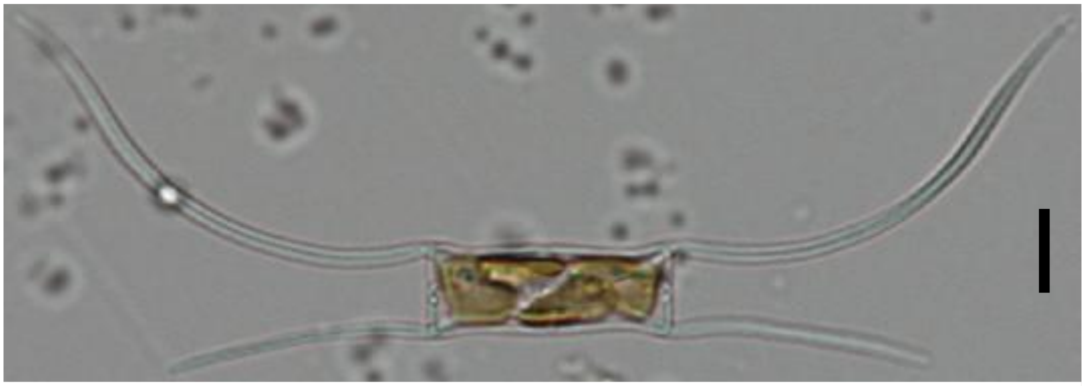
Plate 2 (Scale bars: Figs 1-2=10 µm)

Fig. 1: ***Chaetoceros affinis*** Lauder
Lit.: Lauder 1864, p. 78; pl. 8, fig. 5
Basionym: *Bacteriastrum affine* (Lauder) Tempère & Peragallo 1889
Fig. 1: Barnegat Bay, NJ.

Fig. 2: ***Chaetoceros* sp. 1**
Fig. 2: Barnegat Bay, NJ.



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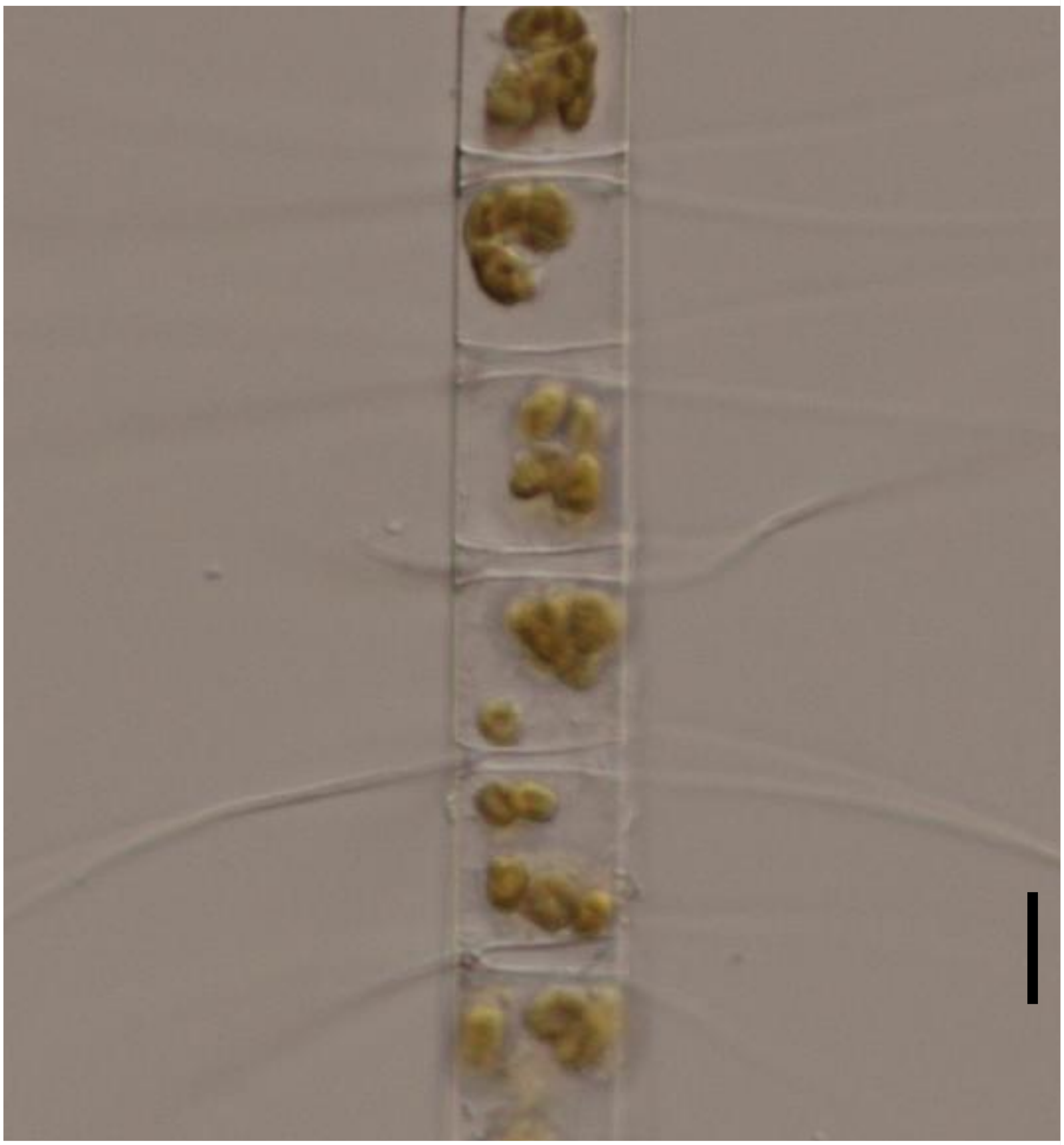


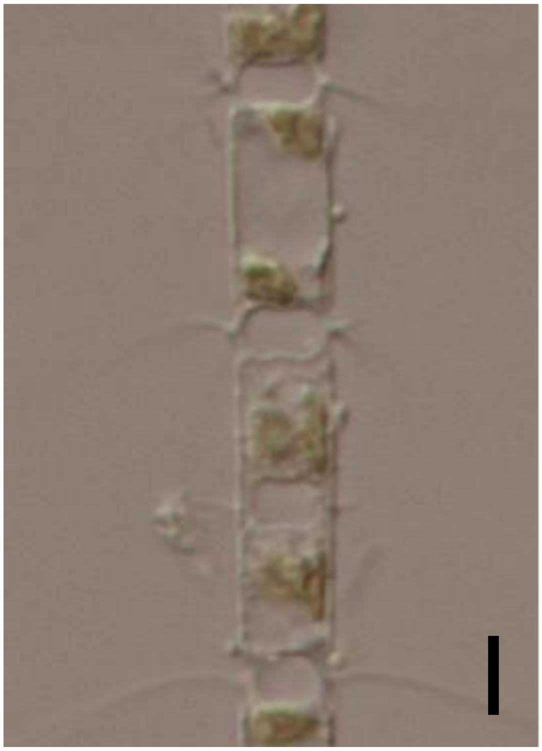
2

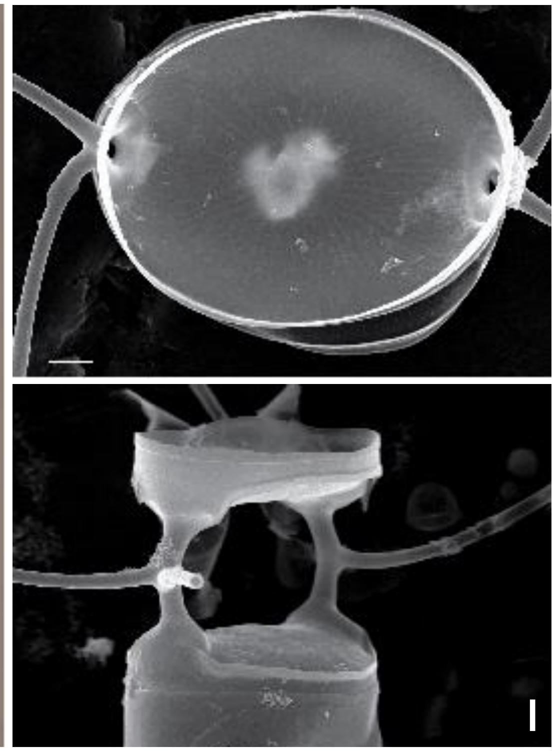
Plate 3 (Scale bars: Fig. 1=10 µm; Figs 2-5=1 µm)

Chaetoceros brevis Schütt

Lit.: Schütt 1895, p. 38; fig. 4

Figs 1-5: Barnegat Bay, NJ.





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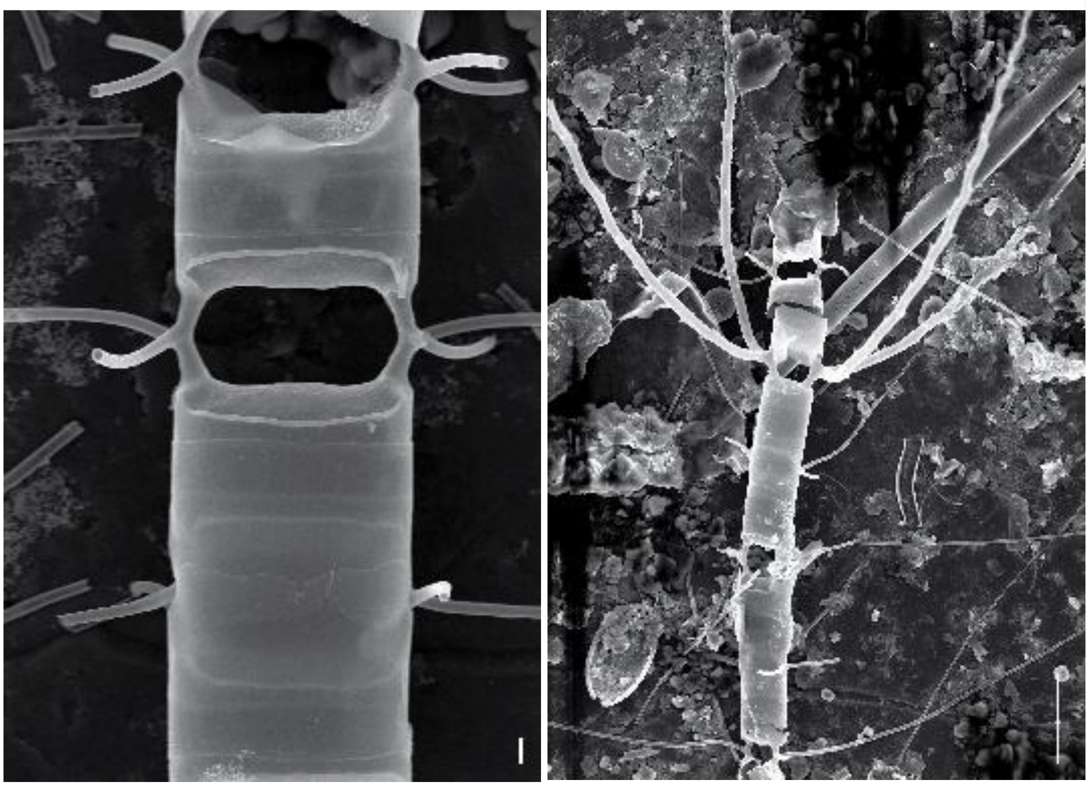


4 - 5

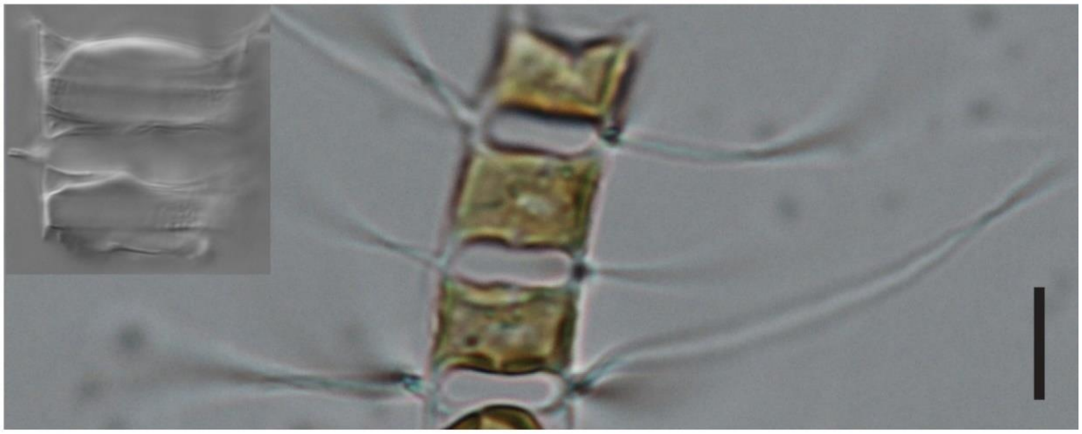
Plate 4 (Scale bars: Fig. 1=10 µm; Figs 4-7=1 µm)

Chaetoceros decipiens Cleve

Lit.: Cleve 1873, p. 11; pl. 1, fig. 5

Fig. 1: Tuckerton Bay, NJ.

Figs 2-8: Barnegat Bay, NJ.



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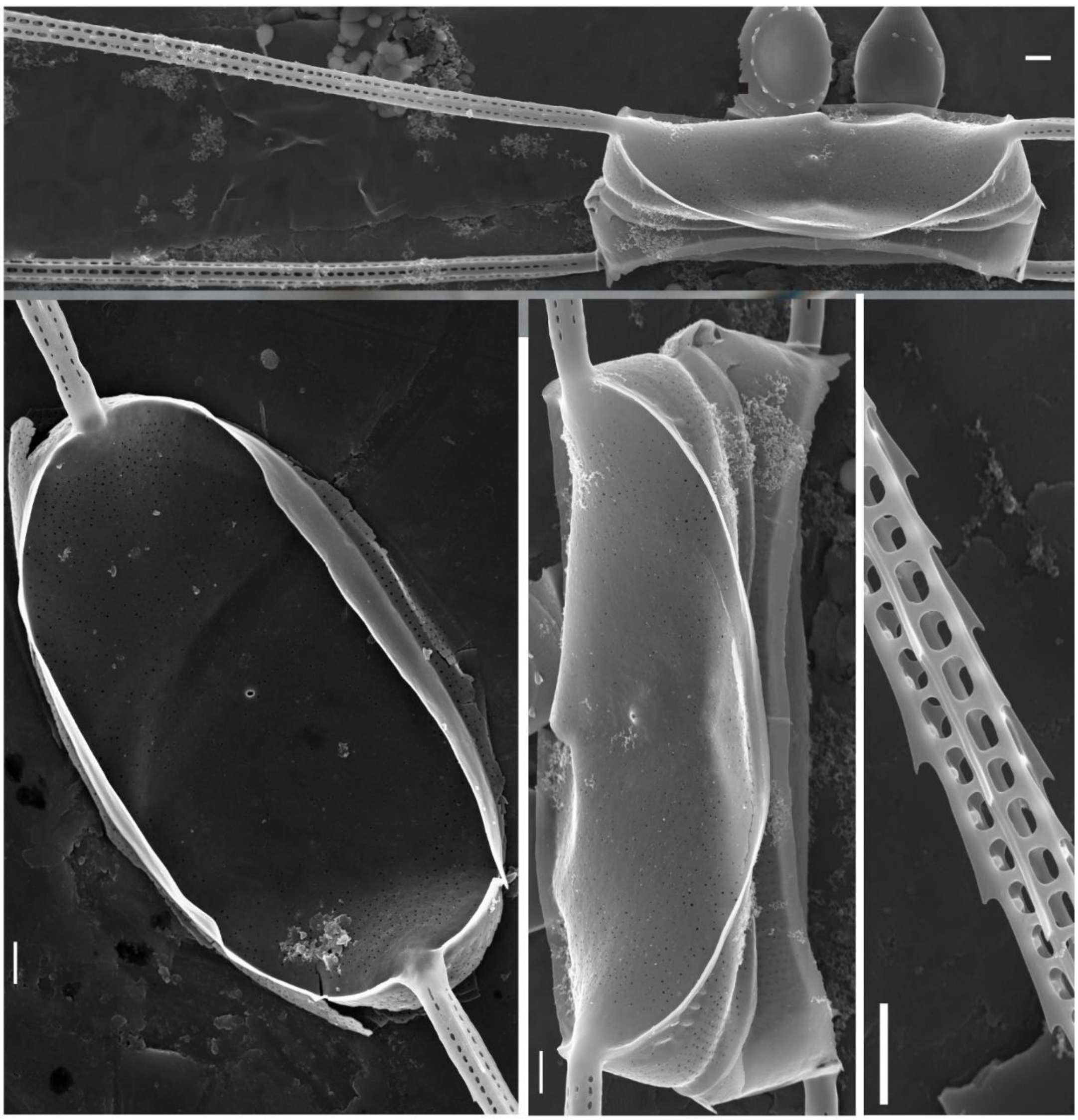
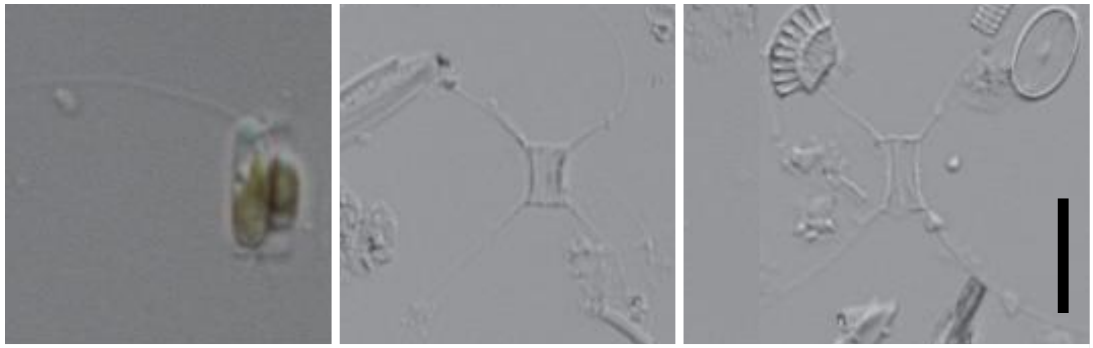


5 - 8

Plate 5 (Scale bars: Figs 1-3=10 μm; Figs 4-6=1 μm)

Chaetoceros* cf. *elegans

Figs 1-6: Barnegat Bay, NJ.
Figs 2-3: Sample BBDC0028, Barnegat Bay, NJ.



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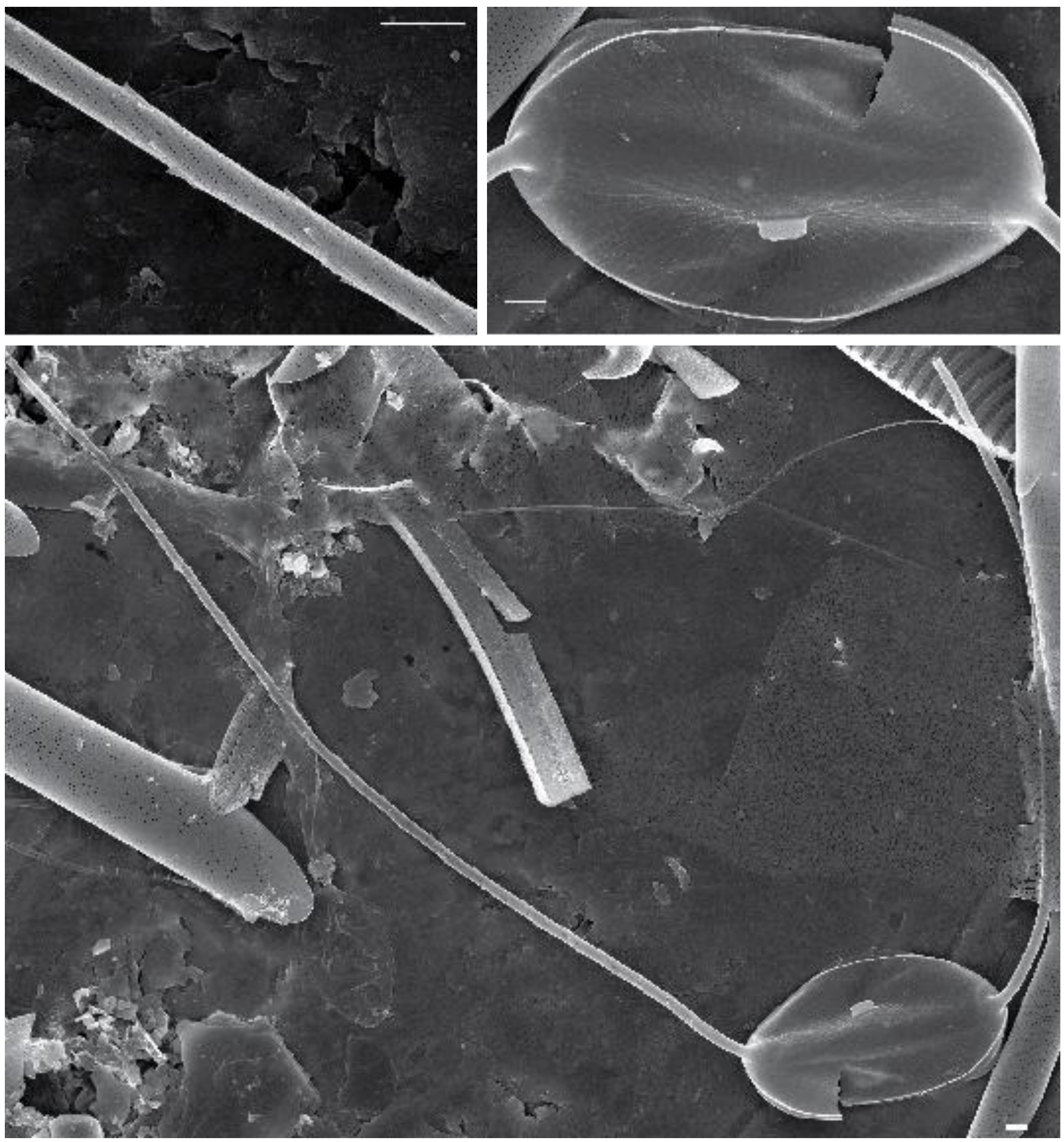


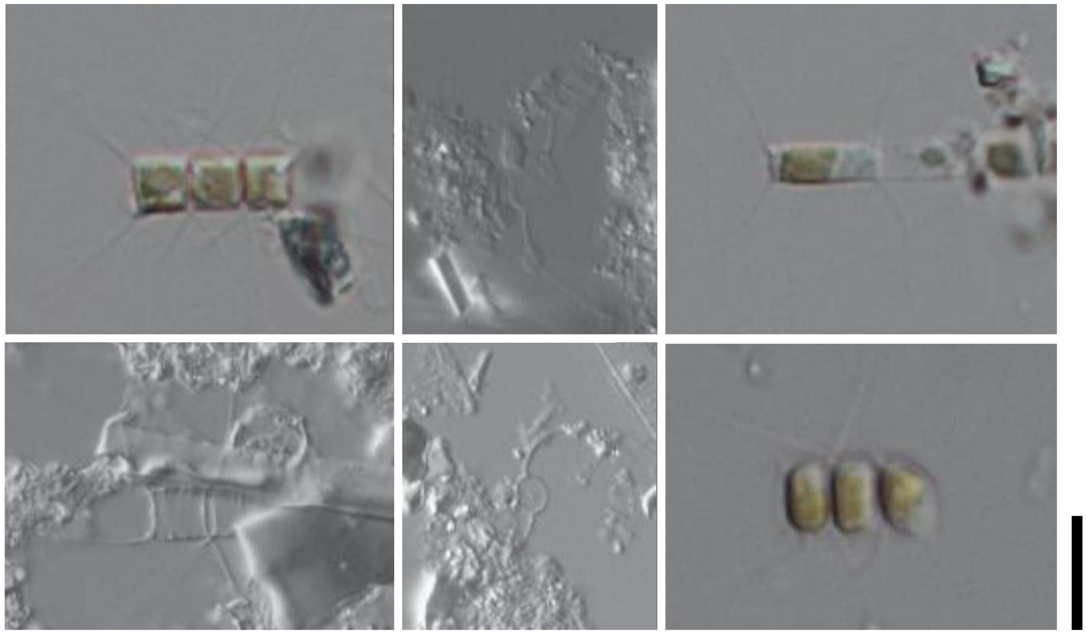
4 - 6

Plate 6 (Scale bars: Figs 1-6=10 µm; Figs 7-10=1 µm)

Chaetoceros tenuissimus Meunier

Lit.: Meunier 1913, p. 49; pl. 7, fig. 55

Figs 1-10: Barnegat Bay, NJ.
Fig. 2: Sample BBDC0002, Barnegat Bay, NJ.
Fig. 4: Sample BBDC0101, Great Bay, NJ.
Fig. 5: Sample BBDC0044, Barnegat Bay, NJ.
Fig. 7: Sample BBDC0016, Barnegat Bay, NJ.
Fig. 8: Sample BBDC0015, Barnegat Bay, NJ.
Fig. 9: Sample COAST096, Grassy Sound, NJ.
Fig. 10: Sample COAST073, North East, NJ shore.



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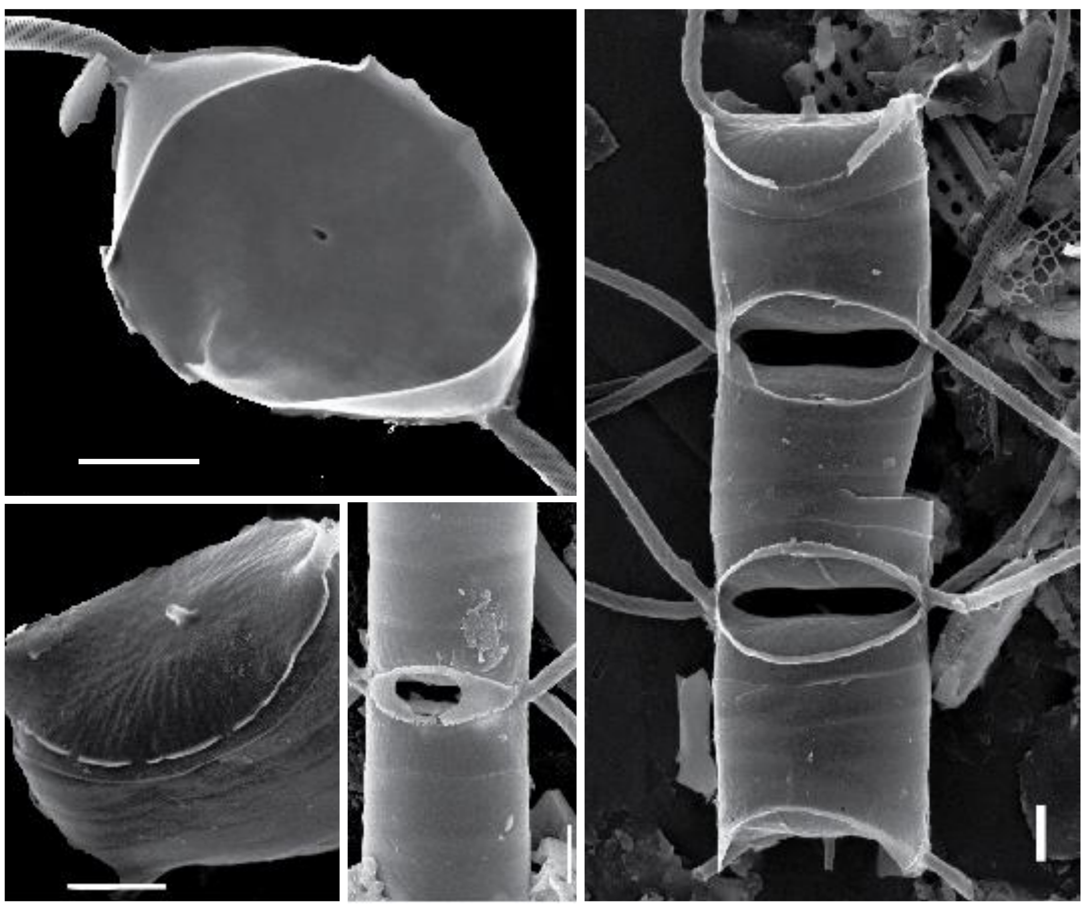


7 - 10

Plate 7 (Scale bar: Fig. 1=10 µm)

***Hemialus* sp. 1**

Fig. 1: Sample BBDC00107, Great Bay, NJ.

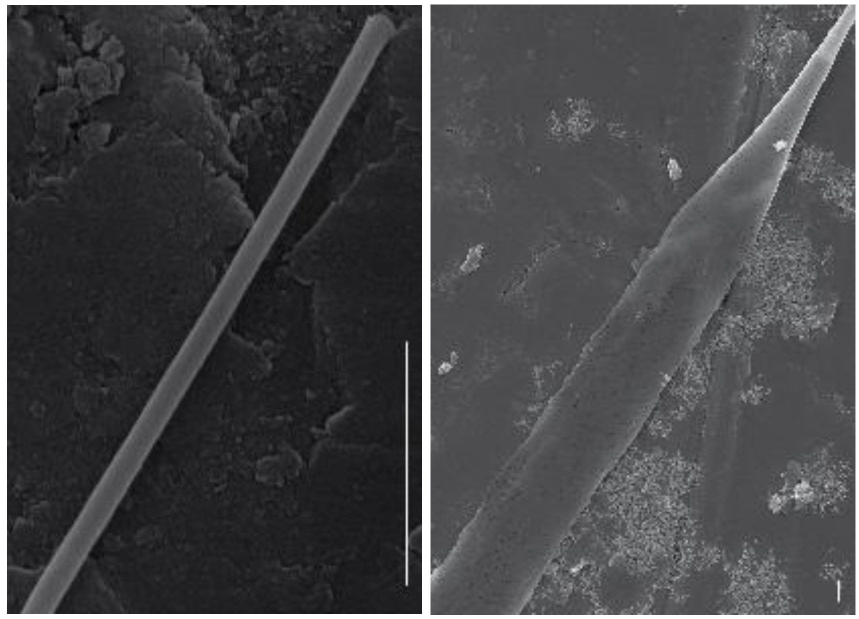
1

Plate 8 (Scale bars: Figs 1-3=10 μm; Figs 4-7=1 μm)

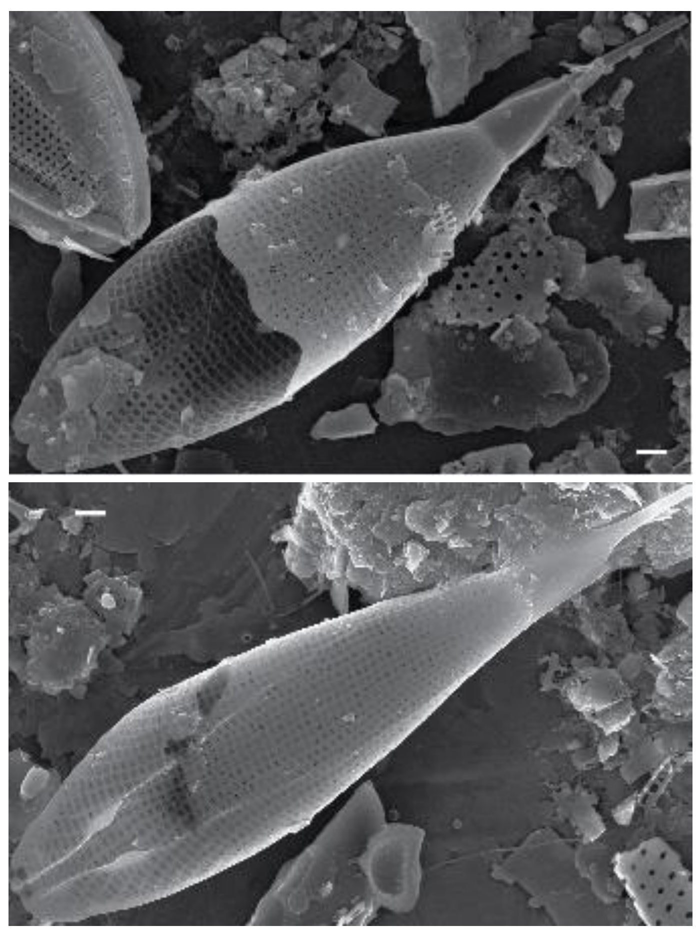
Figs 1-5: ***Rhizosolenia setigera*** Brightwell
Lit.: Brightwell 1858, p. 95; pl. 5, fig. 7
Figs 1-5: Barnegat Bay, NJ.

Figs 6-7: ***Rhizosolenia hyalina*** Ostenfeld
Lit.: Ostenfeld & Schmidt 1901, p. 160; fig. 11
Figs 6-7: Sample COAST096, Grassy Sound, NJ.

1 - 3



4 - 5

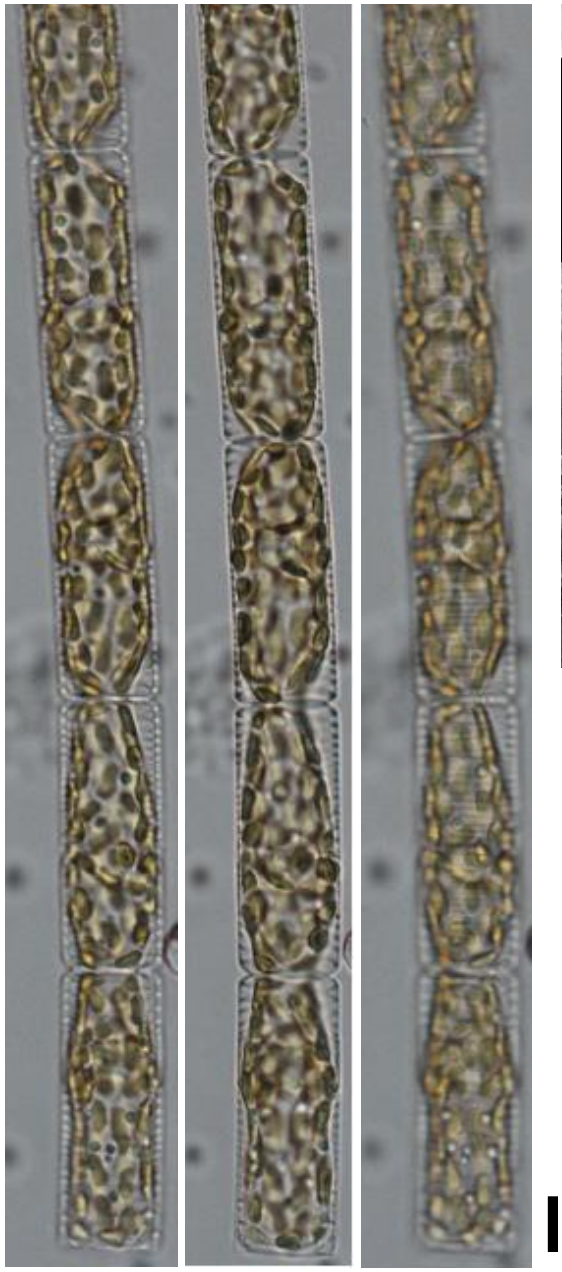


6 - 7

Plate 9 (Scale bars: Figs 1-3,5=10 µm; Fig. 4=1 µm)

Figs 1 – 4: ***Dactyliosolen fragilissimus*** (Bergon) Hasle
Lit.: Hasle & Syvertsen 1996, p. 167, 340; pl. 31
Basionym: *Rhizosolenia fragilissima* Bergon 1903
Figs 1-4: Barnegat Bay, NJ.

Fig. 5: ***Dactyliosolen tenuijunctus*** (Manguin) Hasle
Lit.: Hasle 1975, p. 122-123; fig. 114-120
Basionym: *Rhizosolenia tenuijuncta* Manguin 1957
Fig. 5: Barnegat Bay, NJ.



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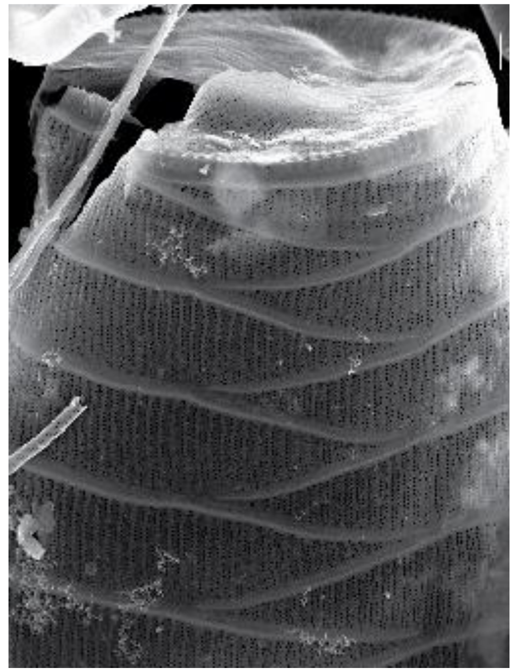

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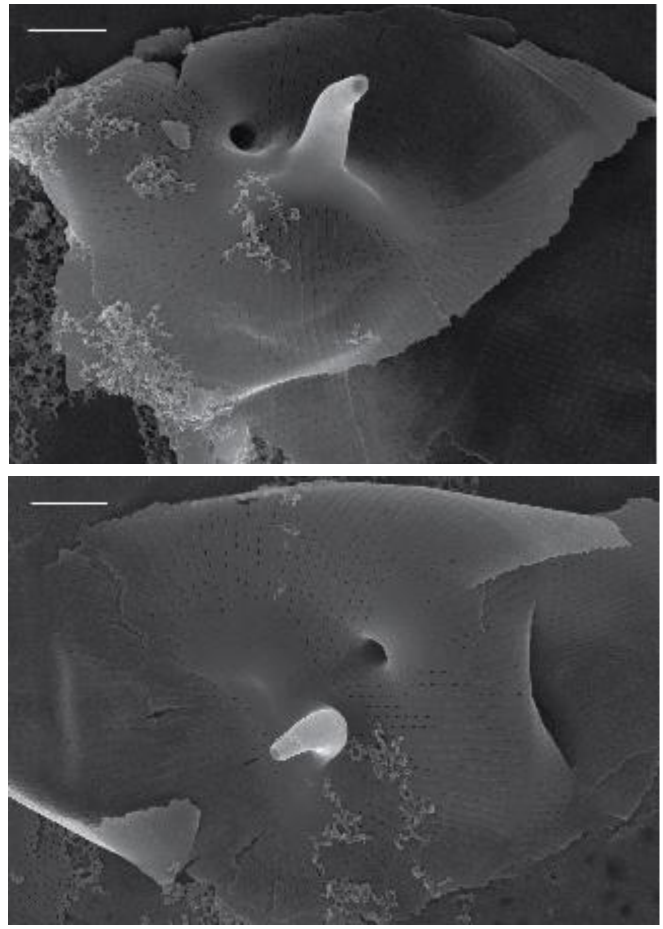
5

Plate 10 (Scale bars: Fig. 1=10 µm; Figs 2-6=1 µm)

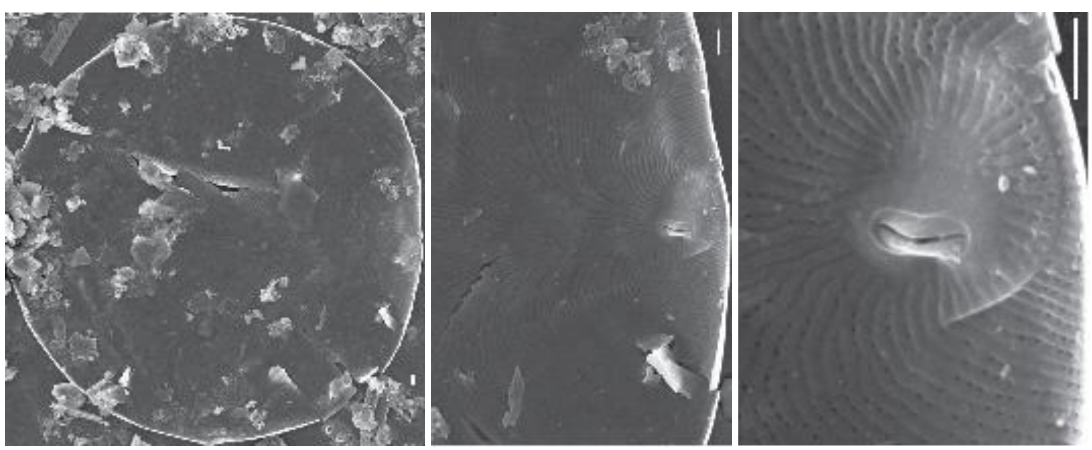
***Guinardia* spp.**

Figs 1-3: Barnegat Bay, NJ.
Figs 4-6: Sample COAST096, Grassy Sound, NJ.

1



2 - 3



4 - 6

Plate 11 (Scale bars: Figs 1=10 µm; Figs 2-6=1 µm)

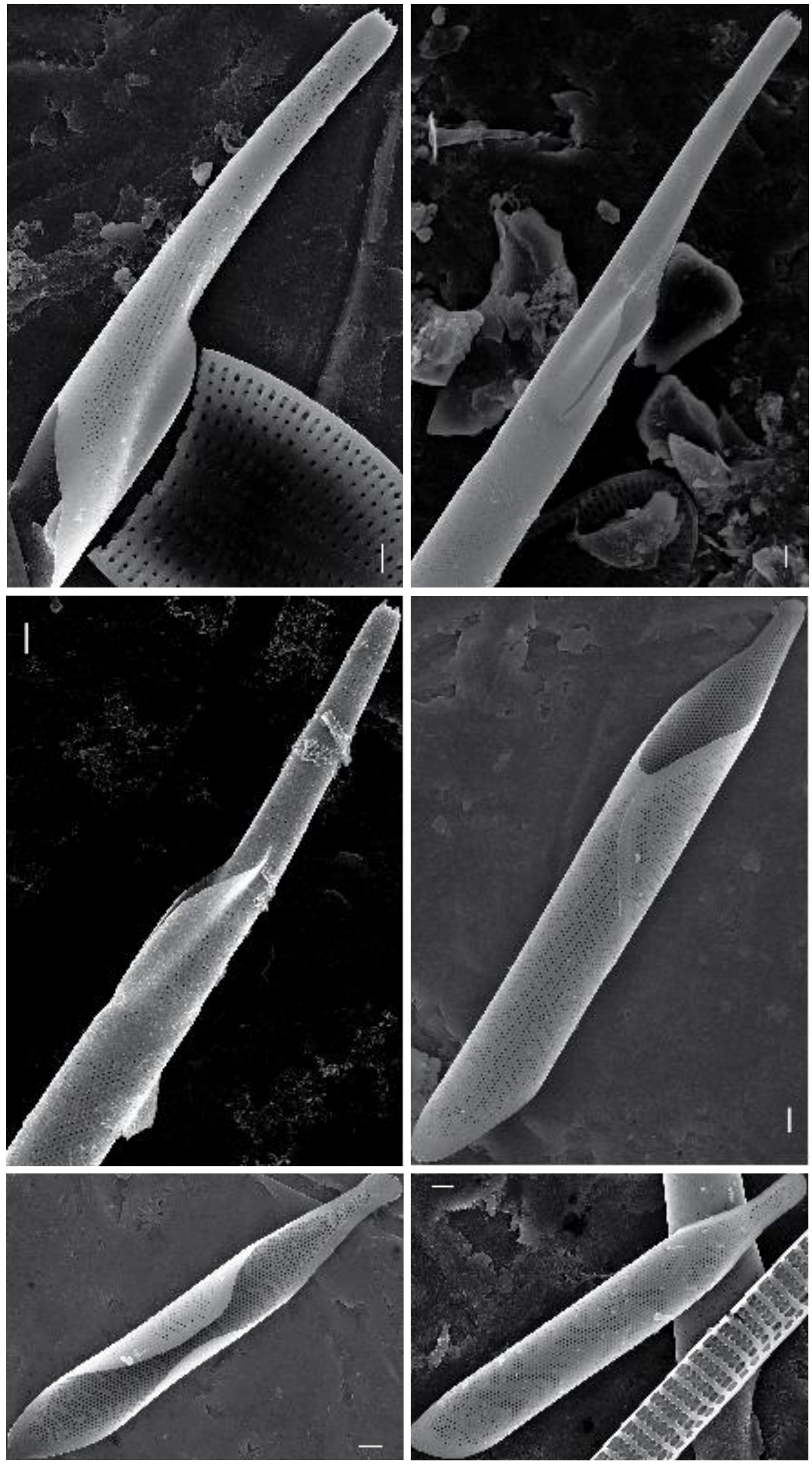
Proboscia alata (Brightwell) Sundstrom

Lit.: Sundstrom 1986, p. 99-100; fig. 258-266

Basionym: *Rhizosolenia alata* Brightwell 1858

Figs 1-6: Barnegat Bay, NJ.

1



2 - 6

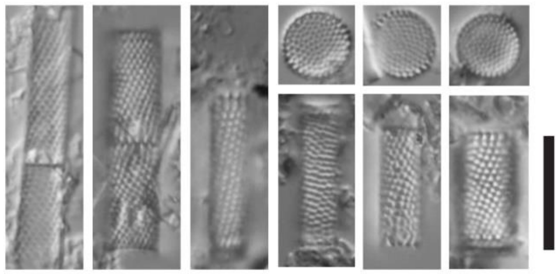
Plate 12 (Scale bars: Figs 1-9; 12-19; =10 µm; Figs 4-7=1 µm)

Figs 1-9: ***Aulacoseira ambigua*** (Grunow) Simonsen
Lit.: Simonsen 1979, p. 56
Basionym: *Melosira crenulata* var. *ambigua* Grunow in Van Heurck 1882
Synonyms: *Melosira ambigua* (Grunow in Van Heurck) Otto Müller 1903
Melosira granulata var. *ambigua* (Grunow in Van Heurck) Thum 1889
Melosira italica var. *ambigua* (Grunow in Van Heurck) Cleve-Euler in Backmann & Cleve-Euler 1922
Melosira italica f. *ambigua* (Grunow in Van Heurck) Balachonzew (Bolochonzew) 1909
Melosira italica subsp. *ambigua* (Grunow) Cleve-Euler 1938
Melosira italica var. *ambigua* (Grunow) Cleve-Euler 1951
Fig. 1: Sample BB0069, Barnegat Bay, NJ.
Fig. 2: Sample BB0056, Barnegat Bay, NJ.
Figs 3,6: Sample BB0060, Barnegat Bay, NJ.
Figs 4,8: Sample BB0055, Barnegat Bay, NJ.
Fig. 7: Sample BB0059, Barnegat Bay, NJ.
Fig. 9: Sample BB0053, Barnegat Bay, NJ.

Figs 10-11: ***Aulacoseira valida*** (Grunow in Van Heurck) Krammer
Lit.: Krammer 1991, p. 98
Basionym: *Melosira crenulata* var. *valida* Grunow in Van Heurck 1882
Synonyms: *Melosira distans* var. *valida* (Grunow in Van Heurck) F.W. Mills 1934
Melosira italica var. *valida* (Grunow in Van Heurck) Hustedt 1927
Melosira polymorpha var. *valida* (Grunow in Van Heurck) Bethge 1925
Melosira valida (Grunow in Van Heurck) Meister 1912
Figs 10-11: Sample BB0010, Barnegat Bay, NJ.

Figs 12-14: ***Aulacoseira pusilla*** (Meister) Tuji & Houki
Lit.: Tuji & Houki 2004, p. 38
Basionym: *Melosira pusilla* Meister 1913
Fig. 12: Sample BBDC0006, Barnegat Bay, NJ.
Fig. 13: Sample BB0054, Barnegat Bay, NJ.
Fig. 14: Sample BB0060, Barnegat Bay, NJ.

Figs 15-19: ***Aulacoseira crassipunctata*** Krammer
Lit.: Krammer 1991, p. 490; fig. 71-79
Figs 15, 16: Sample BBDC0004, Barnegat Bay, NJ.
Fig. 17: Sample BB0071, Barnegat Bay, NJ.
Fig. 18: Sample BBDC0007, Barnegat Bay, NJ.
Fig. 19: Sample BB0035, Barnegat Bay, NJ.



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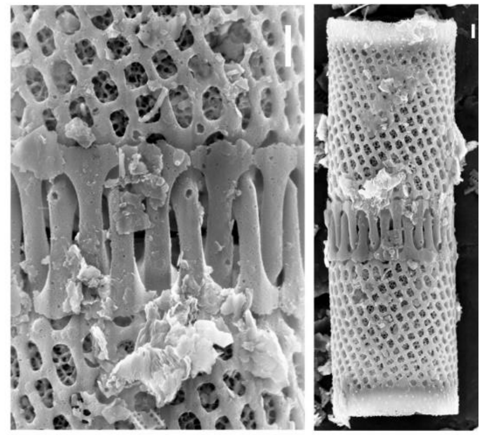
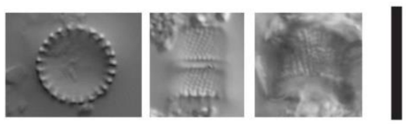
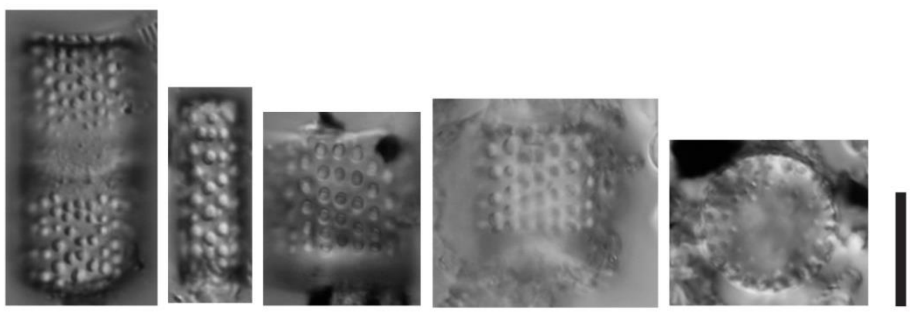


10 - 11



12 - 14



15 - 19

Plate 13 (Scale bars: Figs 1-5=10 µm; Figs 6-9=1 µm)

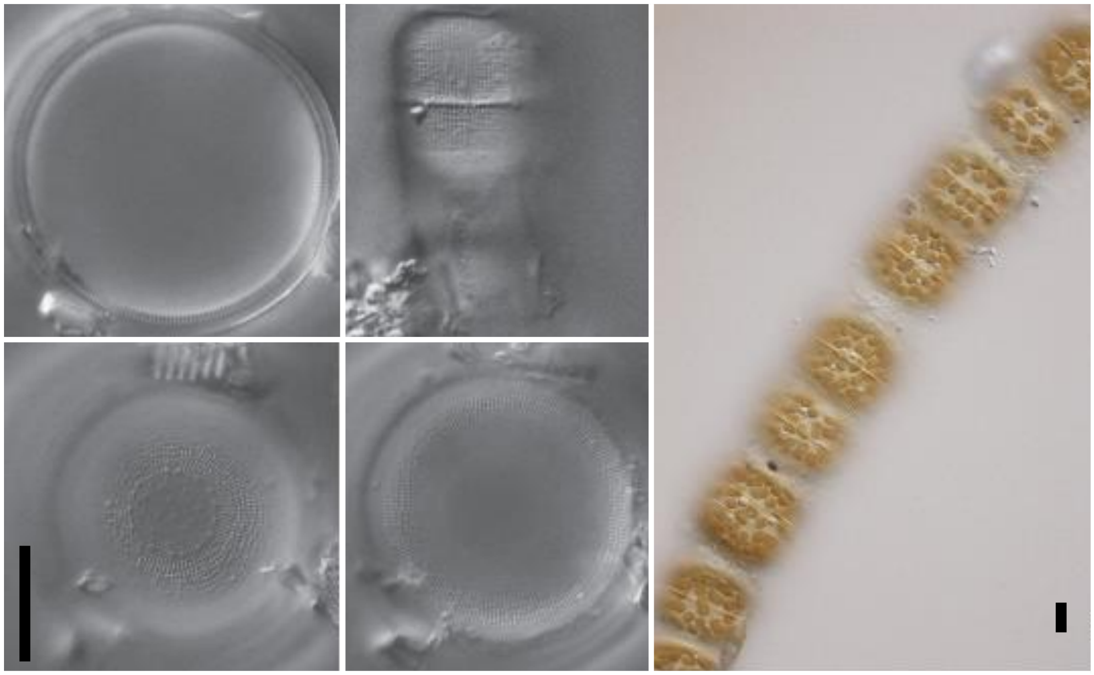
Melosira nummuloides (Dillwyn) Agardh

Lit.: Agardh 1824, p. 8; Crawford 1975 p. 323-338, Figs 1-29

Basionym: *Conferva nummuloides* Dillwyn 1809

Synonym: *Fragilaria nummuloides* (Dillwyn) Lyngbye 1819
Gaillonella nummuloides (Dillwyn) Bory 1831
Lysigonium nummuloides (Dillwyn) Trevisan 1848

Figs 1, 3-4: Sample BBDC0058, Barnegat Bay, NJ.
Fig. 2: Sample GB001, Great Bay, NJ.
Fig. 5: Barnegat Bay, NJ.
Figs 6,8: Sample BBDC0106, Great Bay, NJ.
Fig. 7: Sample BB0032, Barnegat Bay, NJ.
Fig. 9: Sample BBDC0016, Barnegat Bay, NJ.



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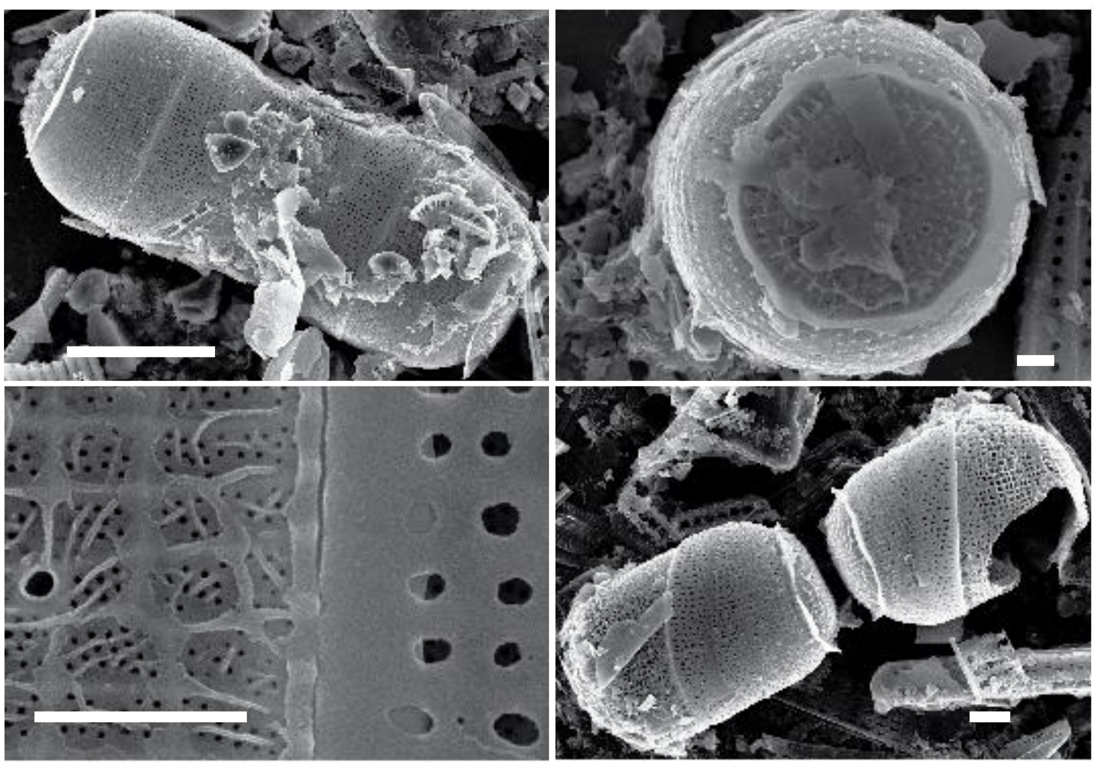
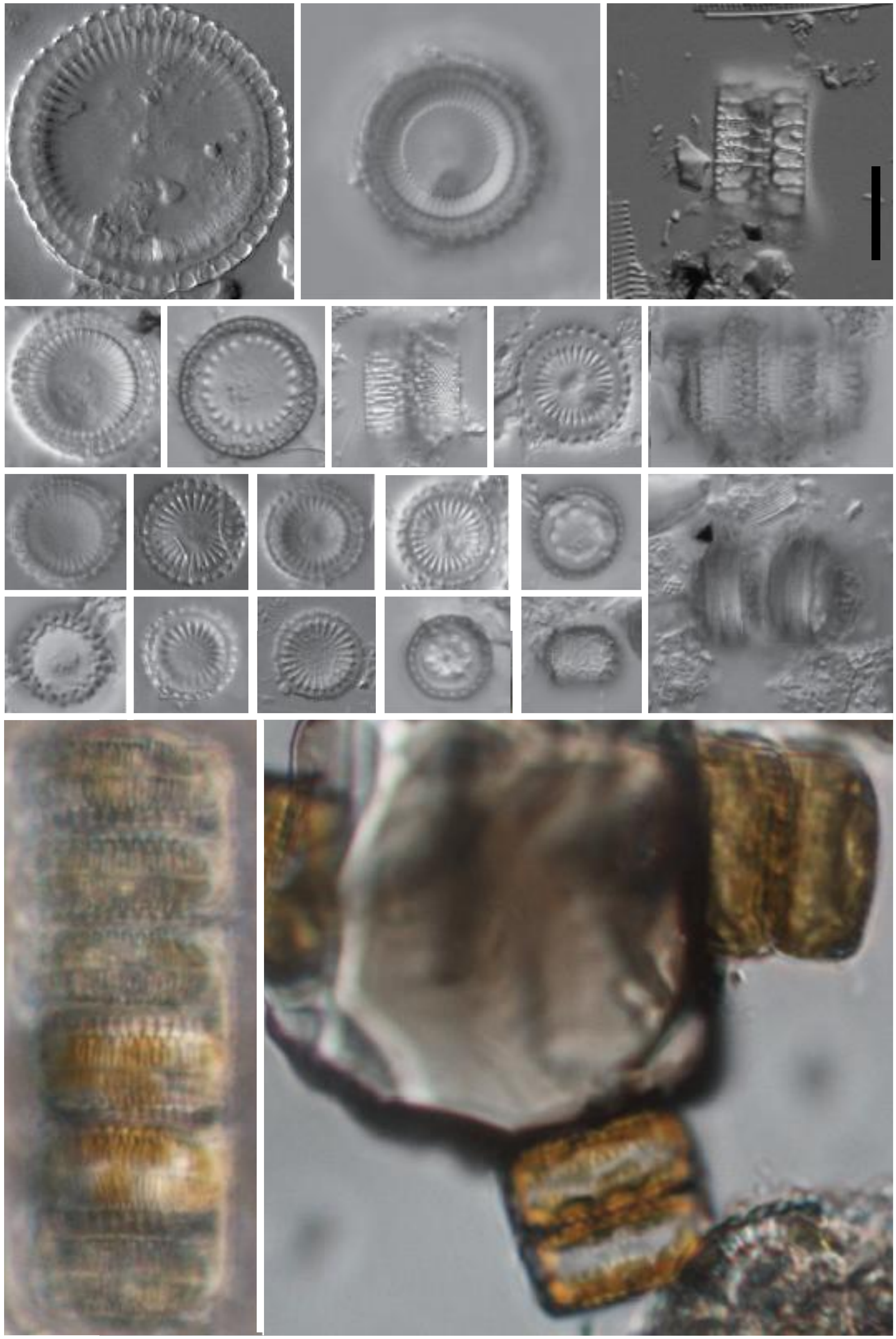


6 - 9

Plate 14 (Scale bar: Figs 1-21=10 μm)

Paralia sulcata (Ehrenberg) Cleve
Lit.: Cleve 1873, p. 7
Basionym: *Gaillonella (Gallionella) sulcata* Ehrenberg 1838
Synonyms: *Melosira sulcata* (Ehrenberg) Kützing 1844
Lysigonium sulcatum (Ehrenberg) Trevisan 1848
Orthosira sulcata (Ehrenberg) O'Meara 1875
Melosira sulcata (Ehrenberg) Hanna 1932

Fig. 1: Sample BBDC0012, Barnegat Bay, NJ.
Figs 2,5,13,17-18: Sample BBDC0044, Barnegat Bay, NJ.
Fig. 3: Sample BB0052, Barnegat Bay, NJ.
Fig. 4: Sample BB0068, Barnegat Bay, NJ.
Fig. 6: Sample BBDC0045, Barnegat Bay, NJ.
Fig. 7: Sample COAST062, Great Bay, NJ.
Fig. 8: Sample BBDC0042, Barnegat Bay, NJ.
Fig. 9: Sample BB0066, Barnegat Bay, NJ.
Fig. 10: Sample BBDC0002, Barnegat Bay, NJ.
Fig. 11: Sample BB0069, Barnegat Bay, NJ.
Fig. 12: Sample BB0076, Barnegat Bay, NJ.
Fig. 14: Sample BBDC0110, Great Bay, NJ.
Fig. 15: Sample BBDC0065, Barnegat Bay, NJ.
Fig. 16: Sample BBDC0007, Barnegat Bay, NJ.
Fig. 19: Sample BB0073, Barnegat Bay, NJ.
Figs 20-21: Barnegat Bay, NJ.



1 - 21

Plate 15 (Scale bars: Figs 1-9=10 µm; Figs 10-12=1 µm)

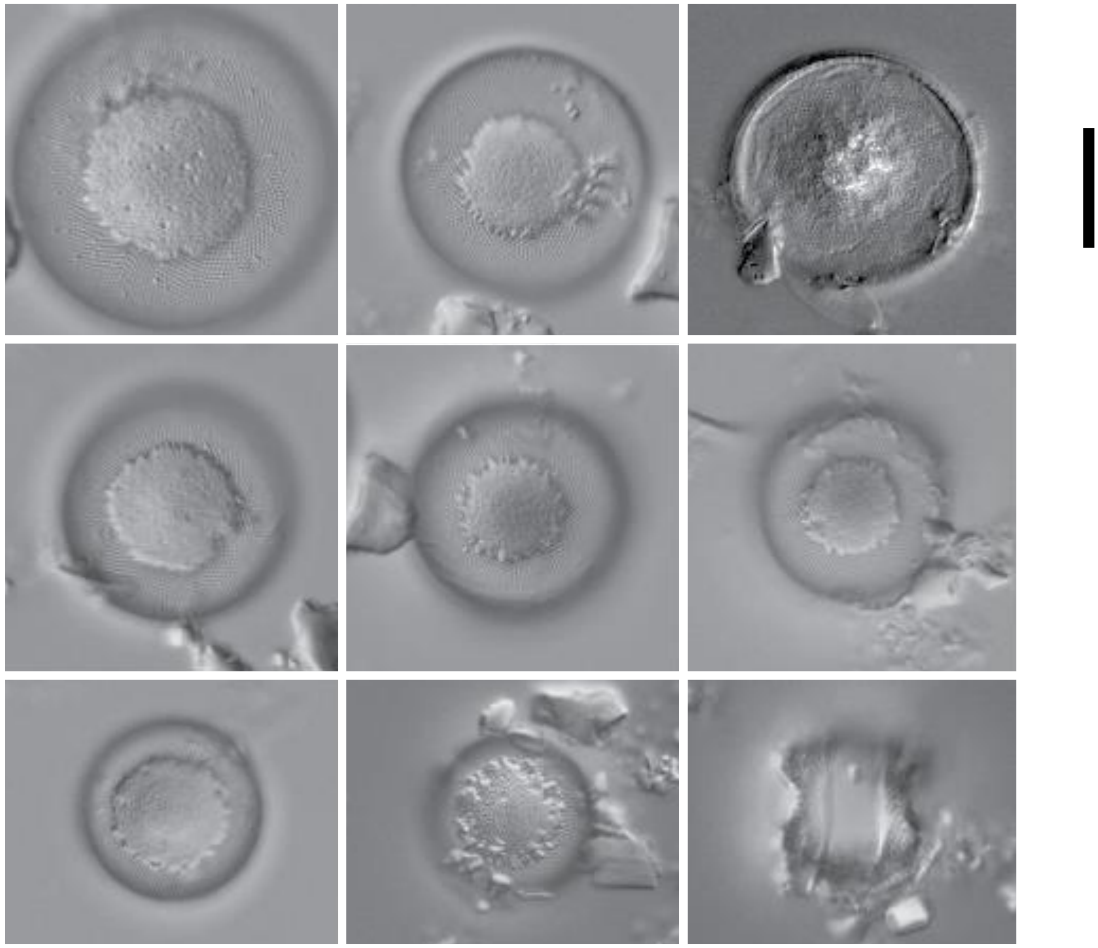
Hyalodiscus scoticus (Kützing) Grunow

Lit.: Grunow 1879, p. 690; pl. 21, fig. 5

Basionym: *Cyclotella scotica* Kützing 1844

Synonyms: *Hyalodiscus subtilis* var. *scotica* (Kützing) Peragallo & Peragallo 1897-1908
Cycloplea scotica (Kützing) Trevisan 1848

Figs 1-2,5,9: Sample BBDC0044, Barnegat Bay, NJ.
Fig. 3: Sample BBDC0001, Barnegat Bay, NJ.
Figs 4, 10-12: Sample BBDC0051, Barnegat Bay, NJ.
Figs 6-7: Sample BBDC0041, Barnegat Bay, NJ.
Fig. 8: Sample BB0066, Barnegat Bay, NJ.
Fig. 7: Sample COAST062, Great Bay, NJ.



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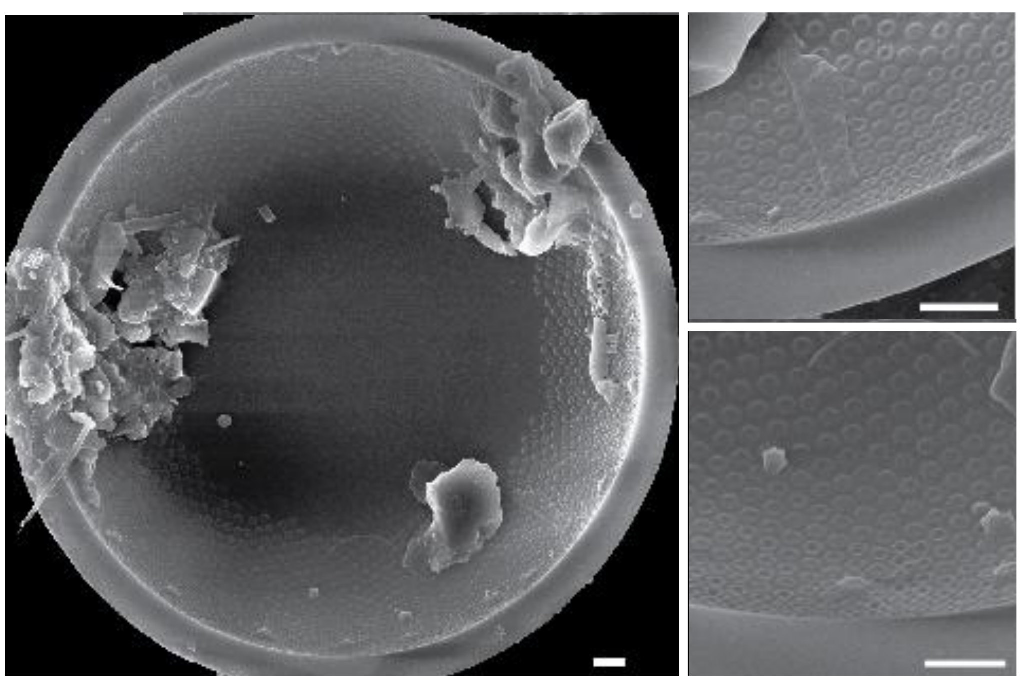


10 - 12

Plate 16 (Scale bar: Figs 1-5=10 µm)

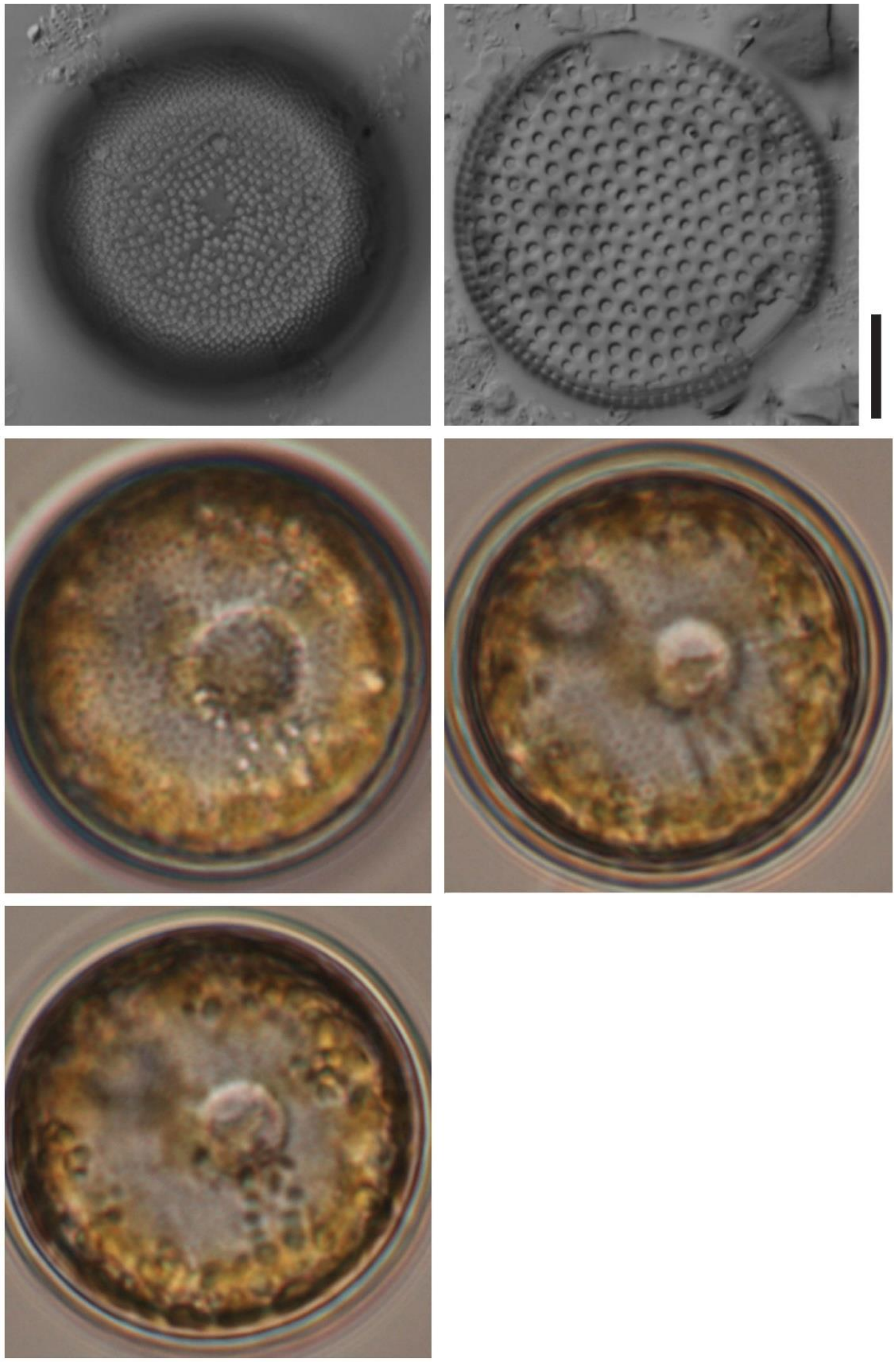
Actinocyclus normanii (Gregory ex Greville) Hustedt

Lit.: Hustedt 1957, p. 218; pl. 1, fig. 5-6

Basionym: *Coscinodiscus normanii* Gregory ex Greville 1859

Synonyms: *Coscinodiscus curvatulus* var. *normanni* (Gregory manuscript in Greville) Cleve 1883
Coscinodiscus rothii var. *normani (normanii)* (Gregory) Van Heurck 1885
Coscinodiscus subtilis var. *normannii (-manii, -manni)* (Gregory) Van Heurck 1885
Coscinodiscus normannicus Gregory ex Greville Gregory in Van Heurck 1883

Fig. 1: Sample BBDC0044, Barnegat Bay, NJ.
Fig. 2: Sample BBDC0072, Barnegat Bay, NJ.
Figs 3-5: Barnegat Bay, NJ.



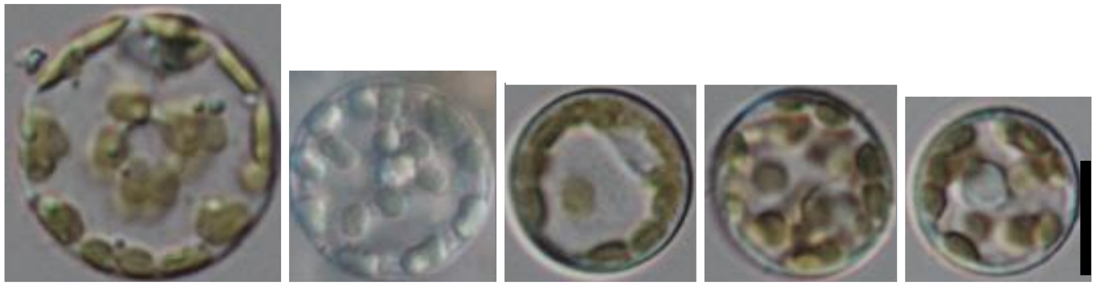
1 - 5

Plate 17 (Scale bars: Figs 1-5=10 µm; Figs 6-8=1 µm)

Actinocyclus theleus Bradbury & Krebs

Lit.: Bradbury & Krebs 1995, p. 12-13; pl. 13, fig. 7, pl. 14, fig. 1-4

Figs 1-8: Barnegat Bay, NJ.



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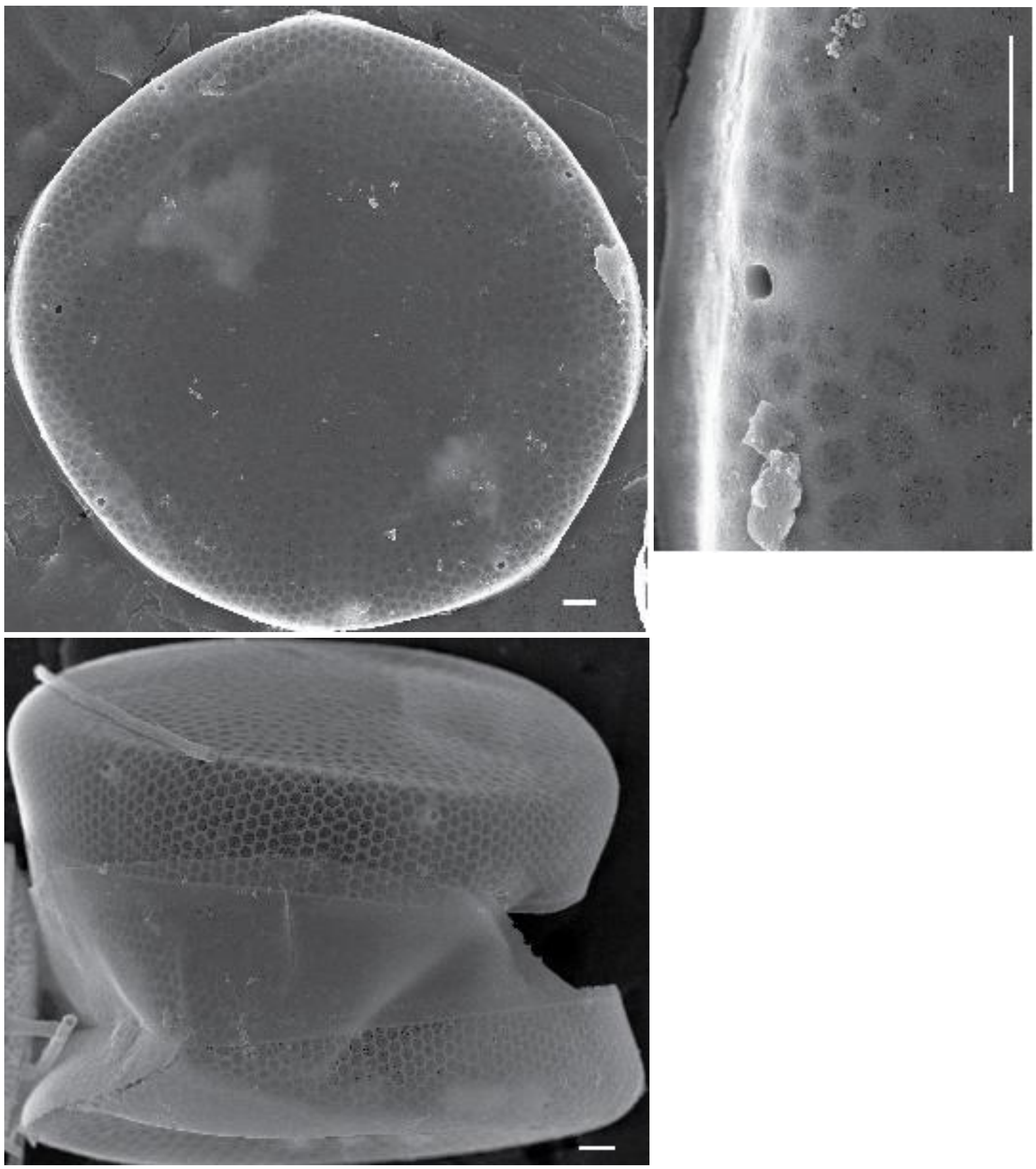


6 - 8

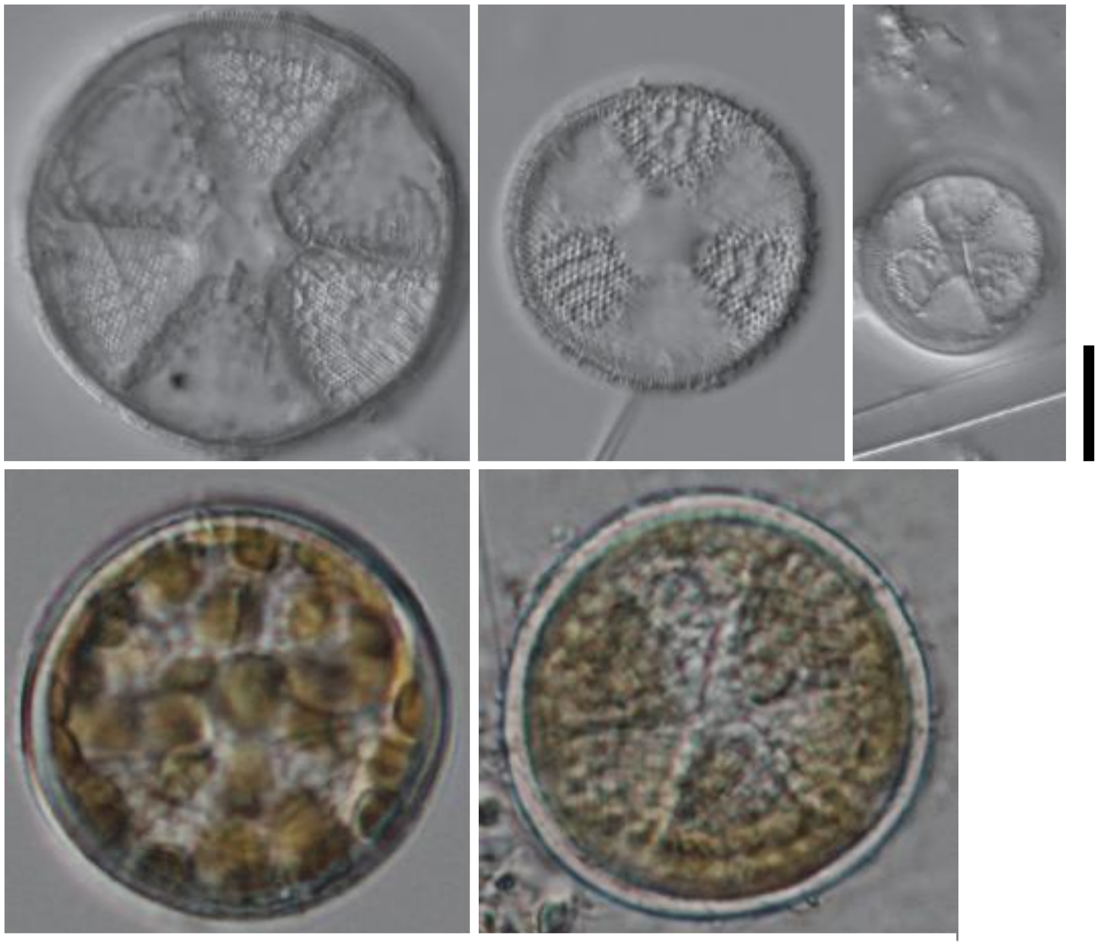
Plate 18 (Scale bars: Figs 1-5=10 µm; Fig 6=1 µm)

Actinoptychus senarius (Ehrenberg) Ehrenberg

Lit.: Ehrenberg 1843, p. 298, 301, 322, 328, 437, 438, 443; pl. I/I, fig. 27, pl. I/III, fig. 21, pl. III/VII, fig. 1

Basionym: *Actinocyclus senarius* Ehrenberg 1837

Figs 1-2: Sample BBDC0044, Barnegat Bay, NJ.
Fig. 3: Sample BBDC0080, Barnegat Bay, NJ.
Figs 4-5: Barnegat Bay, NJ.
Fig. 6: Sample COAST010, Moriches Bay, NY.



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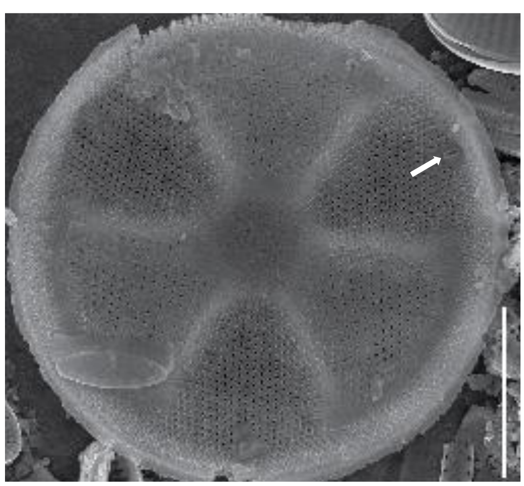


6

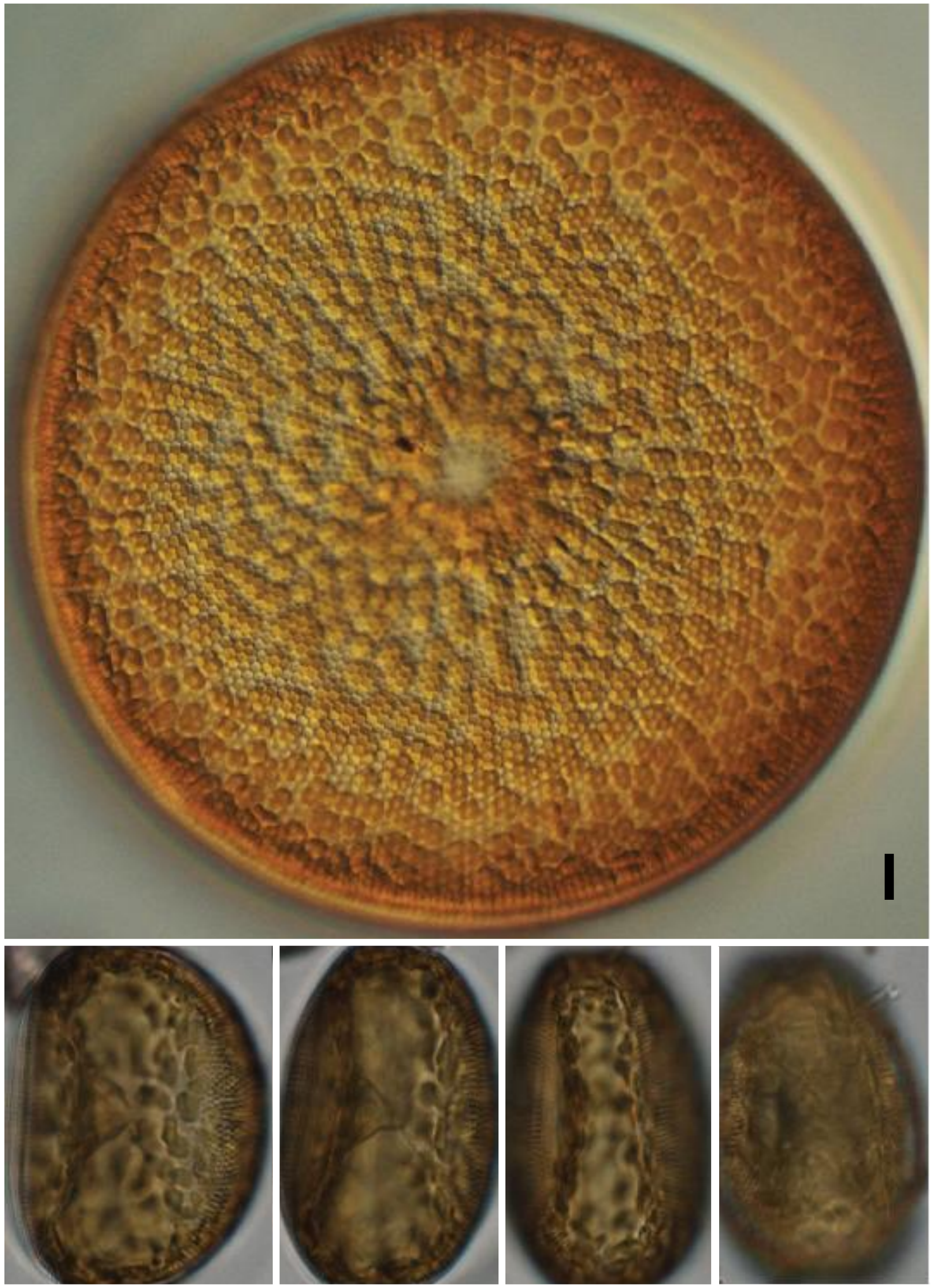
Plate 19 (Scale bars: Figs 1-5=10 µm)

Coscinodiscus centralis Ehrenberg

Lit.: Ehrenberg 1854, p. 9; pl. 21, fig. 3

Synonyms: *Coscinodiscus asteromphalus* var. *centralis (Ehrenberg)* Grunow 1884
Coscinodiscus radiatus var. *centralis* (Ehrenberg; Ehrenberg) Van Heurck 1896

Figs 1-5: Barnegat Bay, NJ.

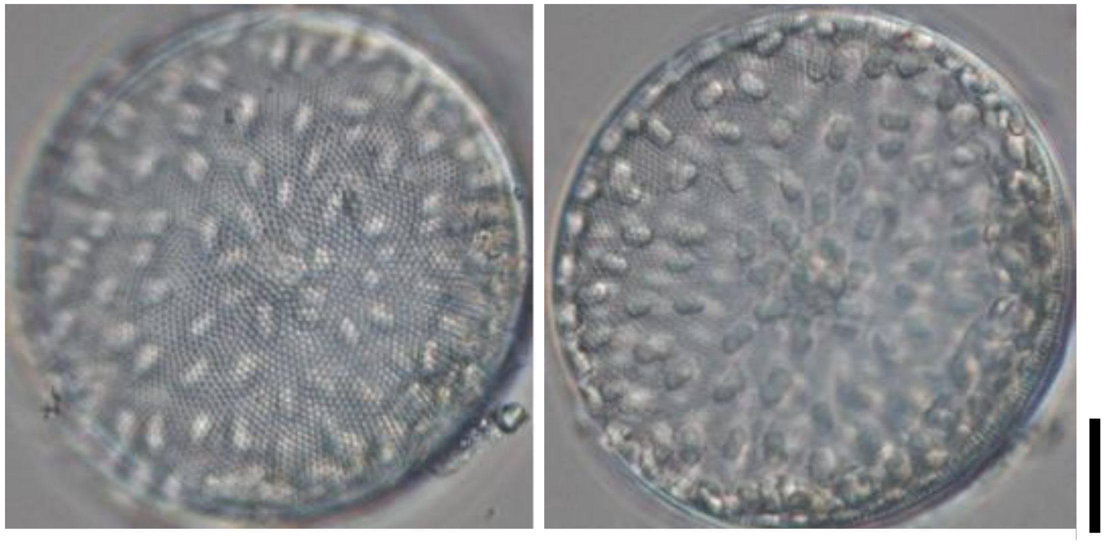


1 - 5

Plate 20 (Scale bars: Figs 1-3=10 μm)

Figs 1-2: ***Coscinodiscus granii*** Gough
Lit.: Gough 1905, p. 338; fig. 313 (335)
Figs 1-2: Barnegat Bay, NJ.

Figs 3: ***Coscinodiscus radiatus*** Ehrenberg
Lit.: Ehrenberg 1854, pl. 21, fig. 1
Fig. 3: Barnegat Bay, NJ.



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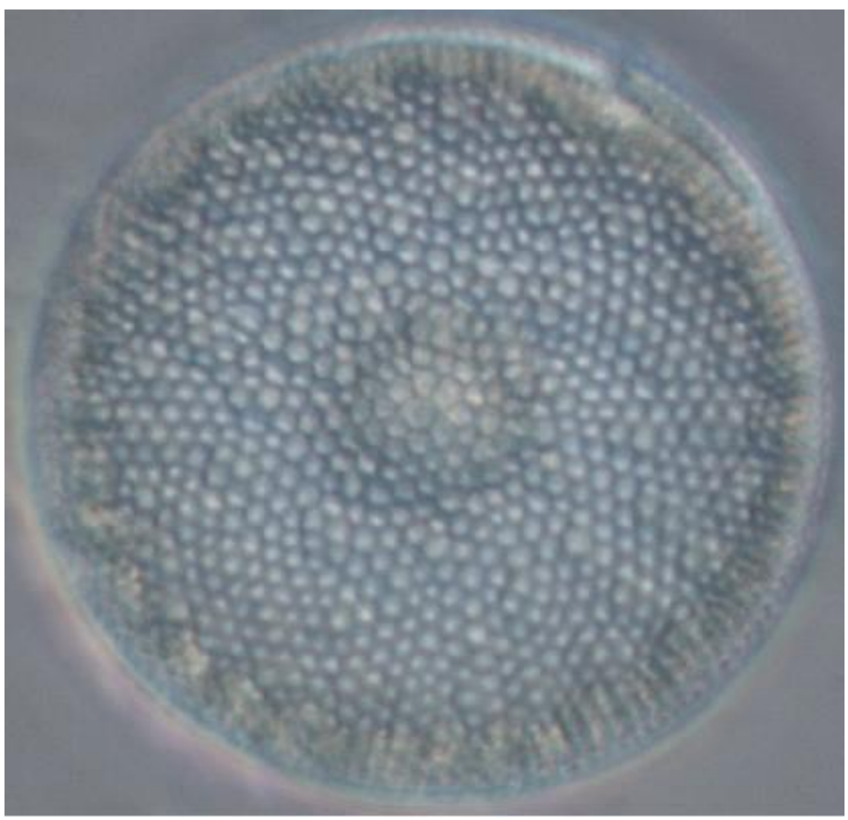


3

Plate 21 (Scale bars: Figs 1-5=10 µm; Fig 6-7=1 µm)

Biddulphia alternans (Bailey) Van Heurck

Lit.: Van Heurck 1885, p. 208

Basionym: *Triceratium alternans* J.W. Bailey 1851

Synonym: *Trigonium alternans* (J.W. Bailey) Mann 1907

Fig. 1: Sample BBDC0002, Barnegat Bay, NJ.

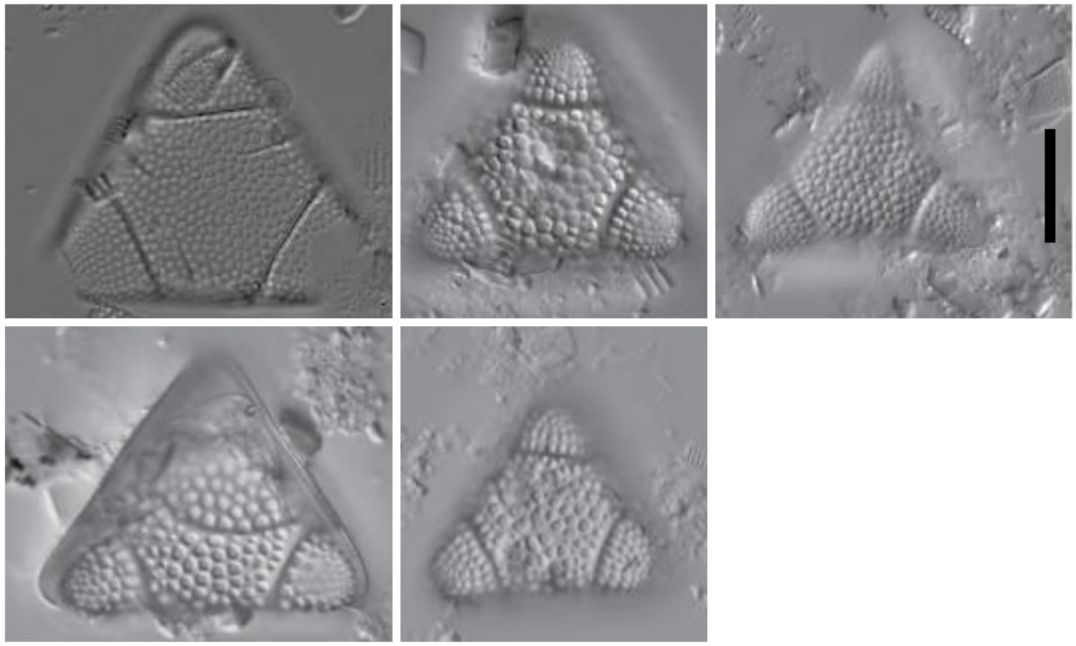
Fig. 2: Sample BBDC0009, Barnegat Bay, NJ.

Fig. 3: Sample BBDC0008, Barnegat Bay, NJ.

Fig. 4: Sample BBDC0045, Barnegat Bay, NJ.

Fig. 5: Sample BBDC0051, Barnegat Bay, NJ.

Figs 6-7: Sample BBDC0001, Barnegat Bay, NJ.



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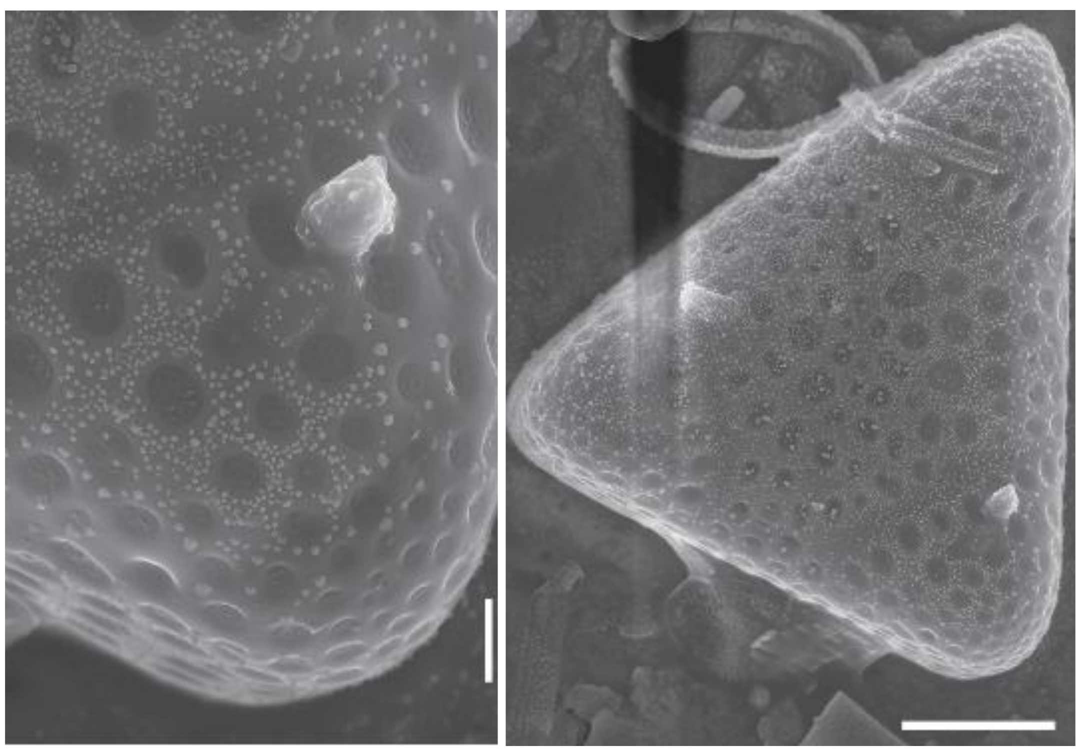
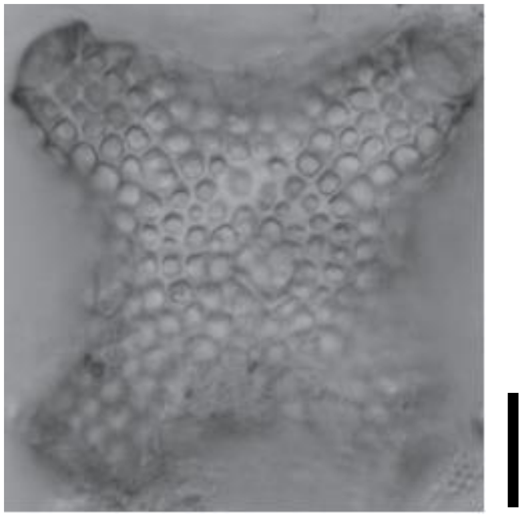


6 - 7

Plate 22 (Scale bars: Figs 1-3=10 µm; Fig 4-6=1 µm)

Fig.1: ***Biddulphia antediluviana*** (Ehrenberg) Van Heurck
Lit.: Van Heurck 1885, p. 208
Basionym: *Amphitetras antediluviana* Ehrenberg 1840
Synonyms: *Odontella antediluviana* (Ehrenberg) M. Peragallo 1903
Triceratium antediluvianum (Ehrenberg) Grunow 1867
Fig. 1: Sample BBDC0074, Barnegat Bay, NJ.

Figs 2-6: ***Biddulphia pulchella*** Gray
Lit.: Gray 1821, p. 294
Synonyms: *Conferva biddulphiana* J.E. Smith 1790-1814
Biddulphia biddulphiana (J.E. Smith) Boyer 1900
Biddulphia pulchella var. *quinquelocularis* (Kützing) Rabenhorst 1864
Biddulphia quinquelocularis Kützing 1844
Diatoma biddulphianum (J.E. Smith) Agardh 1824
Diatoma biddulphiana (J.E. Smith) Agardh 1817
Figs 1-2: Barnegat Bay, NJ.
Figs 4-6: Sample BBDC0038, Barnegat Bay, NJ.



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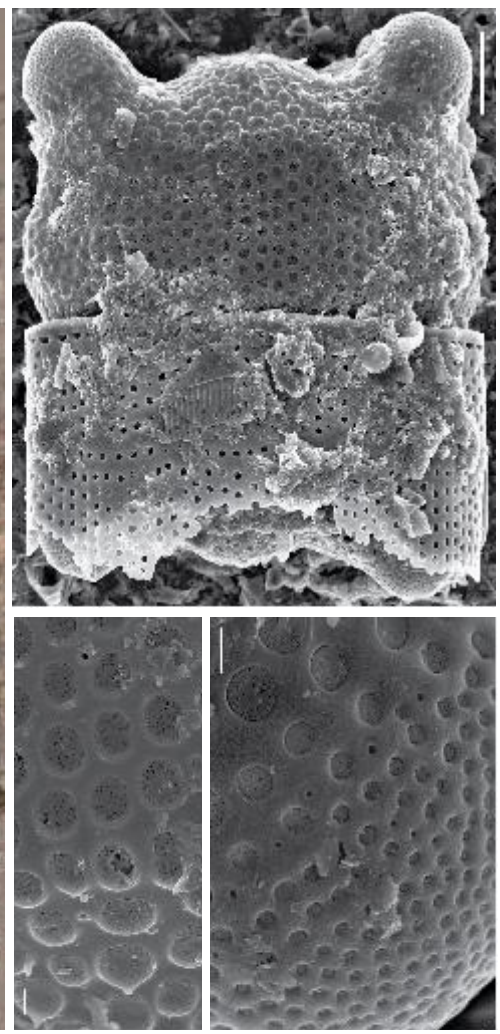


4 - 6

Plate 23 (Scale bar: Figs 1-3=10 μm)

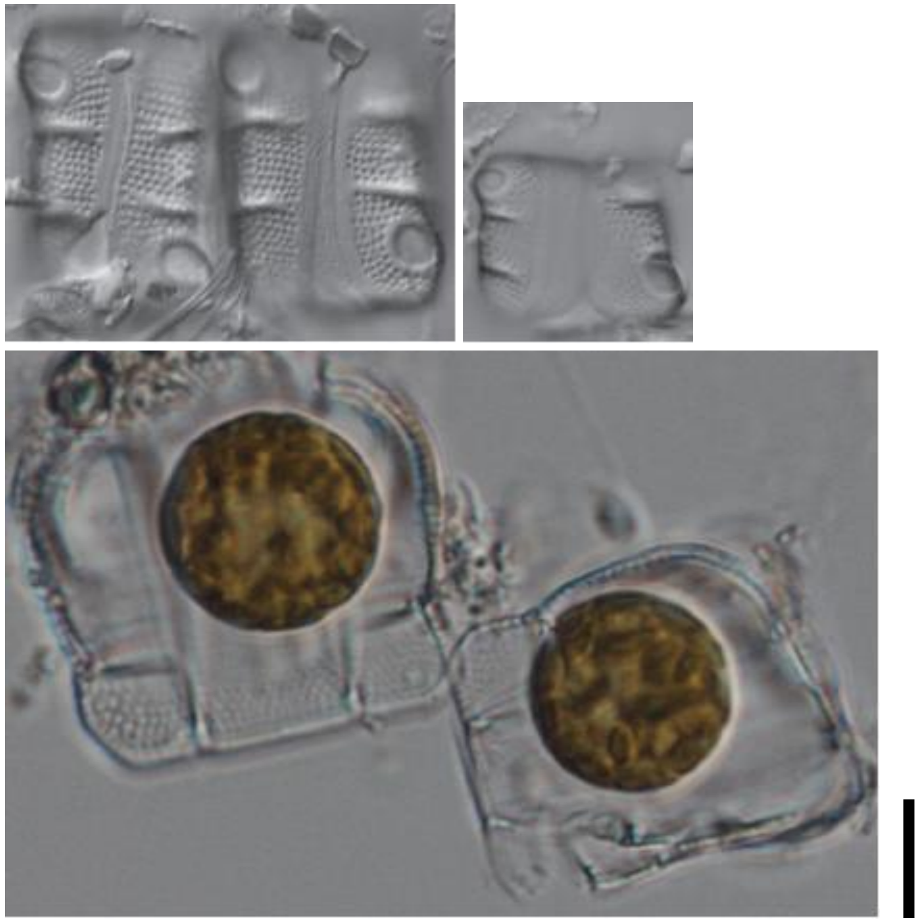
Neohuttonia reichardtii (Grunow) Kuntze

Lit.: Kuntze 1898, p. 417

Basionym: *Cerataulus reichardtii* Grunow 1863

Synonyms: *Huttonia reichardtii* (Grunow) Grunow 1887
Huttoniella reichardtii (reichardti) (Grunow) Hustedt 1955
Huttonia reichardtii (Grunow) Grunow 1888

Fig. 1: Sample BBDC0084, Barnegat Bay, NJ.
Fig. 2: Sample BBDC0094, Great Bay, NJ.
Fig. 3: Barnegat Bay, NJ.



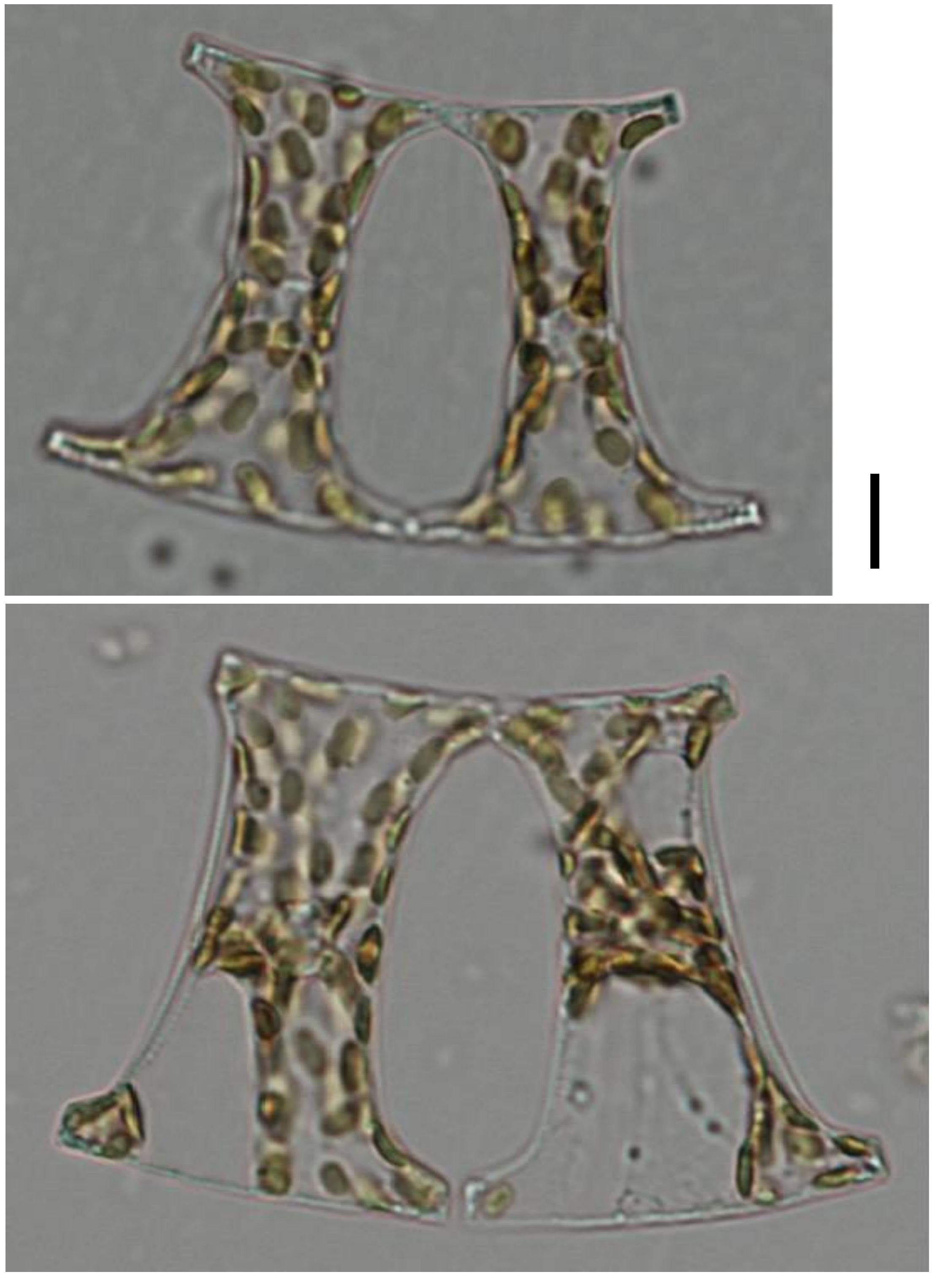
1 - 3

Plate 24 (Scale bar: Figs 1-2=10 µm)

Eucampia zodiacus Ehrenberg

Lit.: Ehrenberg 1840, p. 71 (151); pl. 4, fig. 8

Figs 1-2: Barnegat Bay, NJ.



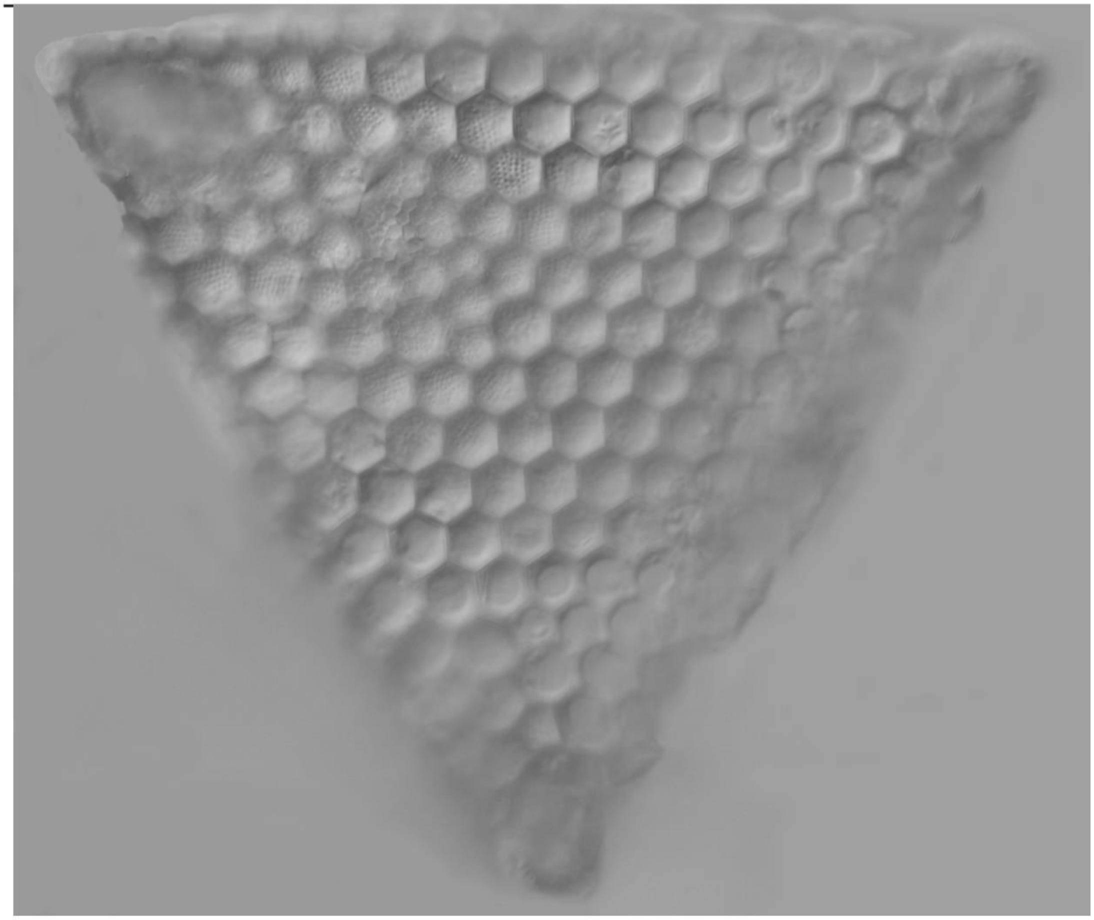
1 - 2

Plate 25 (Scale bar: Figs 1-2=10 µm)

Fig. 1: ***Triceratium favus*** Ehrenberg
Lit.: Ehrenberg 1840, p. 79 (159); pl. 4, fig. 10
Synonyms: *Odontella favus (Ehrenberg) M. Peragallo 1903*
Biddulphia favus (Ehrenberg) Van Heurck 1885
Odontella favus (Ehrenberg) Cleve 1901
Fig. 1: Sample BBDC0063, Barnegat Bay, NJ.

Fig. 2: ***Auliscus sculptus*** (Smith) Brightwell
Lit.: Brightwell 1860, p. 139
Basionym: *Eupodiscus sculptus* W. Smith 1853
Synonym: *Aulacodiscus sculptus* (W. Smith) Brightwell 1860
Fig. 2: Sample BB0015, Barnegat Bay, NJ.

Fig. 3: ***Pseudoauliscus peruvianus*** (Kitton ex Pritchard) Schmidt
Lit.: Schmidt et al. 1875, pl. 32, fig. 29
Basionym: *Eupodiscus peruvianus* Kitton ex Ralfs in Pritchard 1861
Synonyms: *Auliscus peruvianus* (Kitton ex Pritchard) Greville 1862
Eupodiscus peruvianus Kitton ex Ralfs in Pritchard 1861
Fig. 3: Sample BB0066, Barnegat Bay, NJ.



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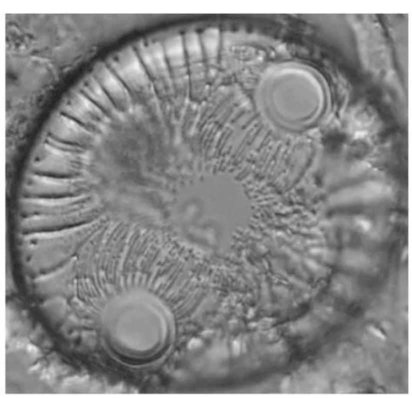

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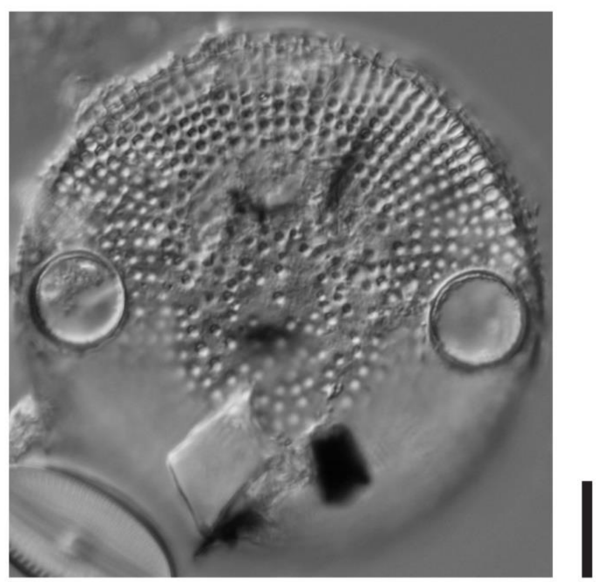


3

Plate 26 (Scale bar: Figs 1-4=10 µm)

Fig. 1: ***Odontella mobilensis*** Bailey
Lit.: Bailey 1851, p. 6
Fig. 1: Barnegat Bay, NJ.

Fig. 2-4: ***Odontella aurita*** Agardh
Lit.: Agardh 1832, p. 56
Fig. 2: Sample BBDC0065, Barnegat Bay, NJ.
Fig. 3: Barnegat Bay, NJ.
Fig. 4: Sample BB0071, Barnegat Bay, NJ.

1

2 - 4

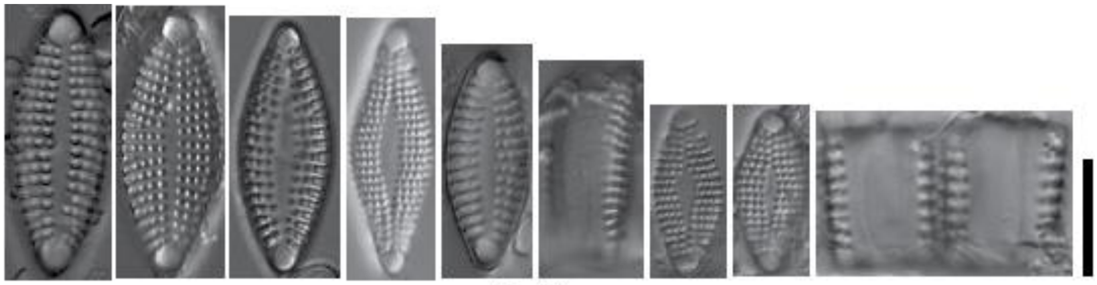
Plate 27 (Scale bars: Figs 1-9;12-17=10 μm; Fig. 10-11=1 μm)

Figs 1-11: ***Dimerogramma minor*** (Gregory) Ralfs
Lit.: Pritchard 1861, p. 790
Basionym: *Denticula minor* Gregory 1857

Fig. 1: Sample BBDC0002, Barnegat Bay, NJ.
Figs 2-3: Sample BBDC0001, Barnegat Bay, NJ.
Fig. 4: Sample RUTG0870, Bayville, NJ.
Fig. 5: Sample BBDC0007, Barnegat Bay, NJ.
Fig. 6: Sample BB0073, Barnegat Bay, NJ.
Fig. 7: Sample BBDC0003, Barnegat Bay, NJ.
Fig. 8: Sample BB0061, Barnegat Bay, NJ.
Fig. 9: Sample BBDC0047, Barnegat Bay, NJ.

Figs 12-17: ***Plagiogrammopsis vanheurckii*** (Grunow) Hasle
Lit.: Hasle, von Stosch & Syvertsen 1983, p. 31-34; text fig. 4, fig. 104-131
Basionym: *Plagiogramma vanheurckii* Grunow in Van Heurck 1881

Figs 12-13,17: Barnegat Bay, NJ.
Fig. 14: Sample RUTG0380, Cheesequake State Park, NJ.
Figs 15-16: Sample BBDC0045, Barnegat Bay, NJ.



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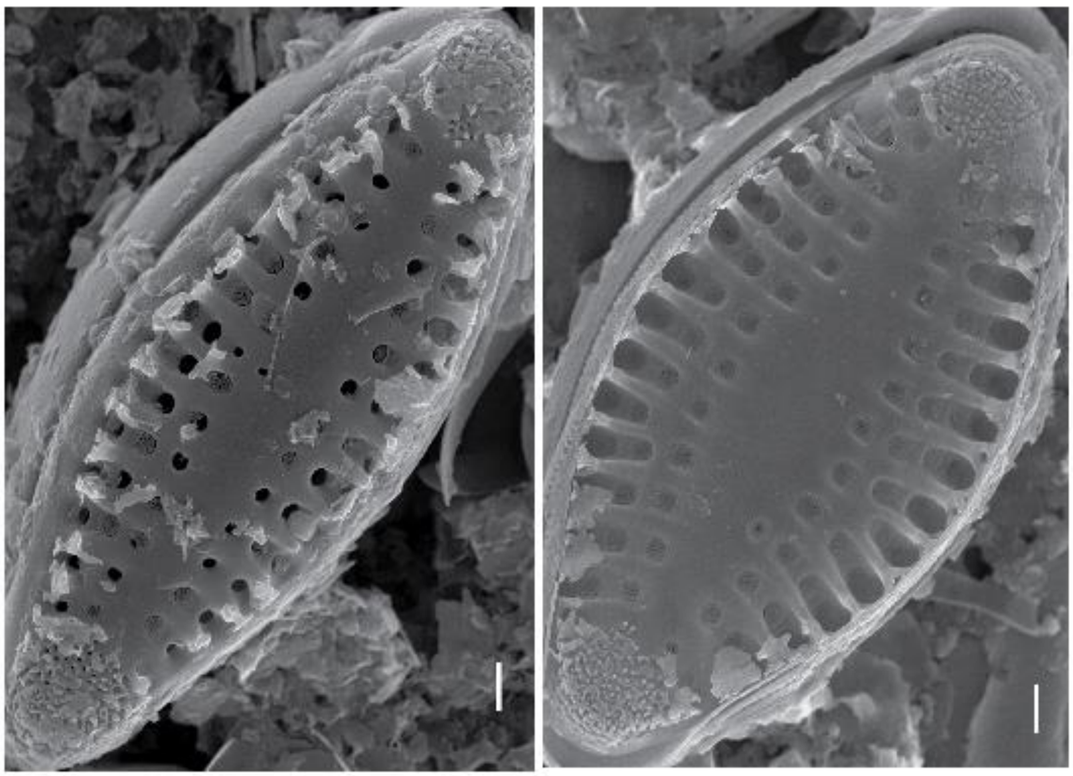
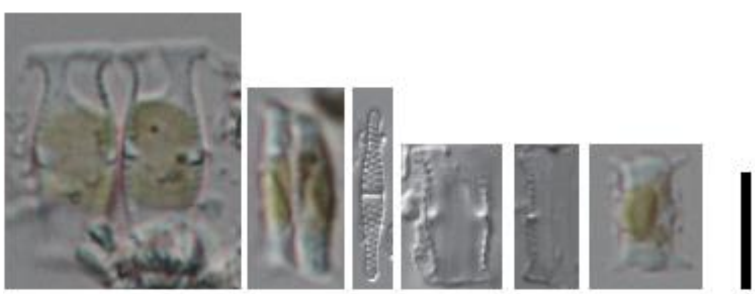


10 - 11



12- 17

Plate 28 (Scale bars: Figs 1-21=10 µm)

Figs 1-17: ***Anaulus balticus*** Simonsen

Lit.: Simonsen 1959, p. 74; pl. 10, fig. 1-3

Fig. 1: Sample BBDC0062, Barnegat Bay, NJ.
Fig. 2: Sample BBDC0069, Barnegat Bay, NJ.
Fig. 3: Sample BB0061, Barnegat Bay, NJ.
Fig. 4: Sample BBDC0047, Barnegat Bay, NJ.
Fig. 5: Sample BB0066, Barnegat Bay, NJ.
Fig. 6: Sample BB0059, Barnegat Bay, NJ.
Fig. 7: Sample BBDC0050, Barnegat Bay, NJ.
Fig. 8: Barnegat Bay, NJ.
Fig. 9: Sample BBDC0051, Barnegat Bay, NJ.
Fig. 10: Sample BB0064, Barnegat Bay, NJ.
Fig. 11: Sample BB0065, Barnegat Bay, NJ.
Fig. 12: Sample BBDC0096, Great Bay, NJ.

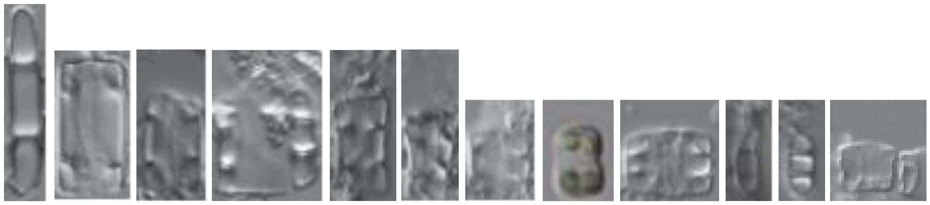
Figs 18-21: ***Eunotogramma marinum*** (W. Smith) Peragallo & Peragallo

Lit.: Peragallo & Peragallo 1908, p. x

Basionym: *Himantidium marinum* W. Smith 1857

Synonym: *Smithiella marina* (W. Smith) Peragallo & Peragallo 1901

Fig. 13,18: Sample COAST062, Great Bay, NJ.
Fig. 14: Sample BBDC0094, Great Bay, NJ.
Fig. 15: Sample BBDC0065, Barnegat Bay, NJ.
Fig. 16: Sample BBDC0108, Great Bay, NJ.
Fig. 17: Sample BBDC0082, Barnegat Bay, NJ.



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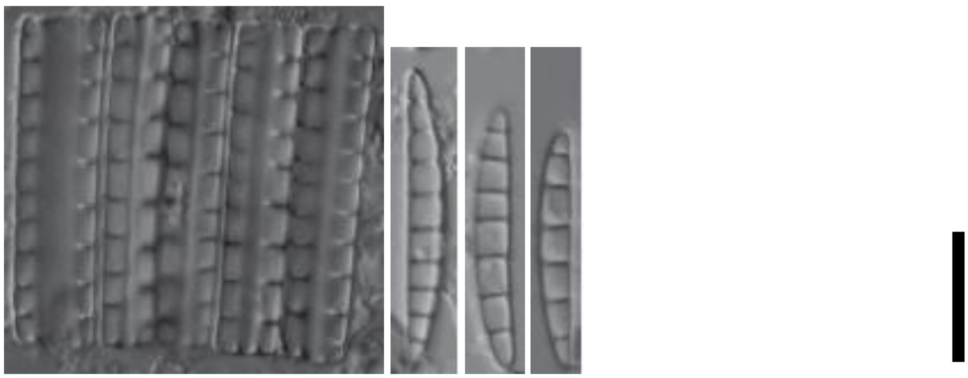


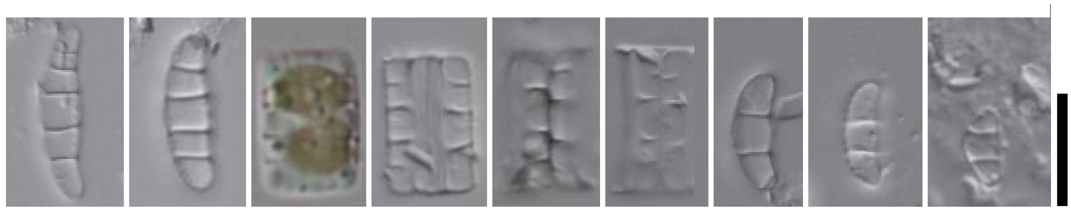
18 - 21

Plate 29 (Scale bars: Figs 1-9=10 µm; Fig 10-15=1 µm)

Eunotogramma dubium Hustedt

Lit.: Hustedt 1939, p. 592; fig. 8-10

Fig. 1: Sample BBDC0072, Barnegat Bay, NJ.
Fig. 2: Sample BBDC0051, Barnegat Bay, NJ.
Fig. 3: Barnegat Bay, NJ.
Figs 4, 10: Sample BBDC0045, Barnegat Bay, NJ.
Figs 5-6, 11-15: Sample BBDC0080, Barnegat Bay, NJ.
Fig. 7: Sample RUTG0803, Cape May, NJ.
Fig. 8: Sample BBDC0110, Great Bay, NJ.
Fig. 9: Sample RUTG0807, Cape May, NJ.



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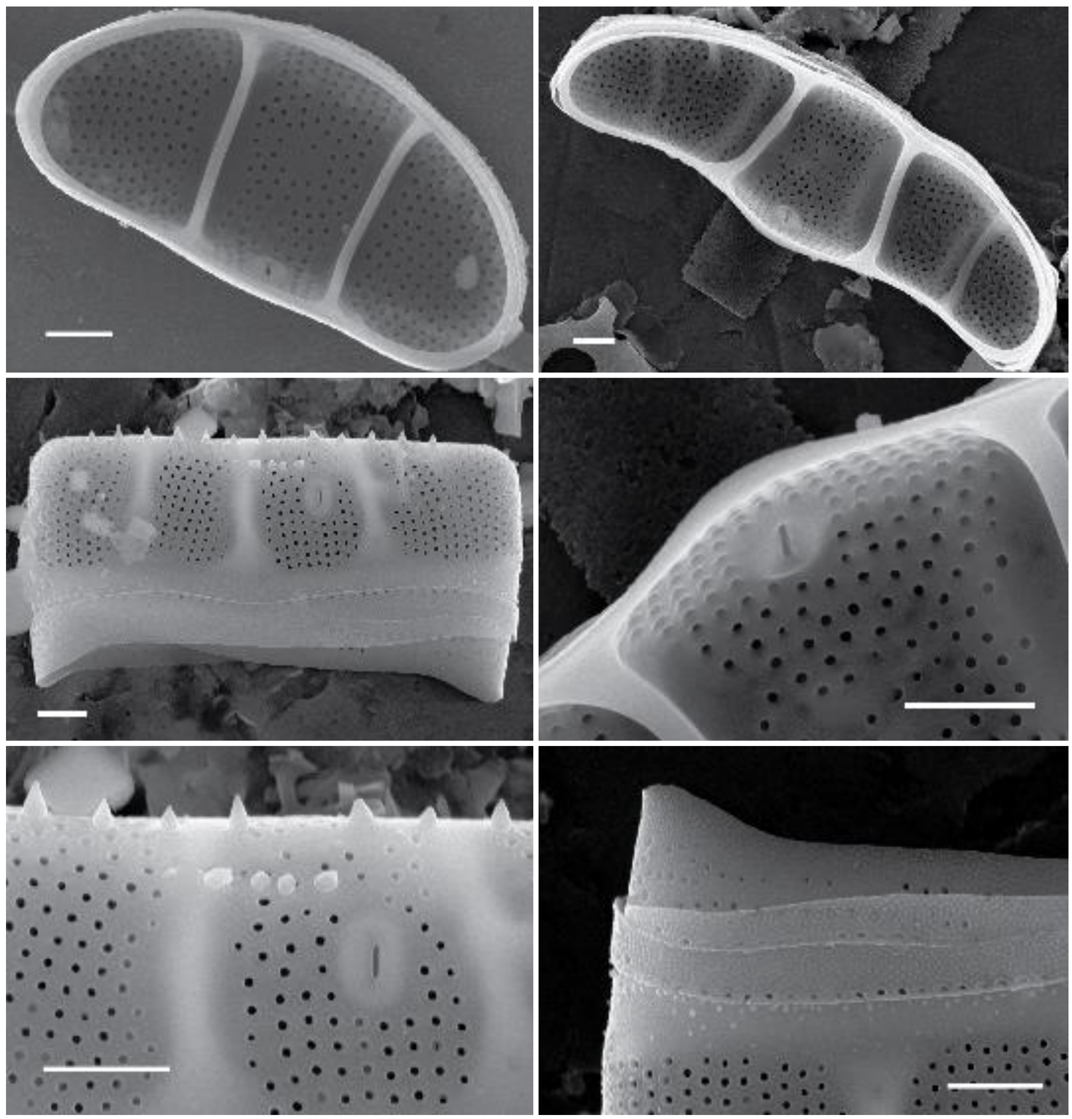


10 - 15

Plate 30 (Scale bars: Figs 1-5=10 μm)

Figs 1-3: ***Lithodesmium undulatum*** Ehrenberg

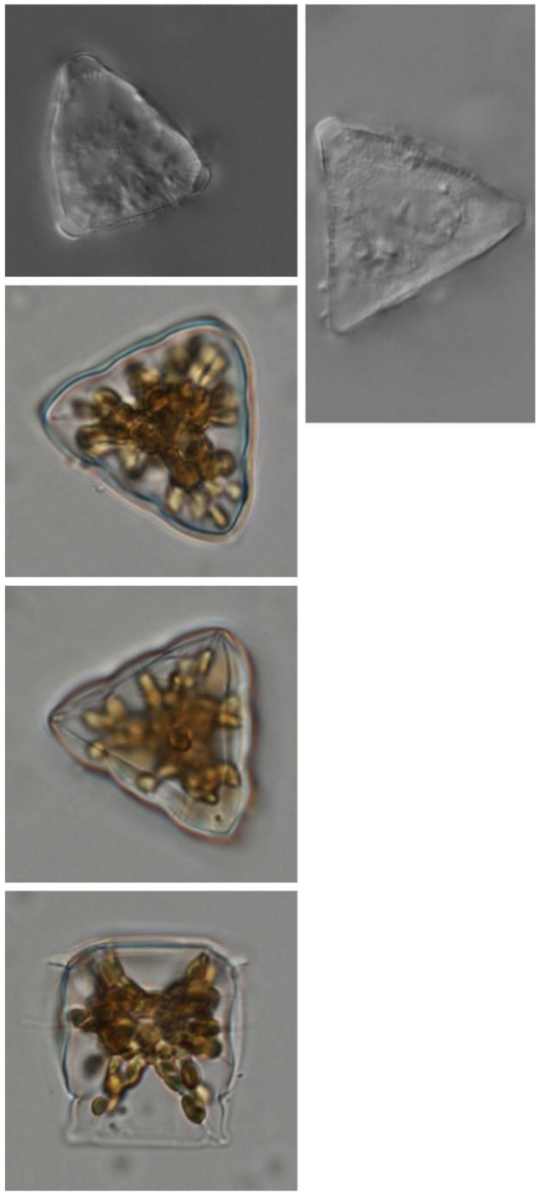
Lit.: Ehrenberg 1840, p. 75(155); pl. 4, fig. 13

Fig. 1: Sample BBDC0107, Great Bay, NJ.
Fig. 2: Sample BBDC0080, Barnegat Bay, NJ.
Figs 3-5: Barnegat Bay, NJ.

Figs 6-7: ***Ditylum brightwellii*** Peragallo & Peragallo

Lit.: Peragallo & Peragallo 1901, pl. 96, fig. 10, 11

Figs 6-7: Barnegat Bay, NJ.



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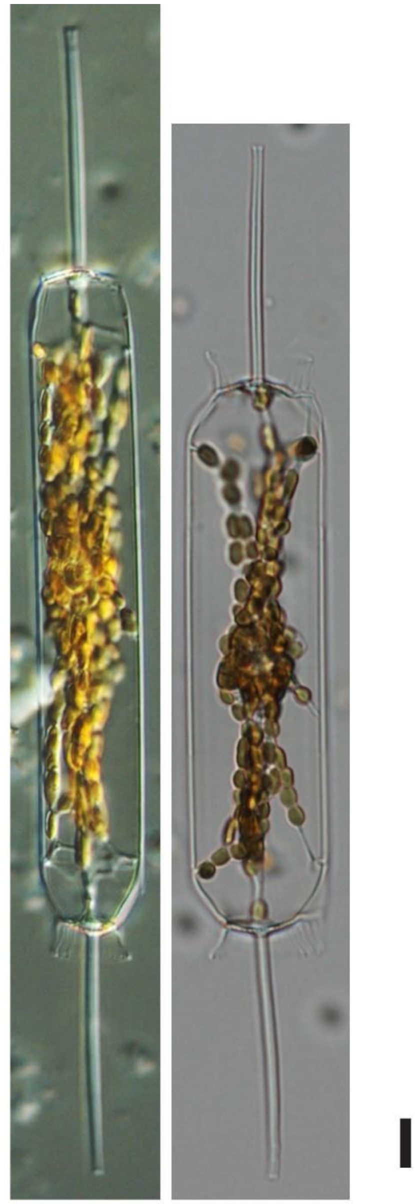


6 - 7

Plate 31 (Scale bars: Figs 1-4=10 μm; Figs 5-11 =1 μm)

Skeletonema costatum (Greville) Cleve

Lit.: Cleve 1873, p. 7

Basionym: *Melosira costata* Greville 1866

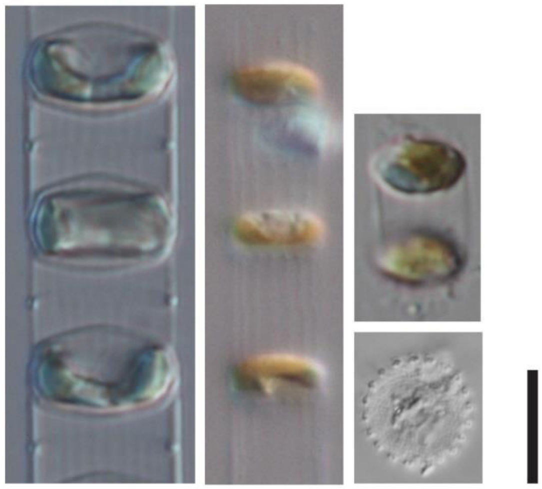
Synonym: *Stephanopyxis costata* (Greville) Hustedt 1956

Figs 1-3: Barnegat Bay, NJ.

Figs 4 -6: Sample BBDC0045, Barnegat Bay, NJ.

Fig. 7-9: Sample COAST015, Great South Bay, NY.

Figs 10-11: Sample COAST054, Barnegat Bay, NJ.



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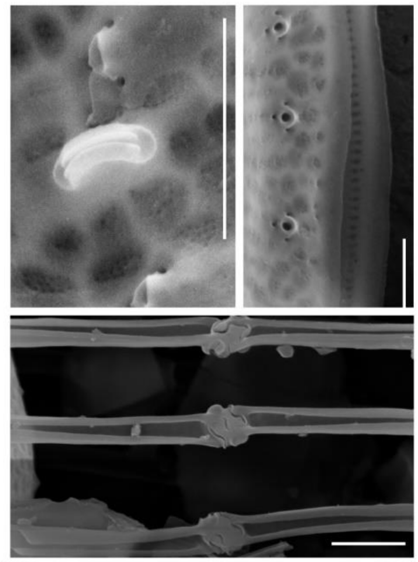
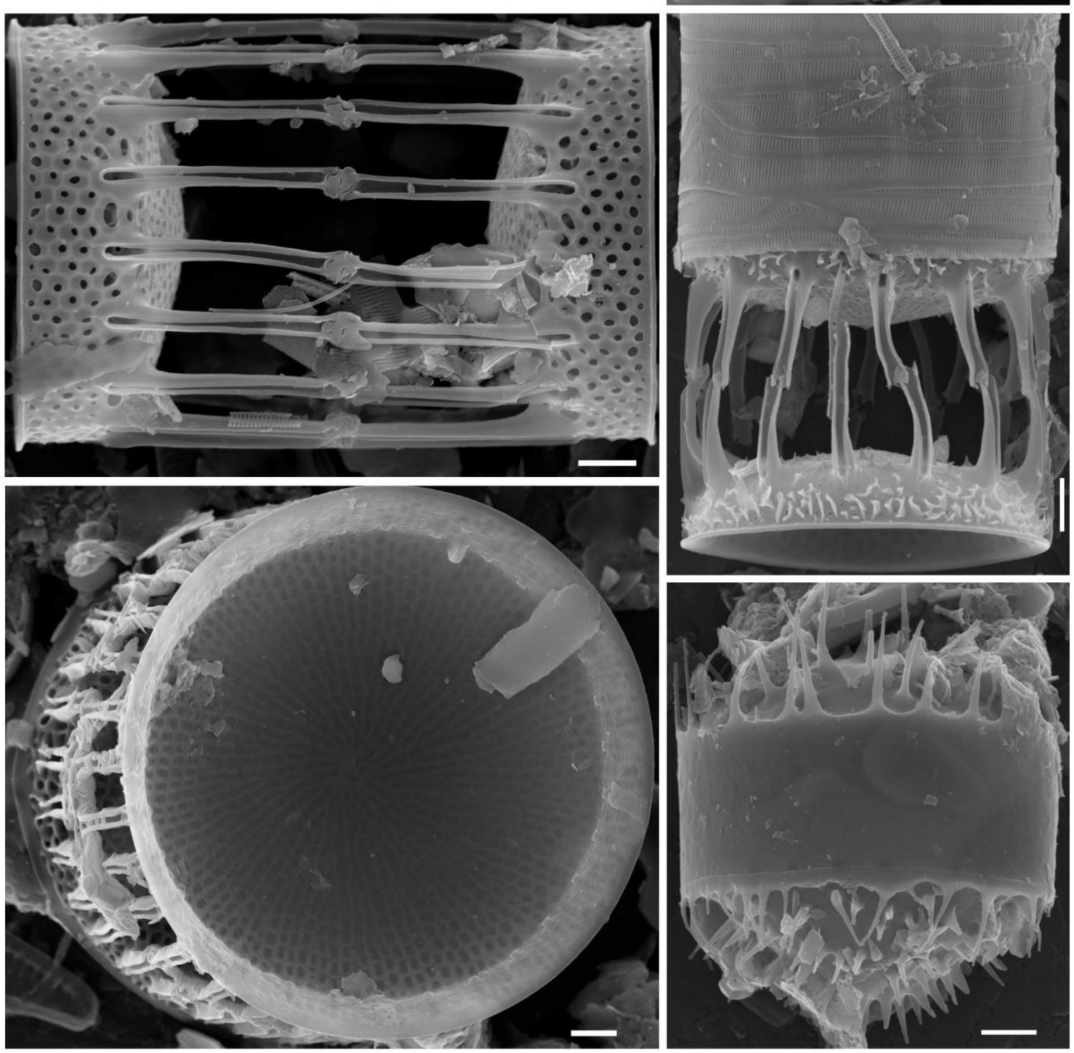


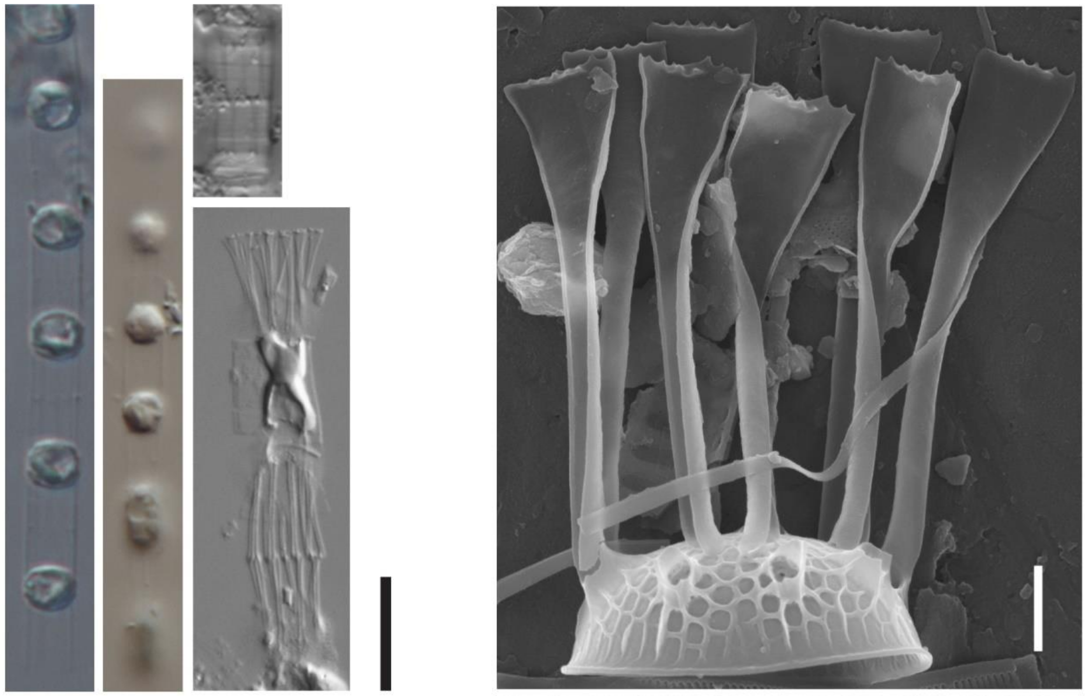


5 - 11

Plate 32 (Scale bars: Figs 1-4=10 µm; Figs 5-9 =1 µm)

Skeletonema marinoi Zingone & Sarno
Lit.: Sarno et al. 2005, p. 160; fig. 5, A-H

Figs 1-4: Barnegat Bay, NJ.
Fig. 5: Sample BBDC0045, Barnegat Bay, NJ.
Fig. 6: Sample BBDC0080, Barnegat Bay, NJ.
Fig. 7: Sample COAST031, Western Bay, NY.
Fig. 8: Sample COAST073, North East, New Jersey shore.
Fig. 9: Sample COAST015, Great South Bay, NY.



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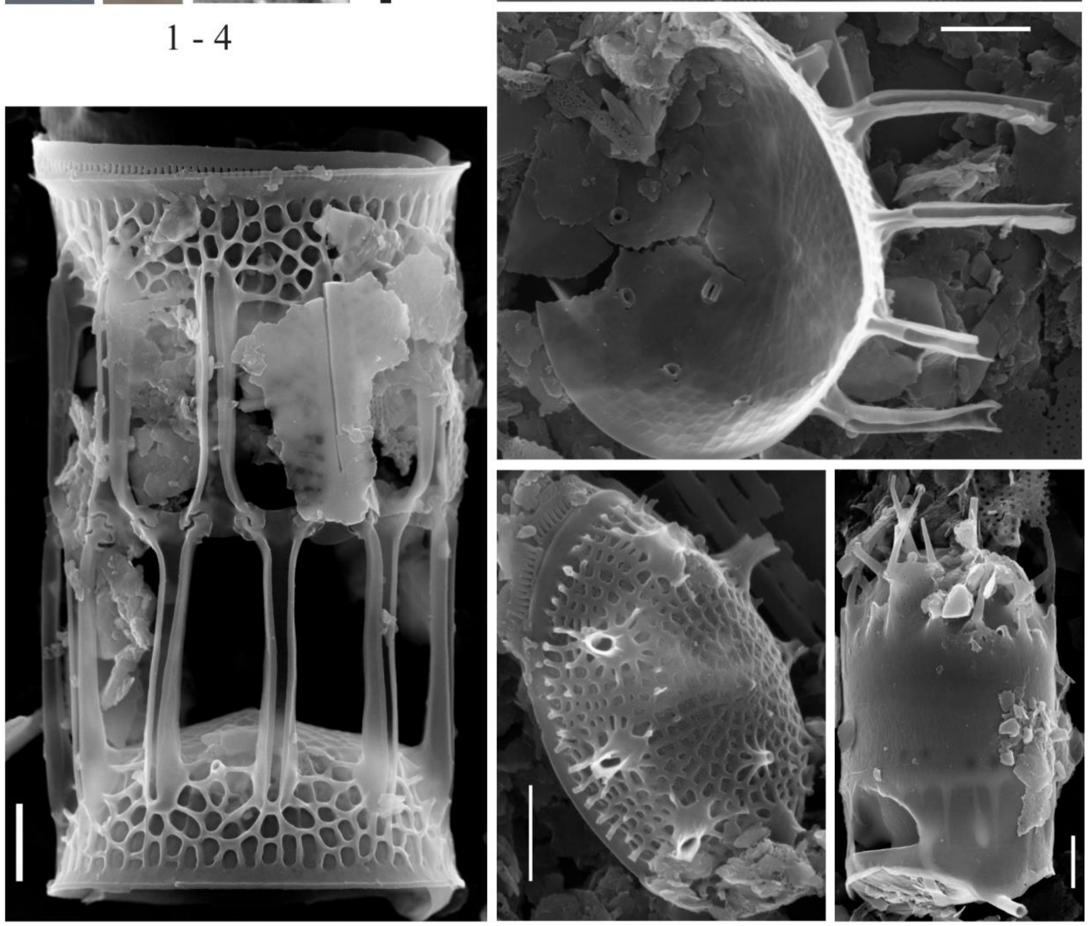
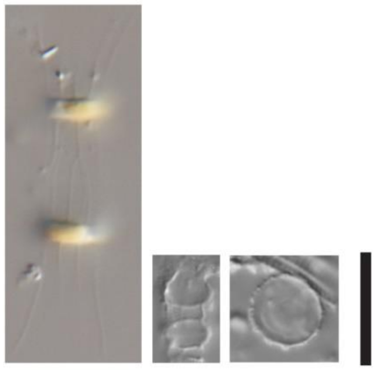


5- 9

Plate 33 (Scale bars: Figs 1-3=10 µm; Figs 4-9 =1 µm)

Skeletonema menzelii Guillard, Carpenter & Reimer
Lit.: Guillard, Carpenter & Reimer, 1974, v. 13: p. 131

Fig. 1: Barnegat Bay, NJ.
Fig. 2: Sample COAST004, Peconic Bay, NY.
Fig. 3: Sample COAST051, Barnegat Bay, NJ.
Fig. 4: Sample COAST073, North East, New Jersey shore.
Fig 5-6: Sample COAST071, North East, New Jersey shore.
Fig 7-9: Sample RUGT0549, Fortescue, New Jersey.



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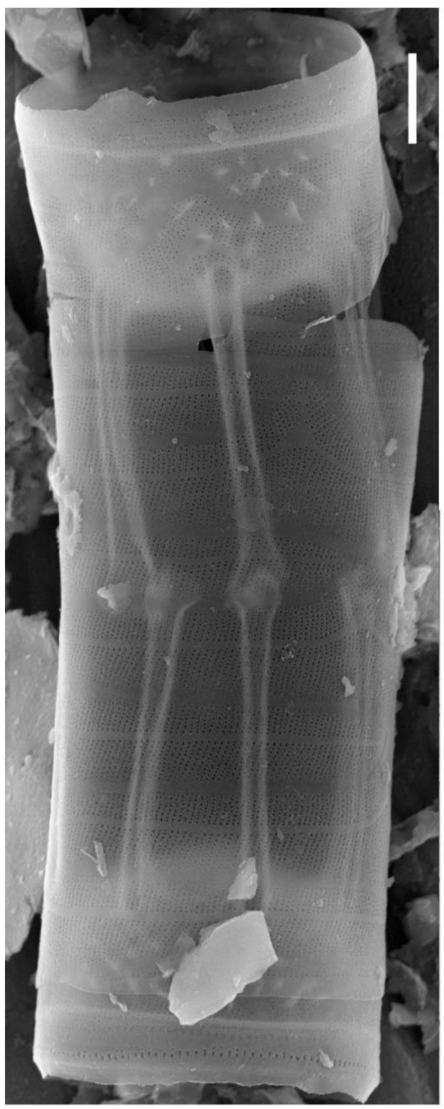
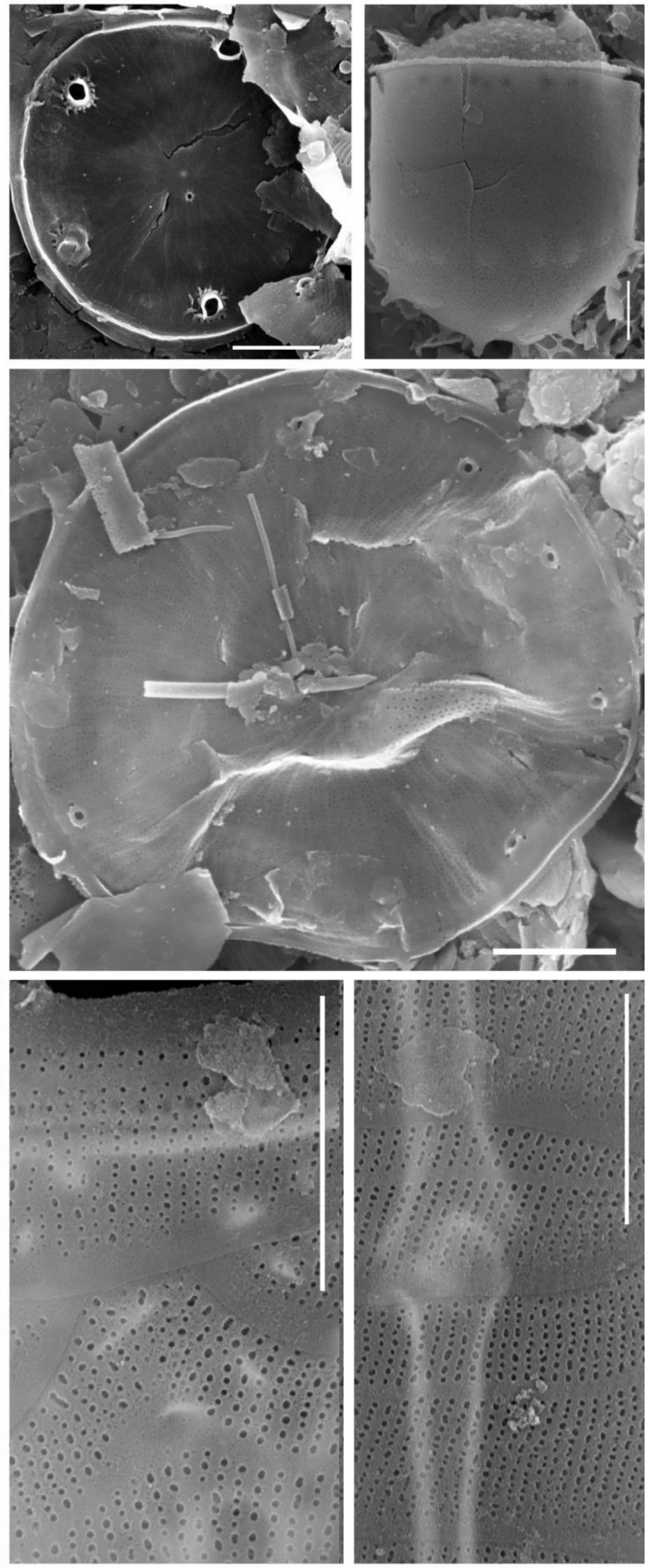




4 - 9

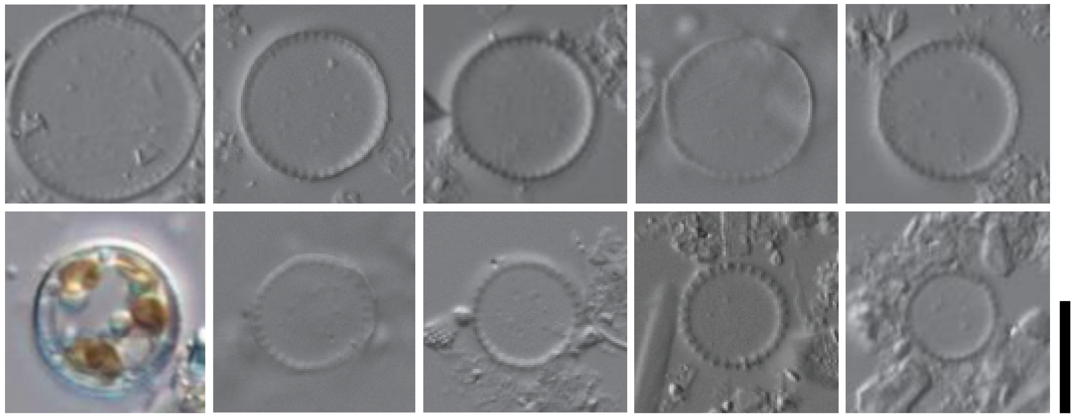
Plate 34 (Scale bars: Figs 1-10=10 µm; Figs 11-18=1 µm)

Conticribra guillardii (Hasle) Stachura-Suchoples & Williams

Lit.: Stachura-Suchoples & Williams 2009, p. 482

Basionym: *Thalassiosira guillardii* Hasle 1978

Figs 1,4,7-8,10: Sample RUTG0804, Cape May, NJ.
Figs 2-3,5,9: Sample RUTG0805, Cape May, NJ.
Fig. 6: Sample RUTG0831, Cheesequake State Park, NJ.
Figs 11-12, 15: Sample RUTG0803, Cape May, NJ.
Fig. 13, 17-18: Sample COAST071, North East, NJ shore.
Fig. 14: Sample RUTG0825, Cheesequake State Park, NJ.
Fig. 16: Sample RUTG0811, Cape May, NJ.



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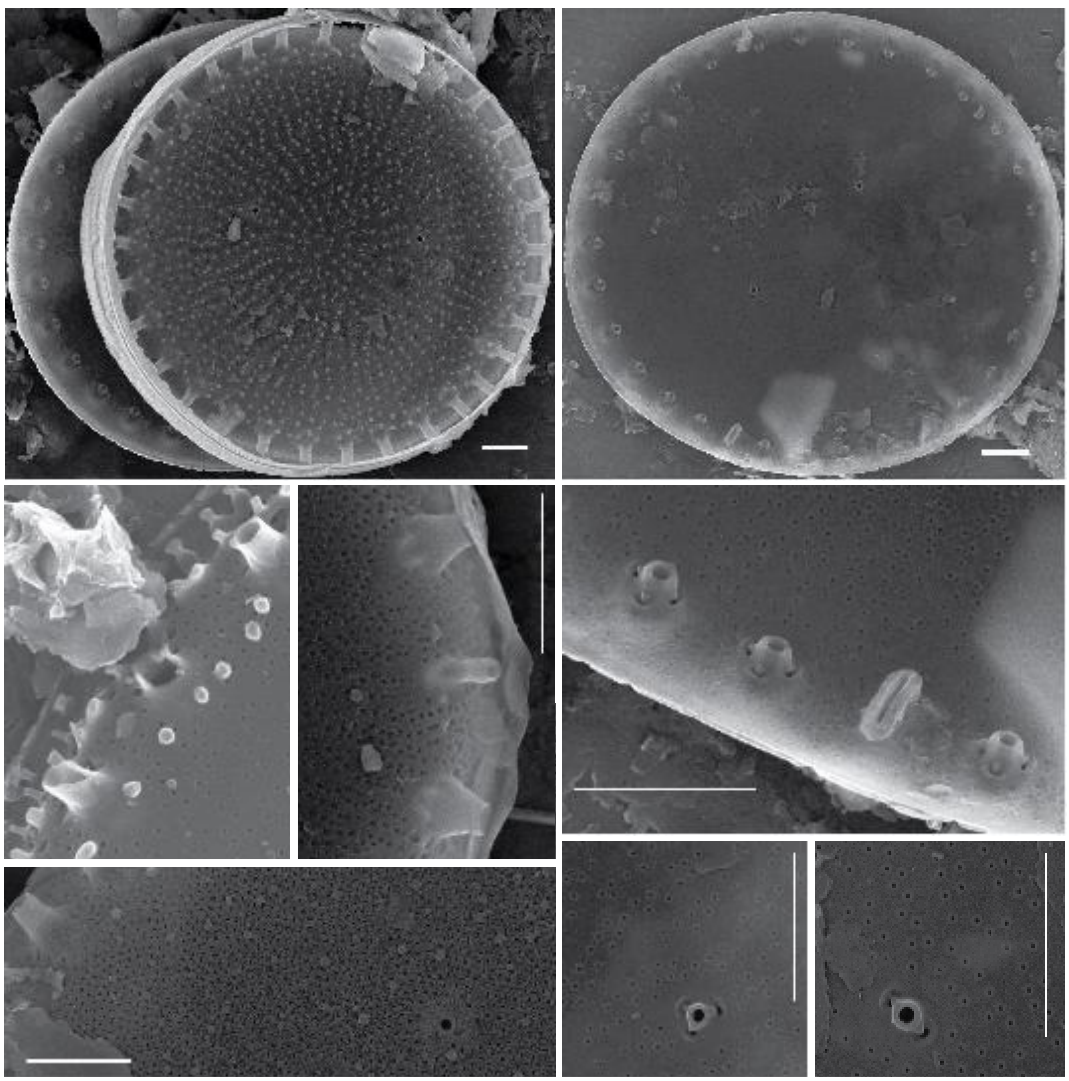


11 - 18

Plate 35 (Scale bars: Figs 1-2=10 μm; Fig 3-6=1 μm)

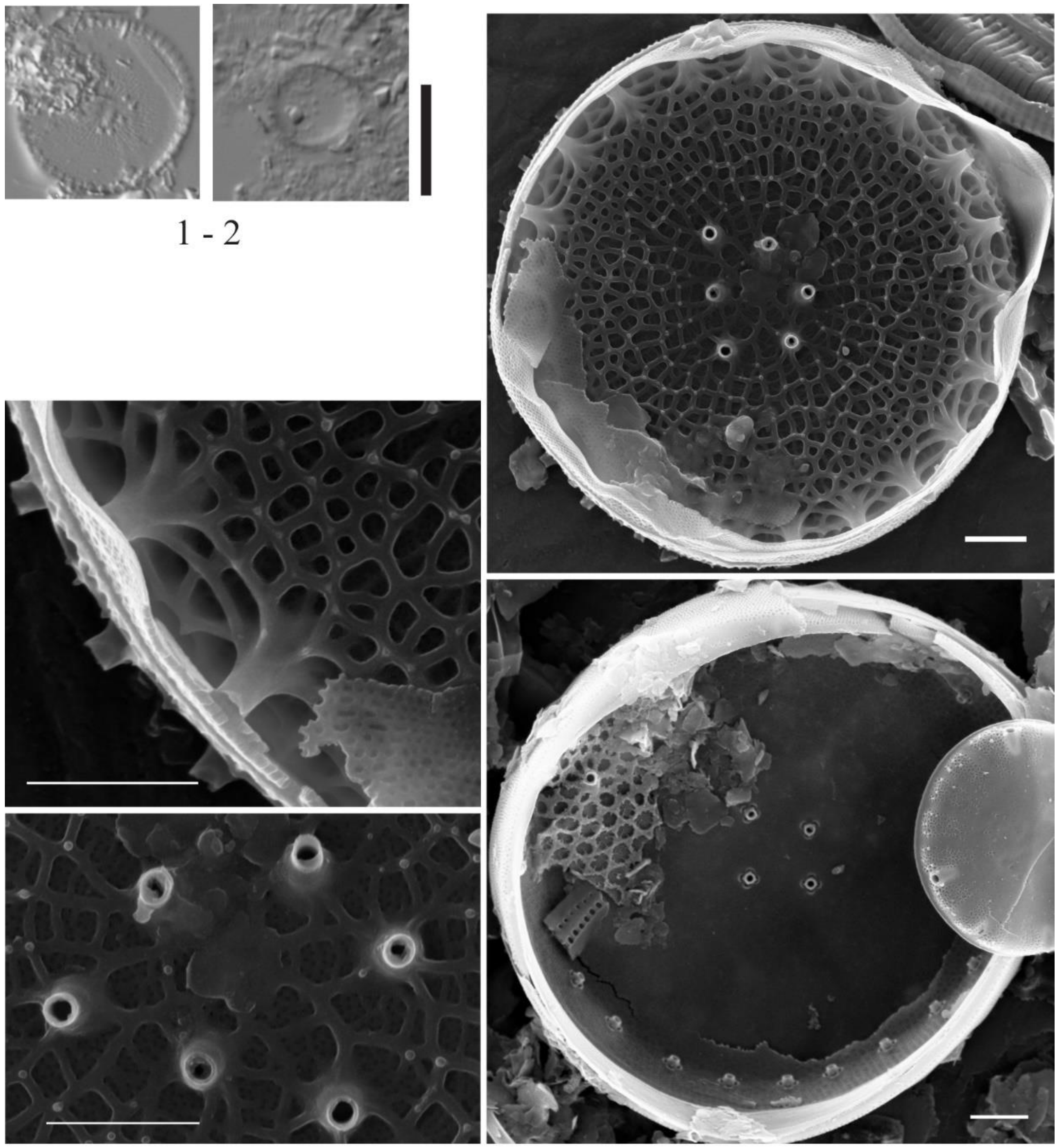
Conticribra weissflogii (Grunow) Stachura-Suchoples & Williams

Lit.: Stachura-Suchoples & Williams 2009, p. 482

Basionym: *Eupodiscus weissflogii* Grunow in Van Heurck 1882-1885

Synonyms: *Micropodiscus weissflogii* Grunow in Van Heurck 1882-1885
Eupodiscus weissflogii (Grunow in Van Heurck) De Toni 1894
Thalassiosira weissflogii (Grunow) G. Fryxell & Hasle 1977
Micropodiscus weissflogii (Grunow in Van Heurck) Grunow in Van Heurck 1885

Fig. 1: Sample BBDC0049, Barnegat Bay, NJ.
Fig. 2: Sample BB0073, Barnegat Bay, NJ.
Figs 3-6: Sample BBDC0071, Barnegat Bay, NJ.



1 - 2

3 - 6

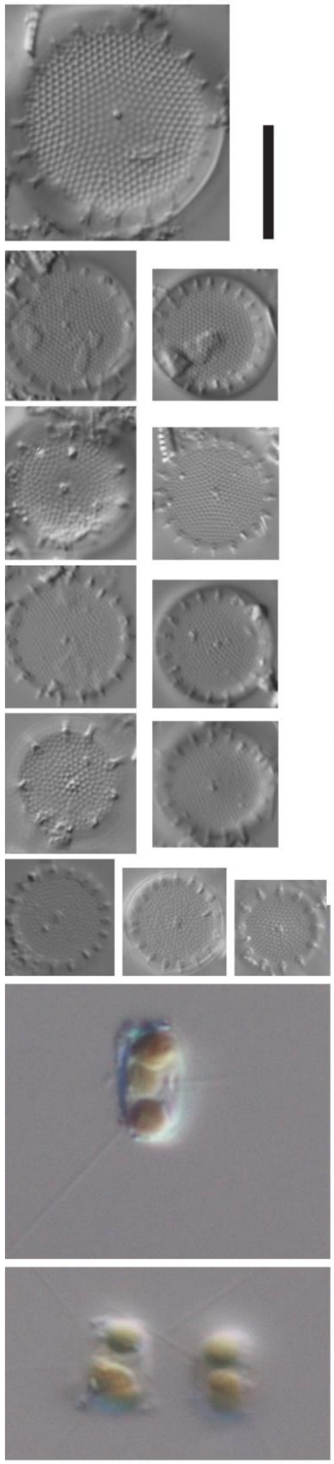
Plate 36 (Scale bars: Figs 1-12=10 µm; Fig 13-14=1 µm)

Thalassiosira nordenskioeldii Cleve

Lit.: Cleve 1873, p. 7; pl. 1, fig. 1

Synonym: *Coscinodiscus nordenskioeldii* (Cleve) Cleve-Euler 1951

Fig. 1: Sample RUTG0842, Leeds Point, NJ.
Figs 2-3,5-7,9,12: Sample COAST003, Peconic Bay, NY.
Figs 4: Sample GB001, Great Bay, NJ.
Fig. 8: Sample COAST015, Great South Bay, NY.
Fig. 10: Sample BBDC0080, Barnegat Bay, NJ.
Fig. 11: Sample COAST004, Peconic Bay, NY.
Figs 13-14: Barnegat Bay, NJ.
Fig. 15: Sample COAST054, Barnegat Bay, NJ.
Fig. 16: Sample COAST002, Peconic Bay, NY.



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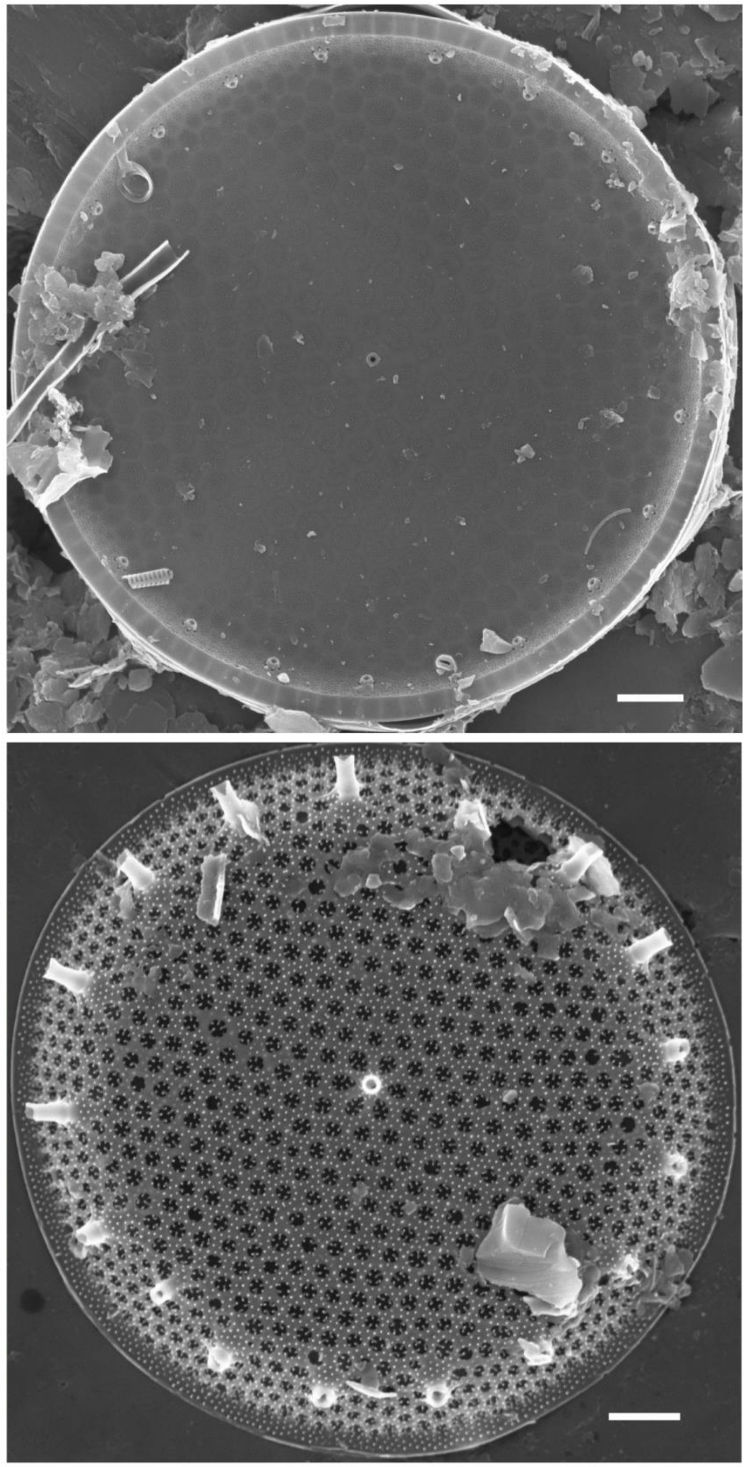


15 - 16

Plate 37 (Scale bars: Figs 1-5=10 μm; Fig 6-7=1 μm)

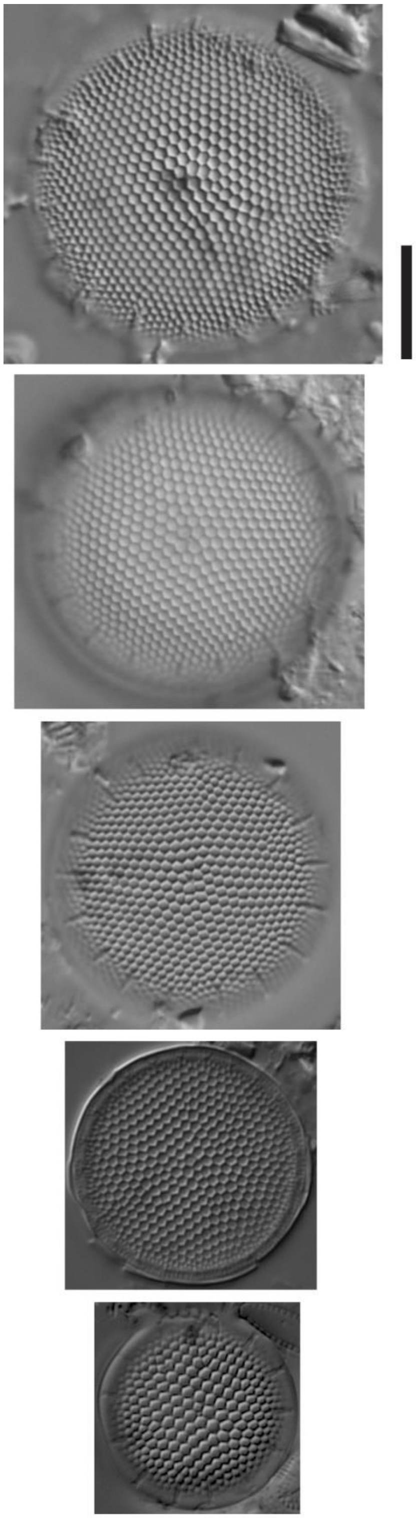
Thalassiosira angulata (Gregory) Hasle

Lit.: Hasle 1978, p. 93; fig. 4, 41, 70-99

Basionym: *Orthosira angulata* Gregory 1857

Synonyms: *Melosira angulata* (Gregory) Rabenhorst 1864
Lysigonium angulatum (Gregory) Kuntze 1891

Figs 1-3: Sample BBDC0080, Barnegat Bay, NJ.
Fig. 4: Sample BBDC0009, Barnegat Bay, NJ.
Fig. 5: Sample BBDC0007, Barnegat Bay, NJ.
Figs 6-7: Barnegat Bay, NJ.



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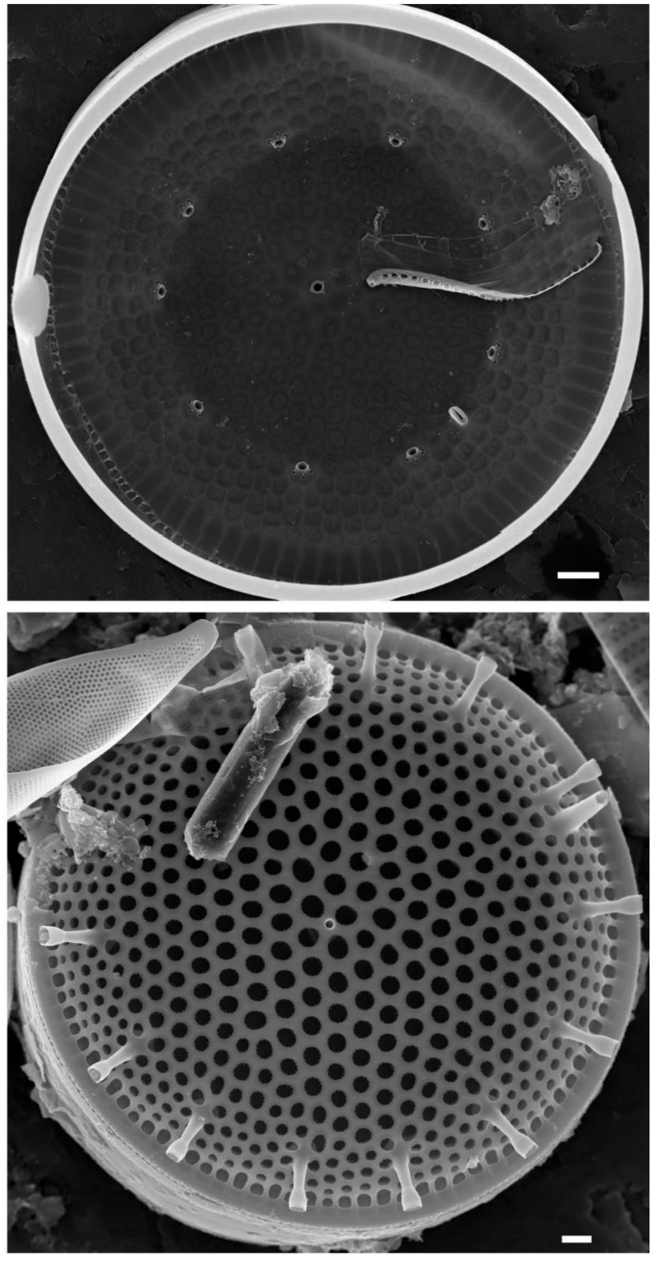


6 - 7

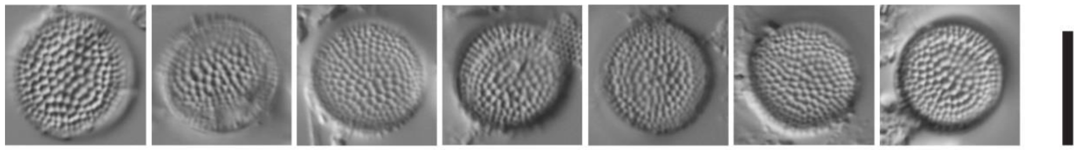
Plate 38 (Scale bars: Figs 1-26=10 µm)

Figs 1-7: ***Thalassiosira cedarkeyansis*** Prasad in Prasad, Fryxell & Livingston
Lit.: Prasad, Fryxell & Livingston 1993, p. 205-206; fig. 3-23
Figs 1,6: Sample RUTG0842, Leeds Point, NJ.
Figs 2-5: Sample BBDC0104, Great Bay, NJ.
Fig. 7: Sample BBDC0064, Barnegat Bay, NJ.

Figs 8-15: ***Thalassiosira tenera*** Proschkina-Lavrenko
Lit.: Proschkina-Lavrenko 1961, p. 33; pl. 1, fig. 1-4, pl. 2, fig. 5-7
Figs 8-9: Sample BBDC0080, Barnegat Bay, NJ.
Figs 10-12,15: Sample RUTG0005, Cape May Courthouse, NJ.
Fig. 13: Sample BBDC0044, Barnegat Bay, NJ.
Fig. 14: Sample BBDC0048, Barnegat Bay, NJ.
Fig. 16: Sample RUTG0619, Sea Breeze, NJ.

Figs 16-17: ***Thalassiosira nanolineata*** (Mann) Fryxell & Hasle
Lit.: Fryxell & Hasle 1977, p. 32-33; fig. 74-80
Basionym: *Coscinodiscus nanolineatus 'nano-lineatus'* Mann 1925
Fig. 16: Sample BBDC0048, Barnegat Bay, NJ.
Fig. 17: Sample BBDC0044, Barnegat Bay, NJ.

Figs 18-26: ***Shionodiscus oestrupii*** (Ostenfeld) Alverson, Kang & Theriot
Lit.: Alverson, Kang & Theriot 2006, p. 258
Basionym: *Coscinosira oestrupii* Ostenfeld 1900
Synonyms: *Thalassiosira oestrupii* (Ostenfeld) Proschkina-Lavrenko ex Hasle 1960
Thalassiosira oestrupii (Ostenfeld) Hasle 1972
Fig. 18: Sample BBDC0067, Barnegat Bay, NJ.
Fig. 19: Sample BB0061, Barnegat Bay, NJ.
Fig. 20: Sample BB0052, Barnegat Bay, NJ.
Fig. 21: Sample BB0076, Barnegat Bay, NJ.
Fig. 22: Sample BB0068, Barnegat Bay, NJ.
Fig. 23: Sample COAST062, Great Bay, NJ.
Fig. 24: Sample BB0067, Barnegat Bay, NJ.
Fig. 25: Sample BBDC0060, Barnegat Bay, NJ.
Fig. 26: Sample COAST015, Great South Bay, NY.



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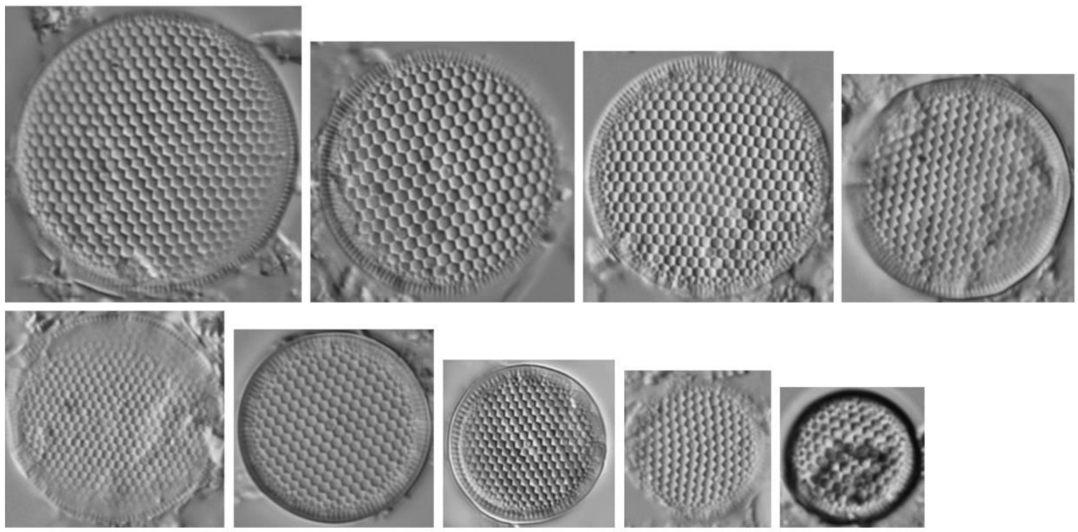
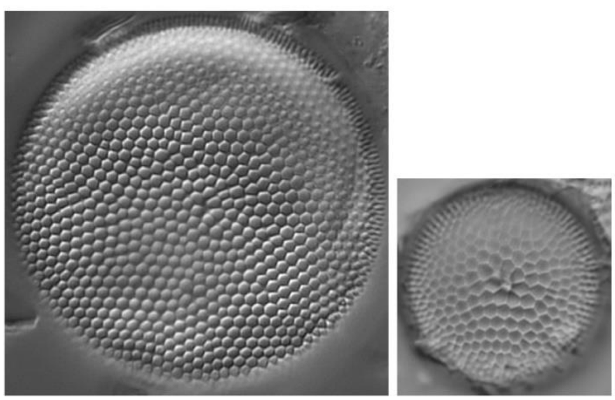
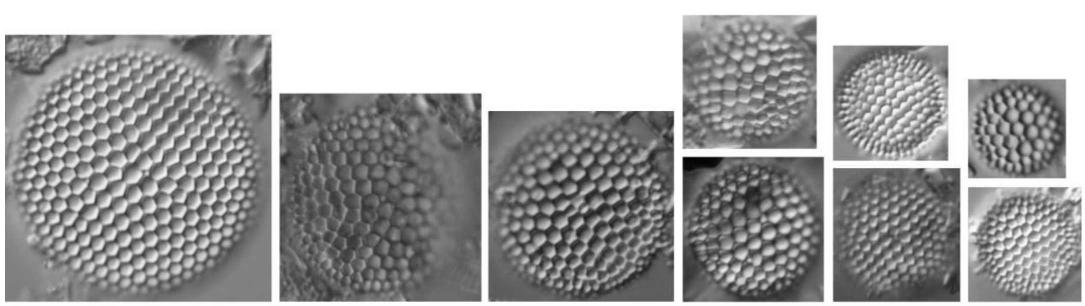


8 - 15



16 - 17



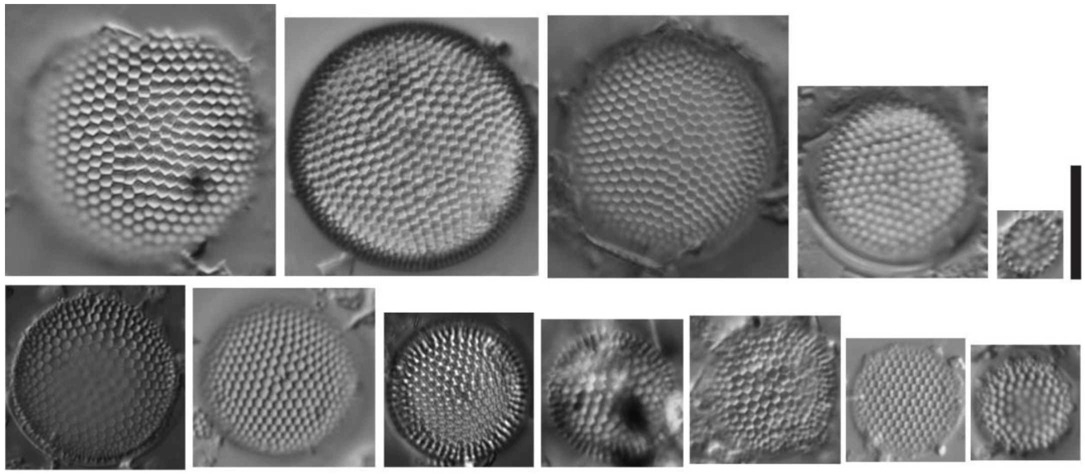
18 - 26

Plate 39 (Scale bars: Figs 1-12=10 µm; Fig. 13=1 µm)

Thalassiosira concaviuscula Makarova

Lit.: Makarova 1978, p. 222-223; pl. 1, fig. 1-11

Fig. 1: Sample BB0068, Barnegat Bay, NJ.
Fig. 2: Sample BBDC0044, Barnegat Bay, NJ.
Fig. 3: Sample BBDC0002, Barnegat Bay, NJ.
Fig. 4: Sample BB0004, Barnegat Bay, NJ.
Fig. 5: Sample BBDC0045, Barnegat Bay, NJ.
Fig. 6: Sample BBDC0003, Barnegat Bay, NJ.
Fig. 7: Sample BBDC0080, Barnegat Bay, NJ.
Fig. 8: Sample BBDC0001, Barnegat Bay, NJ.
Fig. 9: Sample BB0071, Barnegat Bay, NJ.
Fig. 10: Sample BB0066, Barnegat Bay, NJ.
Fig. 11: Sample COAST012, Great South Bay, NY.
Figs 12-13: Sample BBDC0065, Barnegat Bay, NJ.



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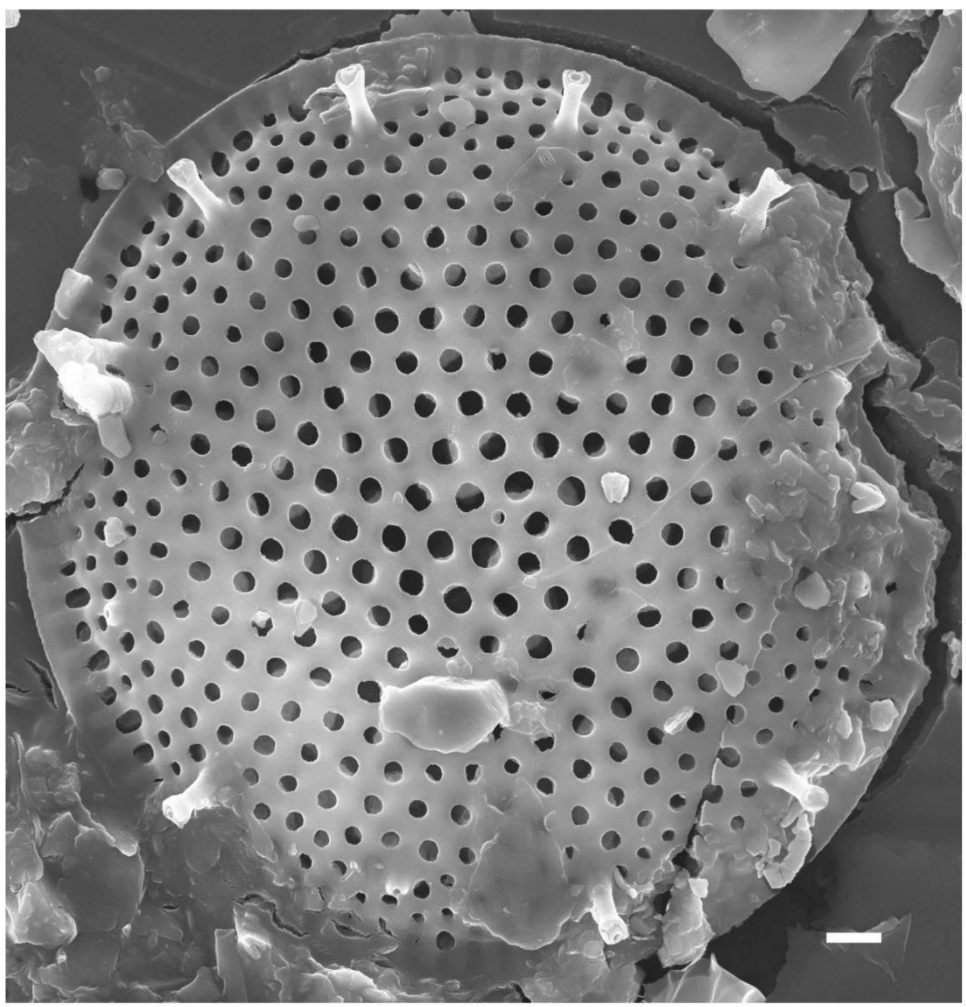


13

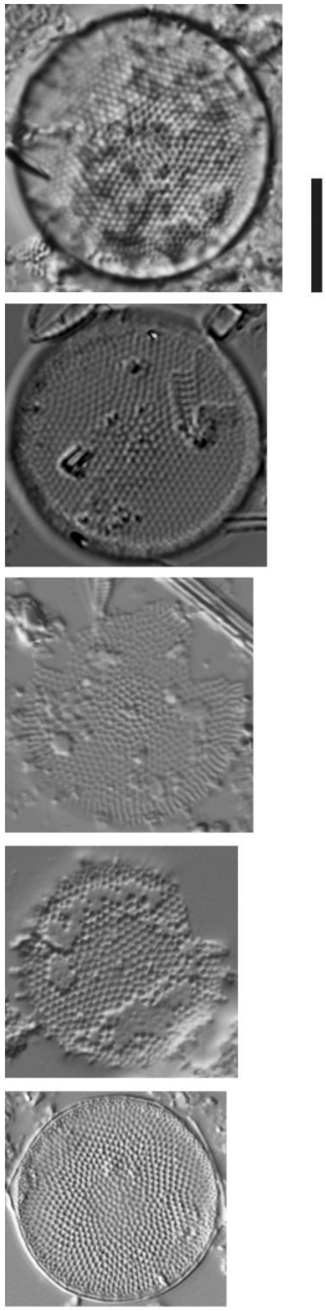
Plate 40 (Scale bar: Figs 1-7=10 μm)

Thalassiosira levanderi Van Goor

Lit.: Van Goor 1924, p. 322; fig. 11

Synonyms: *Coscinodiscus levanderi* (Van Goor) Cleve-Euler 1951
Thalassiosira decipiens f. *levanderi* (Van Goor) Takano 1956

Figs 1,4: Sample BBDC0044, Barnegat Bay, NJ.
Fig. 2: Sample BBDC0001, Barnegat Bay, NJ.
Fig. 3: Sample COAST053, Barnegat Bay, NJ.
Fig. 5: Sample BBDC0048, Barnegat Bay, NJ.
Fig. 6: Sample COAST015, Great South Bay, NY.
Fig. 7: Sample COAST054, Barnegat Bay, NY.



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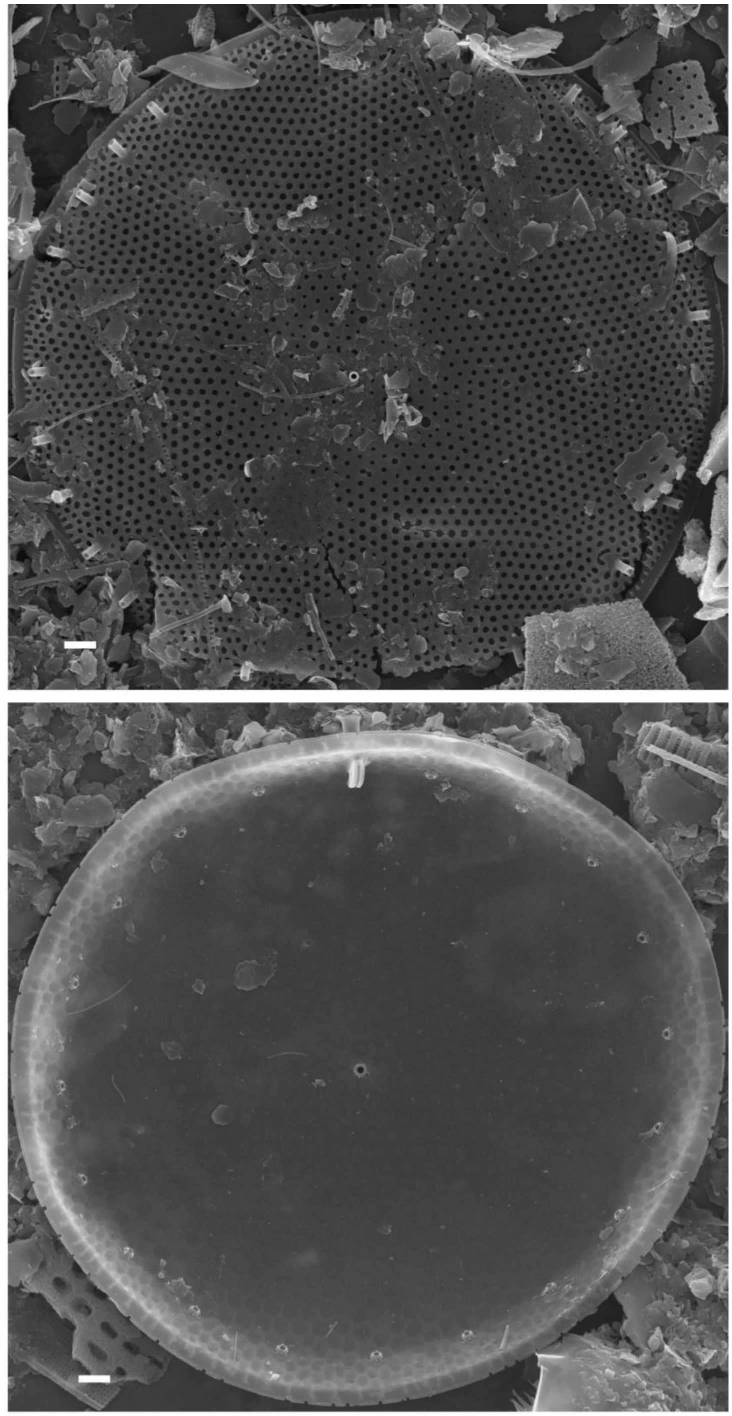


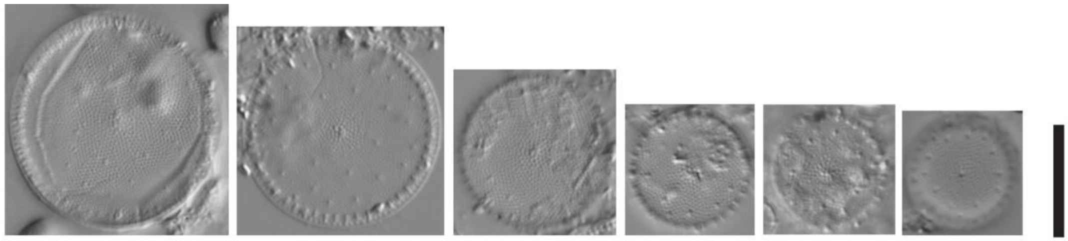
6 - 7

Plate 41 (Scale bar: Figs 1-6=10 µm, Figs 7-11=1 µm)

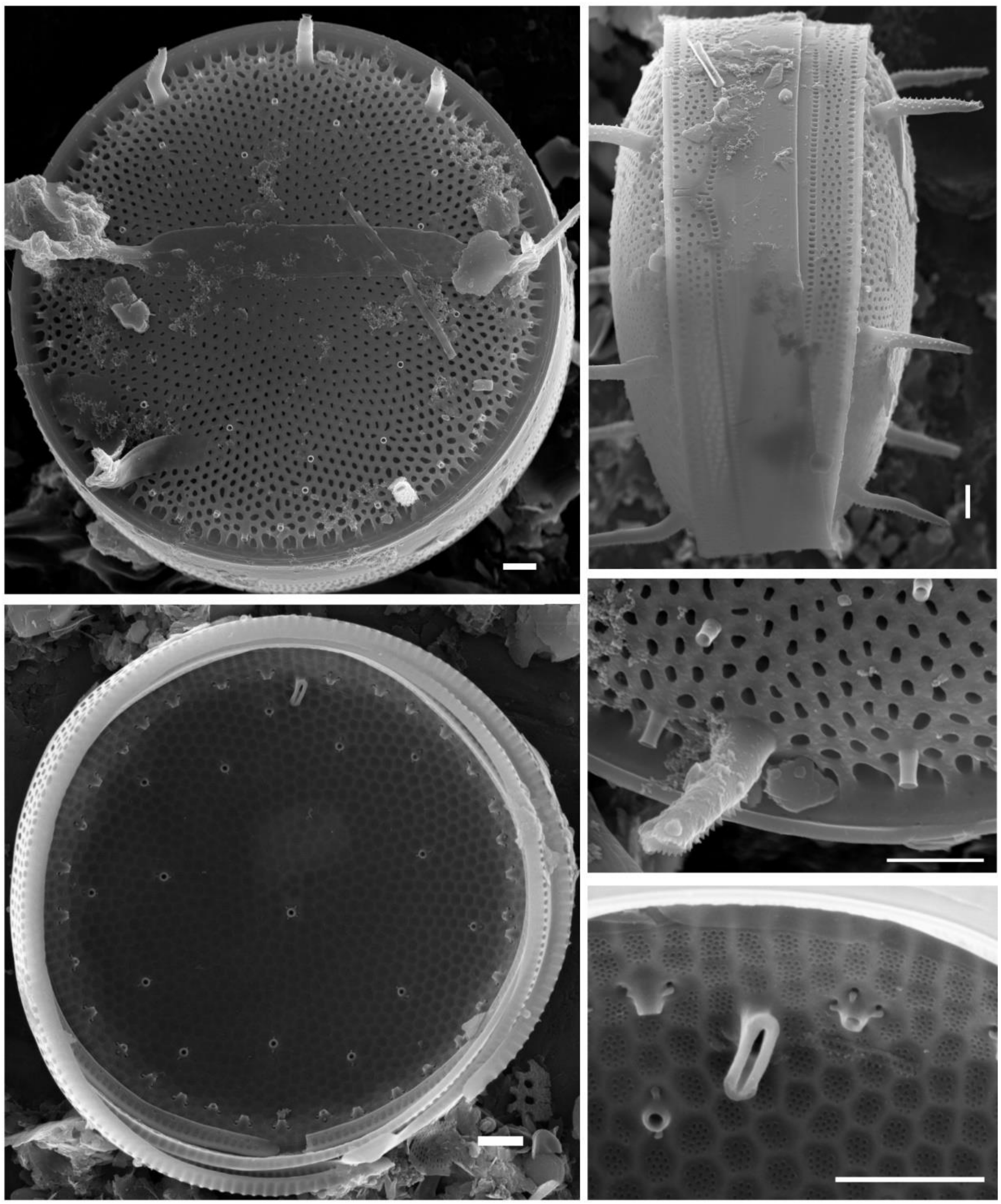
Thalassiosira lundiana Fryxell

Lit.: Fryxell 1975, p. 64-65; text fig. 2A, fig. 14-24

Fig. 1: Sample BBDC0088, Barnegat Bay, NJ.
Fig. 2: Sample COAST031, Western Bay Bay, NY.
Figs 3-4: Sample COAST025, Great South Bay, NY.
Fig. 5: Sample COAST071, North East, New Jersey shore.
Fig. 6: Sample BBDC0045, Barnegat Bay, NJ.
Figs 7-11: Barnegat Bay, NJ.



1 - 6



7 - 11

Plate 42 (Scale bars: Figs 1-8=10 µm, Fig. 8=1µm)

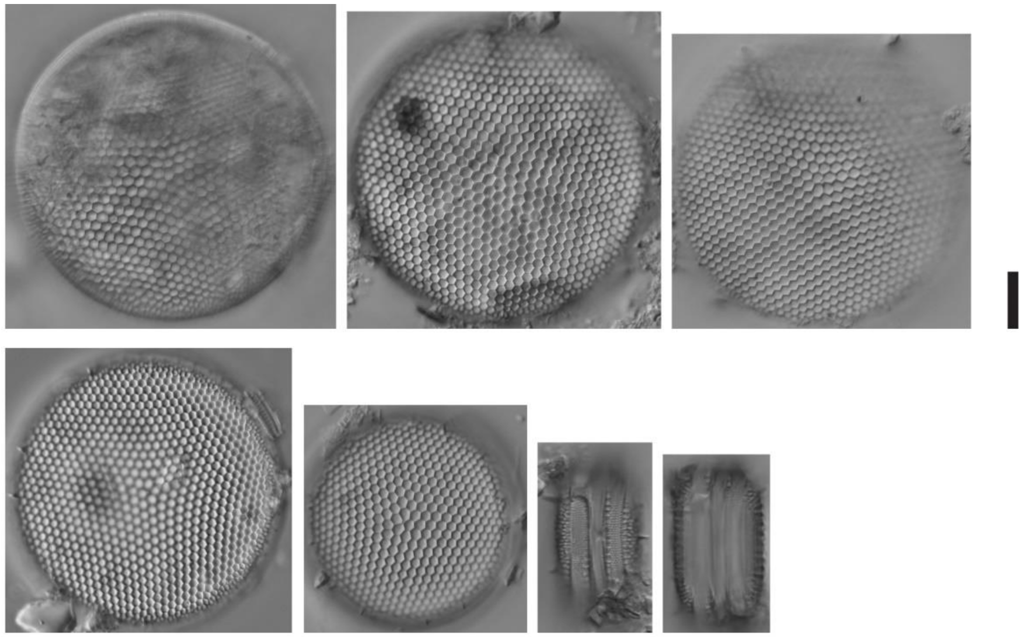
Thalassiosira eccentrica (Ehrenberg) Cleve emend Fryxell & Hasle

Lit.: Fryxell & Hasle 1972, v. 8(4): p. 302; fig. 1-18

Figs 1-2,4,6-8: Sample BBDC0044, Barnegat Bay, NJ.

Fig. 3: Sample BBDC0072, Barnegat Bay, NJ.

Fig. 5: Sample BBDC0051, Barnegat Bay, NJ.



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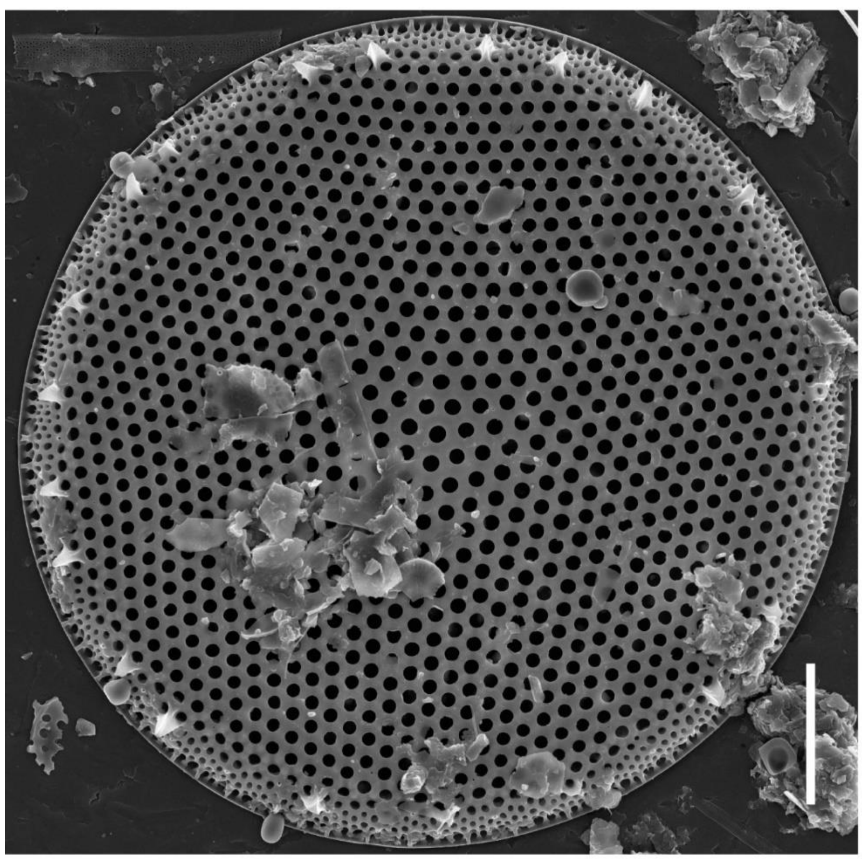


8

Plate 43 (Scale bars: Figs 1-11,14=10 µm; Figs 12-13,15-16=1 µm)

Fig. 1: ***Shionodiscus* cf. *oestrupii***

Fig. 1: Sample BBDC0044, Barnegat Bay, NJ.

Figs 2-7: ***Thalassiosira* cf. *levanderi***

Figs 2,6: Sample BBDC0045, Barnegat Bay, NJ.
Fig. 3: Sample BBDC0072, Barnegat Bay, NJ.
Fig. 4: Sample BBDC0002, Barnegat Bay, NJ.
Fig. 5: Sample COAST054, Barnegat Bay, NJ.
Fig. 7: Sample BBDC0051, Barnegat Bay, NJ.

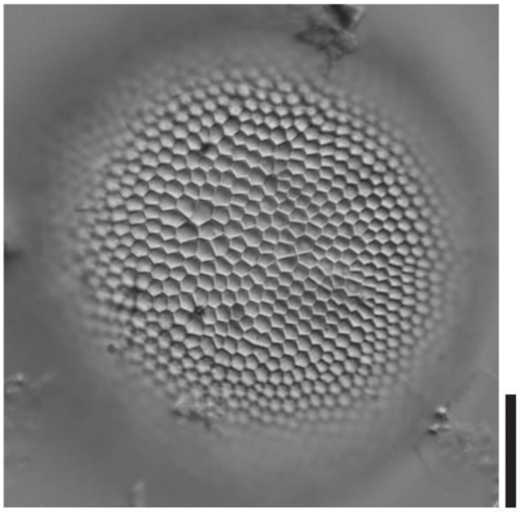
Figs 8-13: ***Thalassiosira curviseriata*** Takano

Lit.: Takano 1981, v. 105: p. 34-35; fig. 1C, 26-38

Figs 8-11: Barnegat Bay, NJ.
Fig. 12: Sample COAST054, Barnegat Bay, NJ.
Fig. 13: Sample COAST096, Cape May Peninsula, NJ.

Figs 14-16: ***Thalassiosira* sp. 2**

Fig. 14: Sample COAST004, Peconic Bay, NY.
Fig. 15: Sample COAST003, Peconic Bay, NY.
Fig. 16: Sample COAST054, Barnegat Bay, NJ.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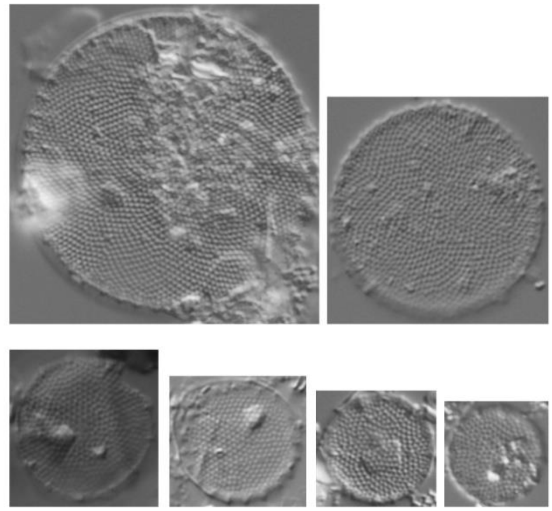
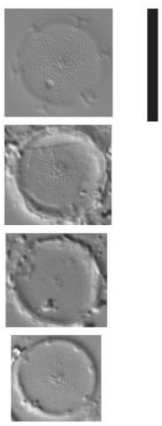
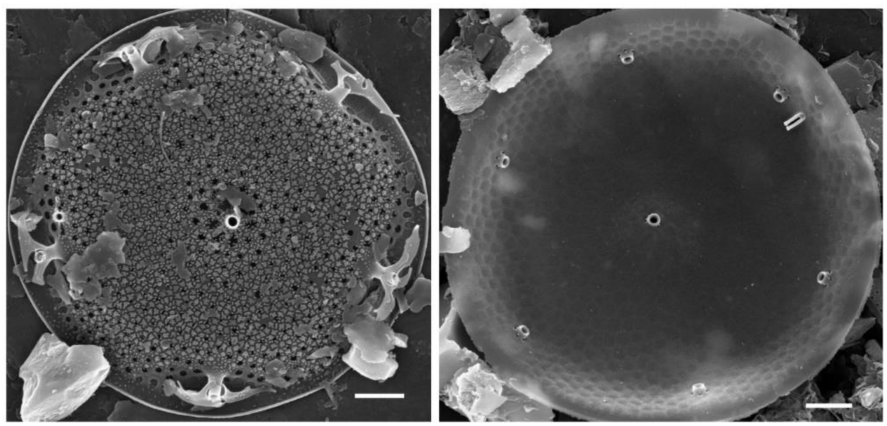
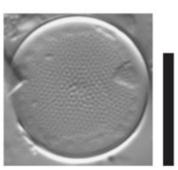

2 - 7


8 - 11


12 - 13


14

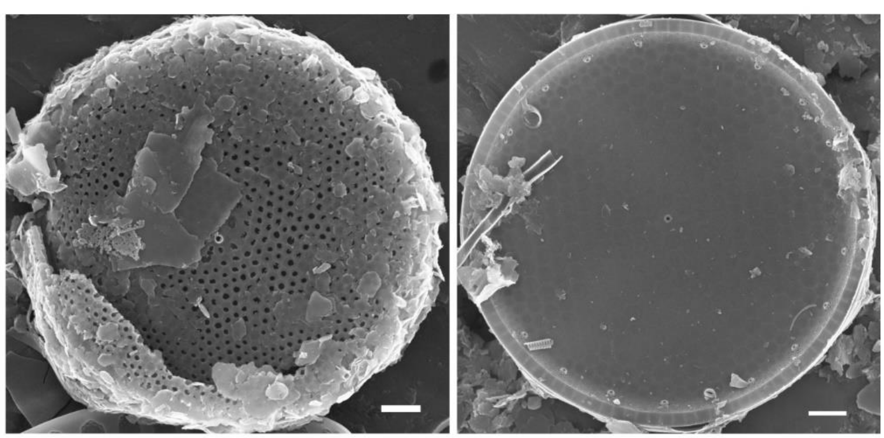

15 - 16

Plate 44 (Scale bar: Figs 1-12=10 µm; Figs 13-15=1 µm)

Thalassiosira gravida Cleve

Lit.: Cleve 1896, p. 12; pl. 2, fig. 14-16

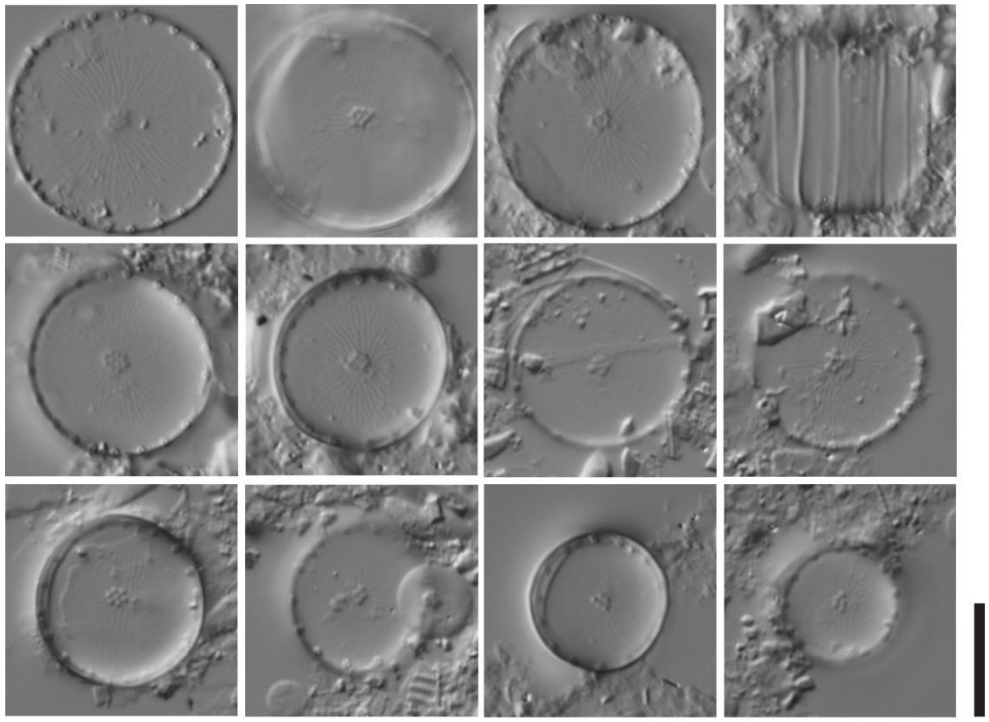
Synonym: *Coscinodiscus gravidus* (Cleve) Cleve-Euler 1951

Figs 1-6,8-12: Sample RUTG0835, Cheesequake State Park, NJ.

Fig. 7: Sample RUTG0843, Leeds Point, NJ.

Fig. 13: Sample BBDC0045, Barnegat Bay, NJ.

Figs 14-15: Barnegat Bay, NJ.



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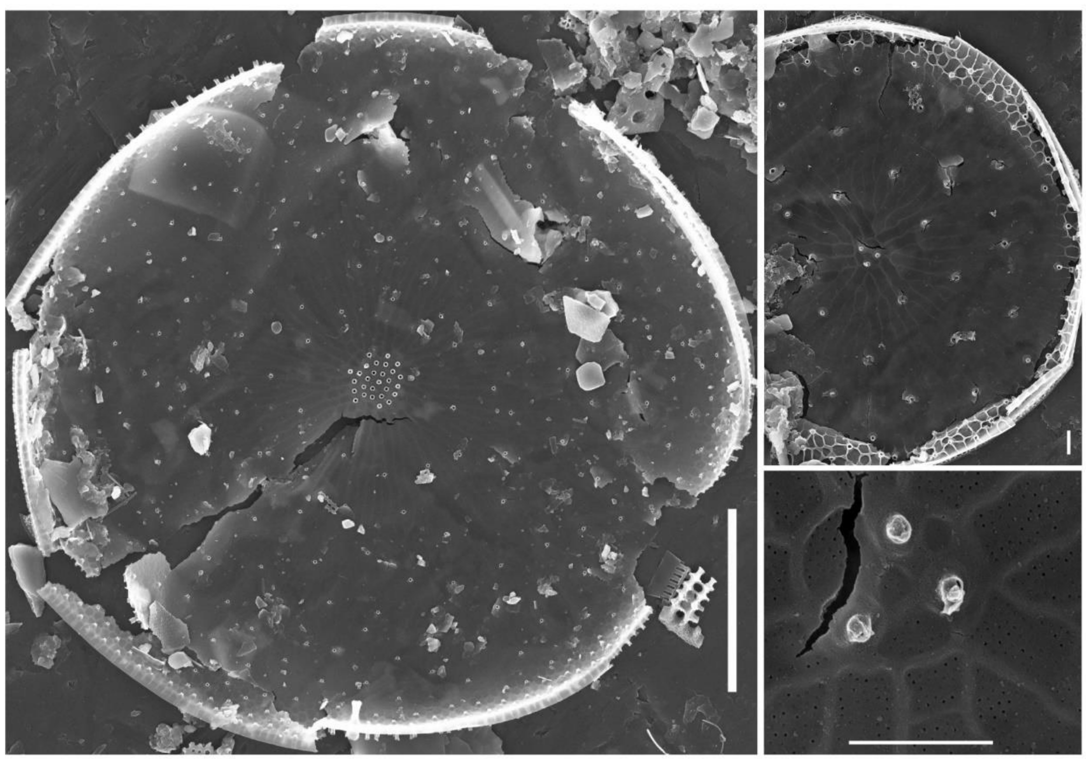


13 - 15

Plate 45 (Scale bars: Figs 1-7=10 µm; Fig 8-11=1 µm)

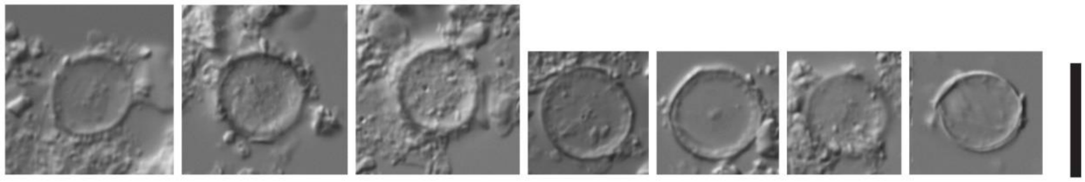
Thalassiosira minima Gaarder emend Hasle

Lit.: Hasle 1980, v. 27(3): p. 167-170; fig. 1-17

Figs 1-7: Sample BBDC0109, Great Bay, NJ.

Figs 8-9,11: Sample BBDC0080, Barnegat Bay, NJ.

Fig. 10: Sample COAST059, Barnegat Bay, NJ.



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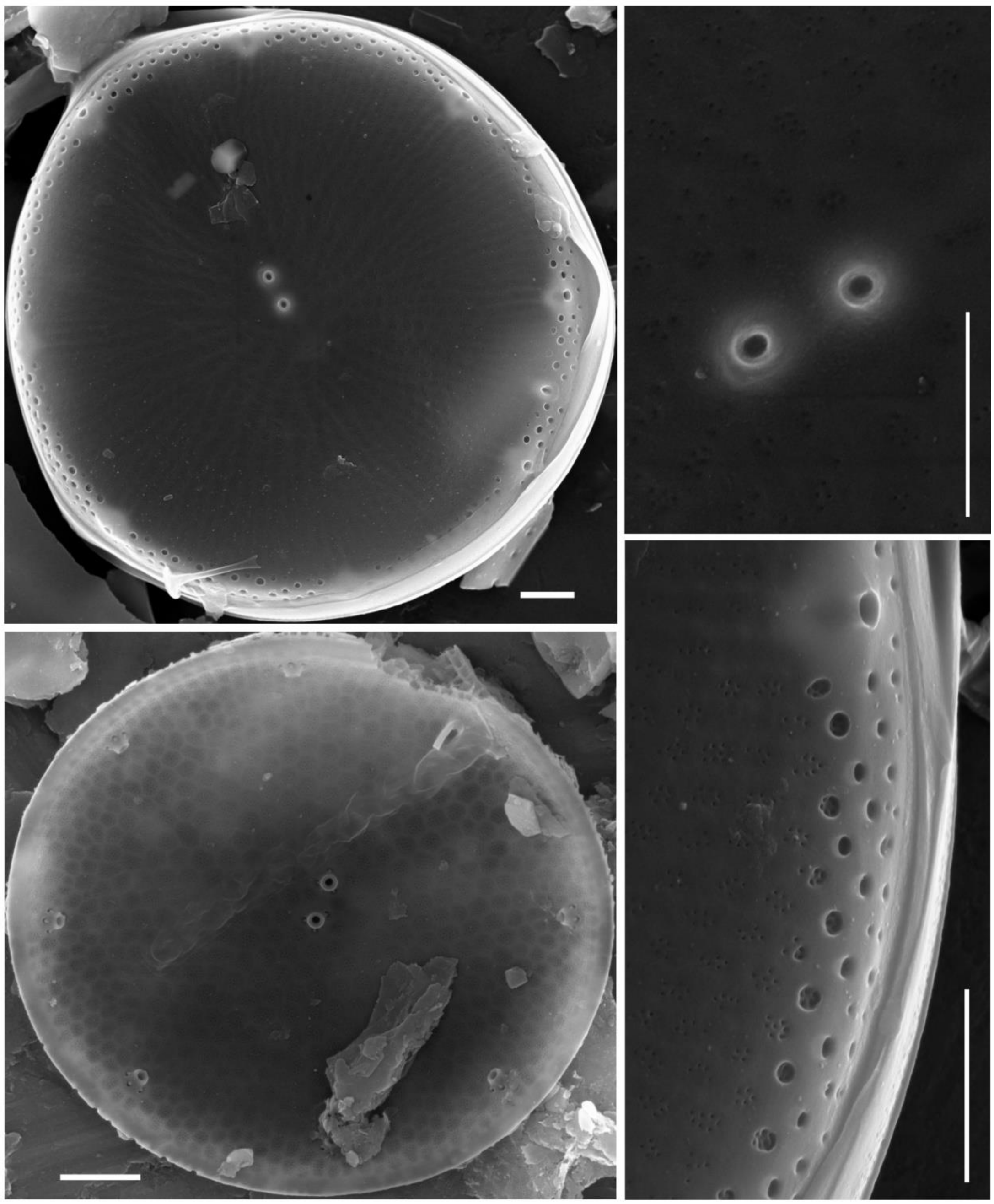


8 - 11

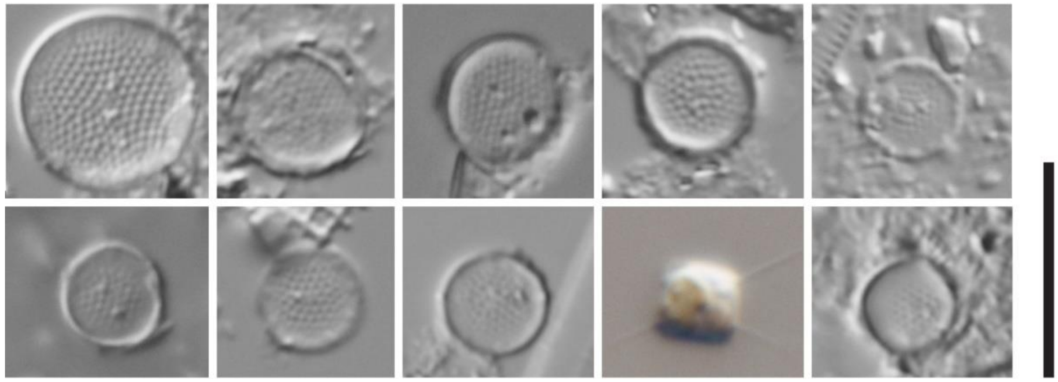
Plate 46 (Scale bars: Figs 1-10=10 µm; Fig 11-14=1 µm)

Minidiscus proschkinae (Makarova) Park & Lee

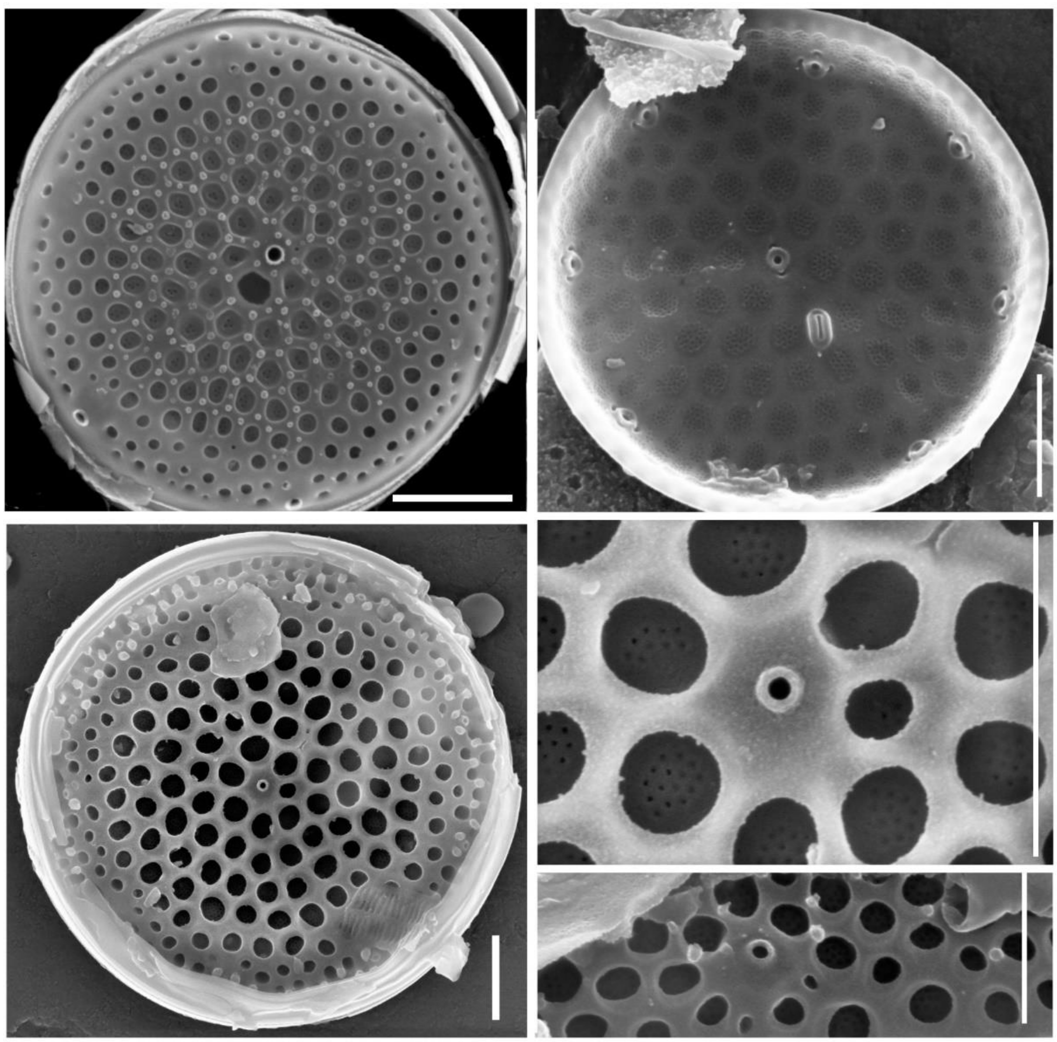
Lit.: Park et al. 2017 p.1-20; fig. 2-5

Basionym: *Thalassiosira proschkinae* Makarova in Makarova, Genkal & Kuzmin 1979

Figs 1, 13-15: Sample BBDC0080, Barnegat Bay, NJ.
Fig. 2,4,8,10: Sample BBDC0044, Barnegat Bay, NJ.
Fig. 3: Sample BBDC0110, Great Bay, NJ.
Fig. 5: Sample COAST051, Barnegat Bay, NJ.
Fig. 6: Sample BB0079, Barnegat Bay, NJ.
Fig. 7: Sample BBDC0045, Barnegat Bay, NJ.
Fig. 9: Barnegat Bay, NJ.
Figs 11-12: Sample COAST025, Great Bay South, NY.



1 - 10



11 - 15

Plate 47 (Scale bar: Figs 1-4=1 µm)

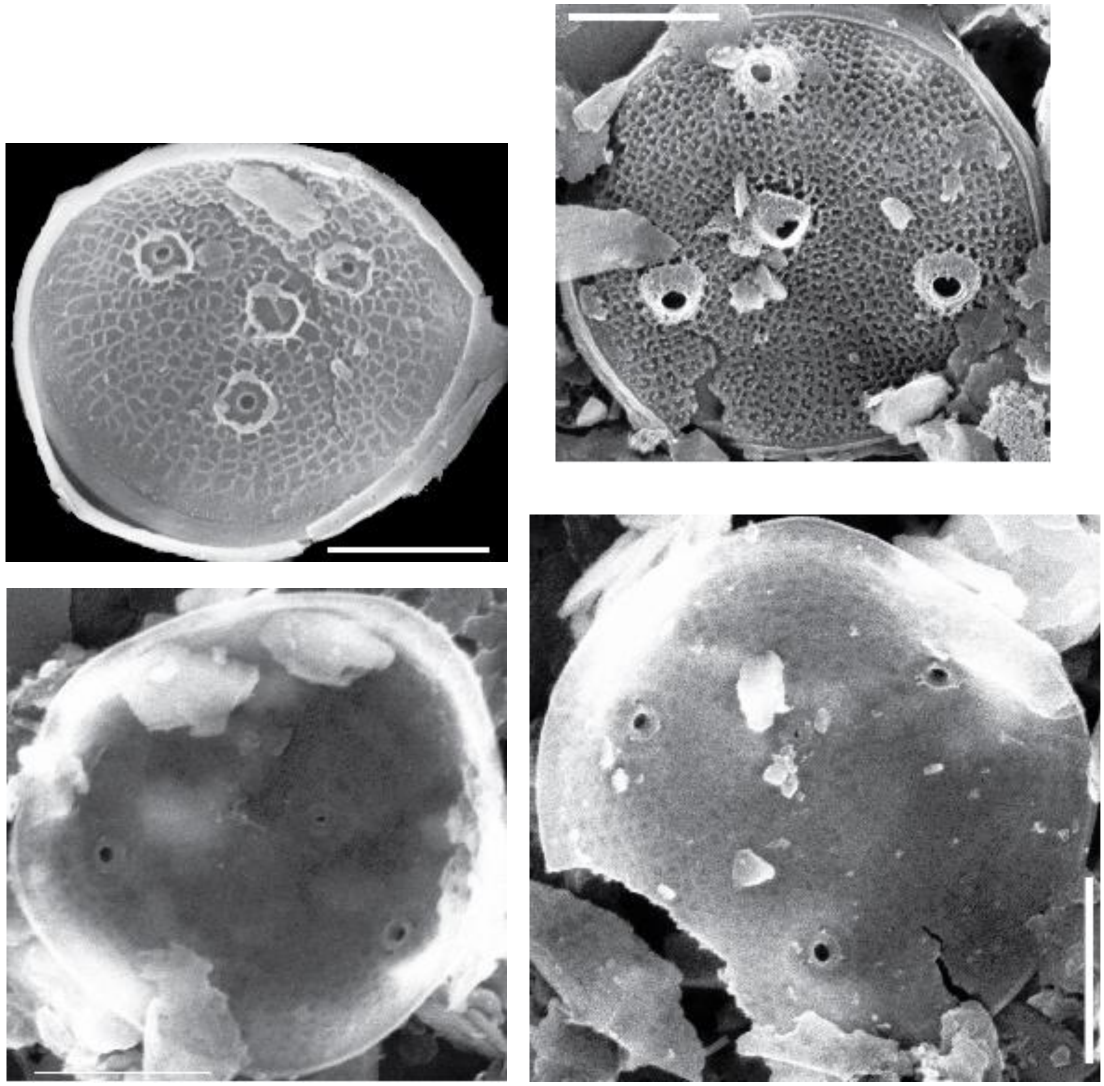
Minidiscus comicus Takano

Lit.: Takano 1981, v. 105: p. 32-33; fig. 1A, 2-13

Fig. 1: Sample COAST071, North East, NJ shore.

Fig. 2: Sample BBEDC027, Tuckerton Bay, NJ.

Figs 3-4: Sample BBEDC026, Tuckerton Bay, NJ.



1 - 4

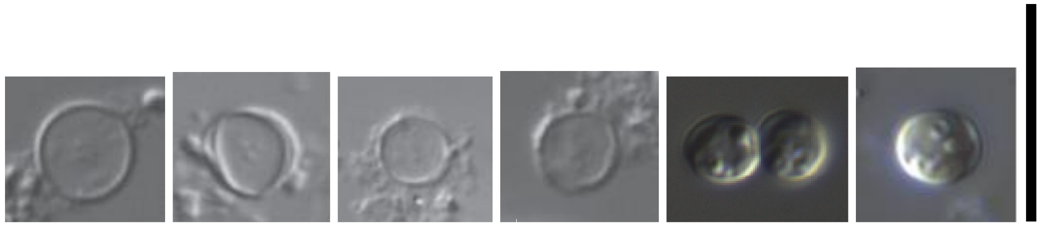
Plate 48 (Scale bars: Figs 1-6=10 µm; Fig 7-12=1 µm)

Minidiscus trioculatus (Taylor) Hasle

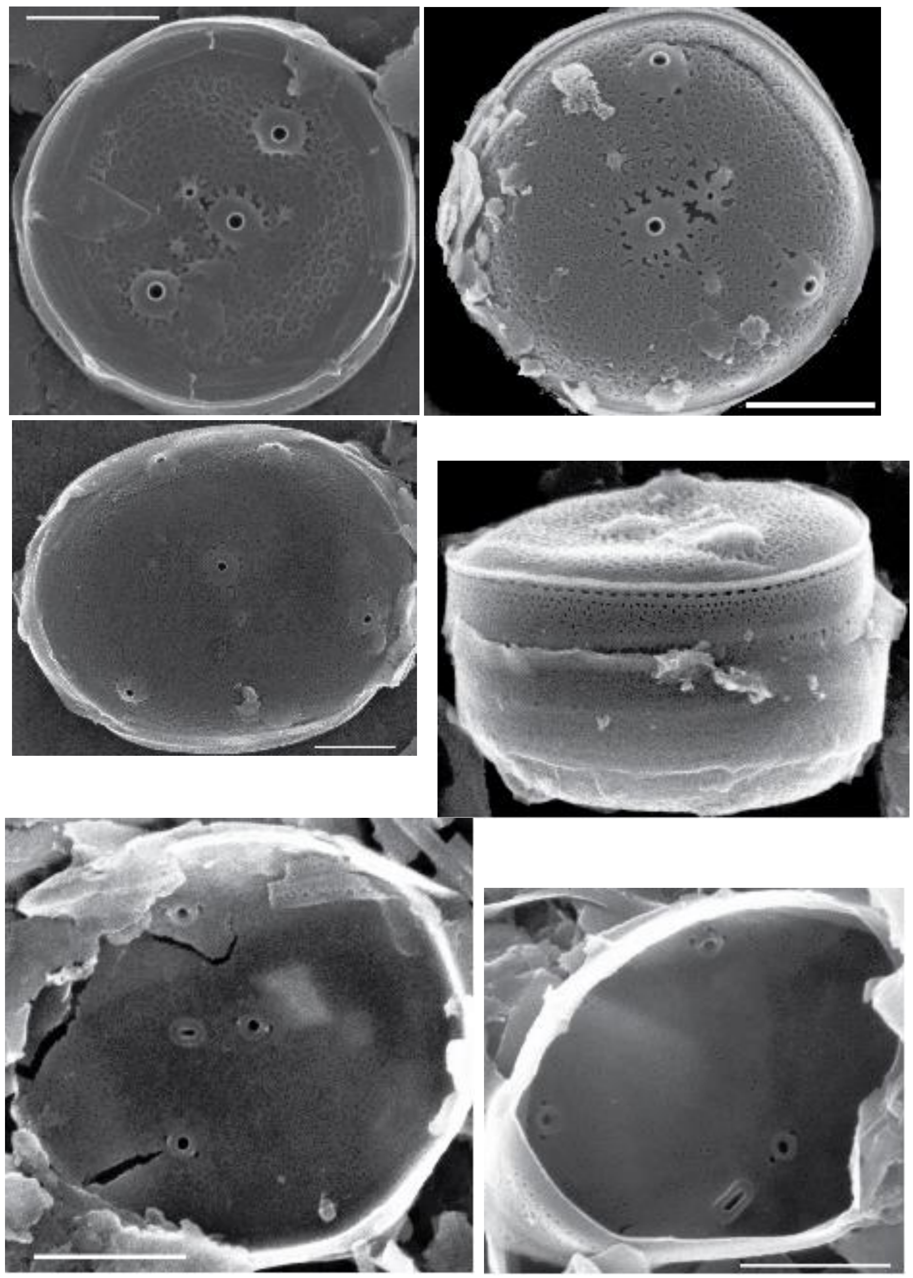
Lit.: Hasle, G.R. 1973, v. 20(1): p. 67-69

Basionym: *Coscinodiscus trioculatus* Taylor 1967

Figs 1,4: Sample BBDC0080, Barnegat Bay, NJ.
Fig. 2: Sample COAST051, Barnegat Bay, NJ.
Fig. 3: Sample COAST007, Peconic Bay, NY.
Figs 5-6: Barnegat Bay, NJ.
Fig. 7: Sample COAST007, Barnegat Bay, NJ.
Fig. 8: Sample COAST096, Grassy Sound, NJ.
Fig. 9: Sample BBDC0030, Barnegat Bay, NJ.
Fig. 10: Sample BBEDC046, Tuckerton Bay, NJ.
Fig. 11: Sample BBEDC026, Tuckerton Bay, NJ.
Fig. 12: Sample COAST011, Great South Bay, NY.



1 - 6



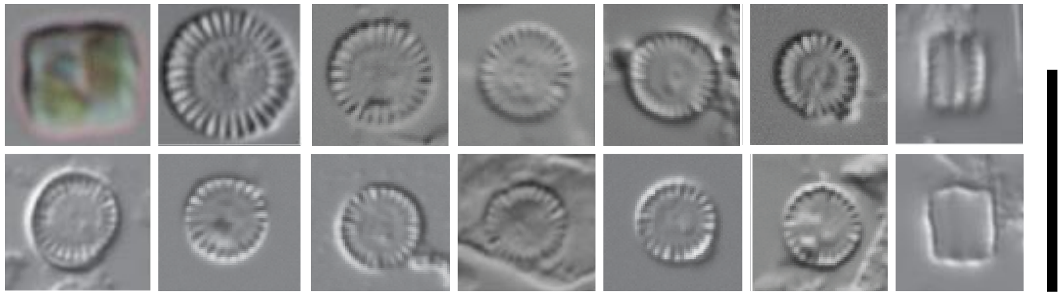
7 - 12

Plate 49 (Scale bars: Figs 1-14=10 µm; Figs 15-21=1 µm)

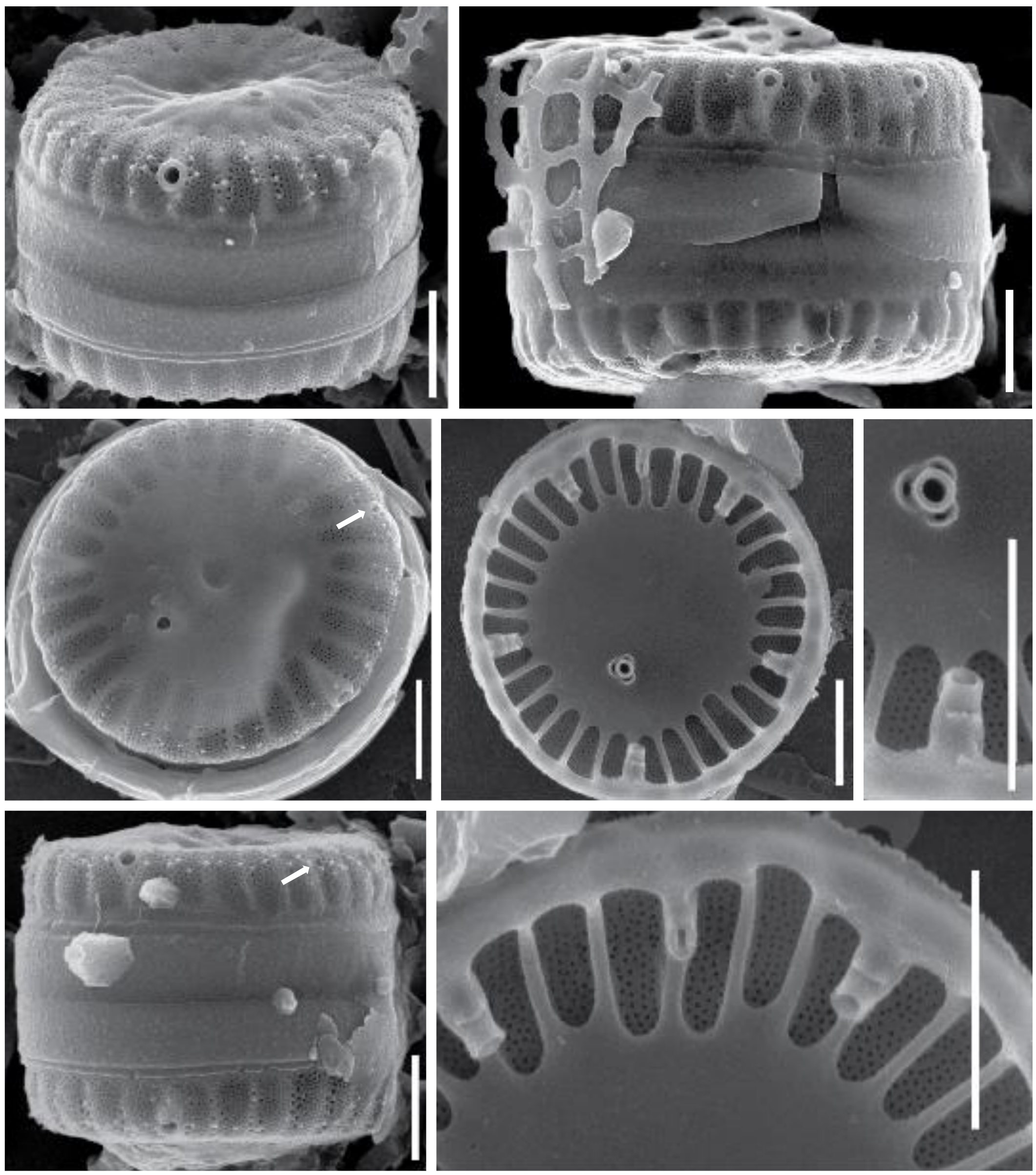
Cyclotella atomus* var. *gracilis Genkal & Kiss

Lit.: Genkal & Kiss 1993, p. 42, figs 10-16, p. 43, figs 17-19

Fig. 1: Barnegat Bay, NJ.
Figs 2-3,6,11: Sample BBDC0041, Barnegat Bay, NJ.
Figs 4-5: Sample BBDC0044, Barnegat Bay, NJ.
Figs 7,9-10,12-13: Sample BBDC0051, Barnegat Bay, NJ.
Fig. 8: Sample COAST071, North East, NJ shore.
Fig. 14: Sample COAST003, Peconic Bay, NY.
Figs 15,20: Sample BBDC0051, Barnegat Bay, NJ.
Figs 16-19,21: Sample BBDC0080, Barnegat Bay, NJ.



1 - 14



15 - 21

Plate 50 (Scale bars: Figs 1-14=10 µm; Figs 15-18=1 µm)

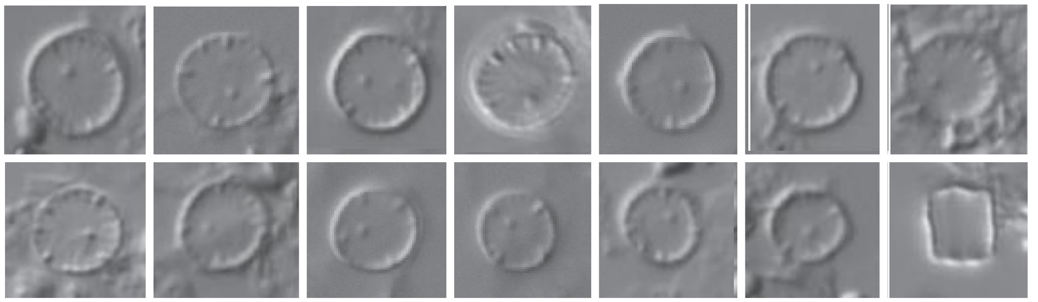
Cyclotella atomus* var. *atomus Hustedt

Lit.: Hustedt 1937, Supplement 15:131-177, pls 9-12.

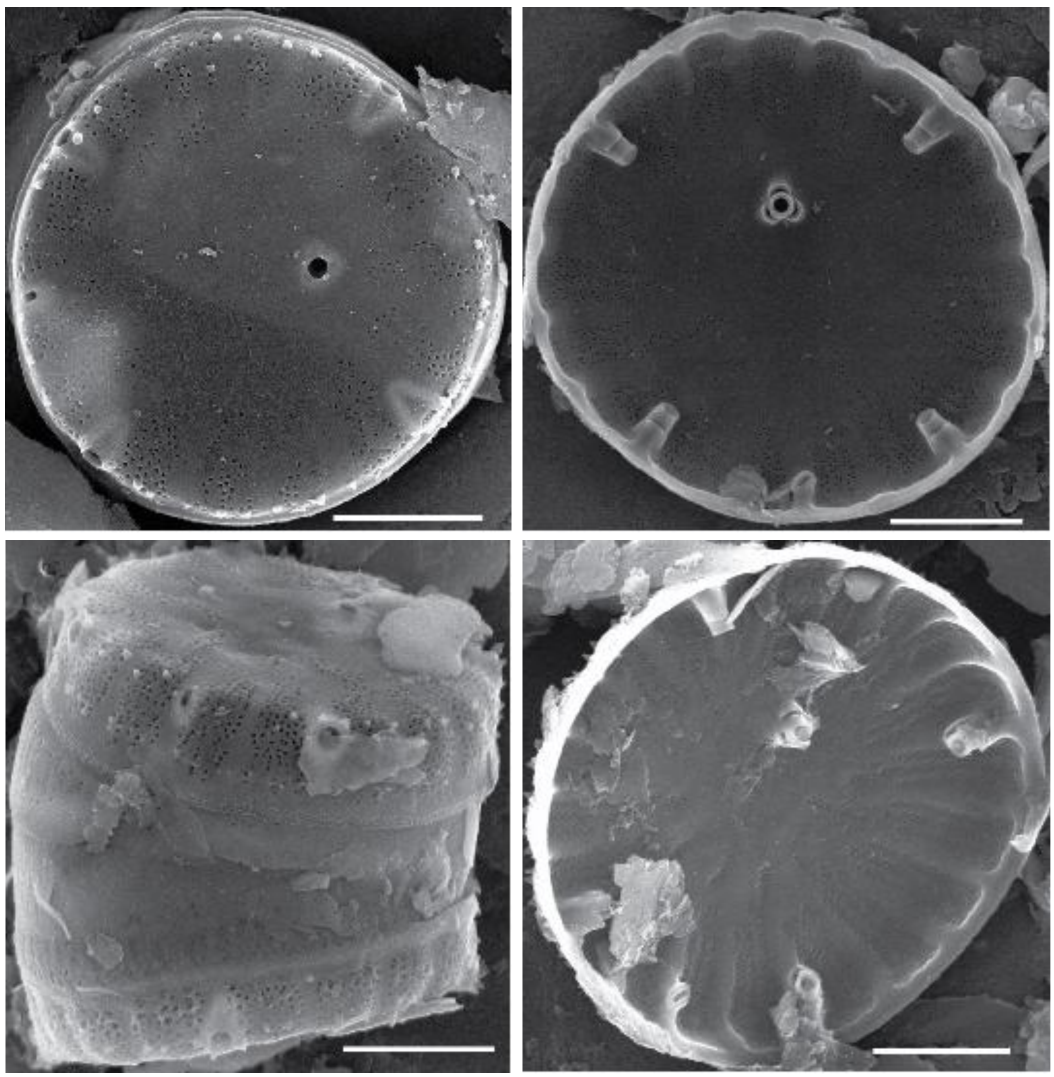
Figs 1-13, 16-18: Sample COAST071, North East, NJ shore.

Fig. 14: Sample COAST003, Peconic Bay, NY.

Fig. 15: Sample BBDC0051, Sluice Creek at South Dennis, NJ.



1 - 14



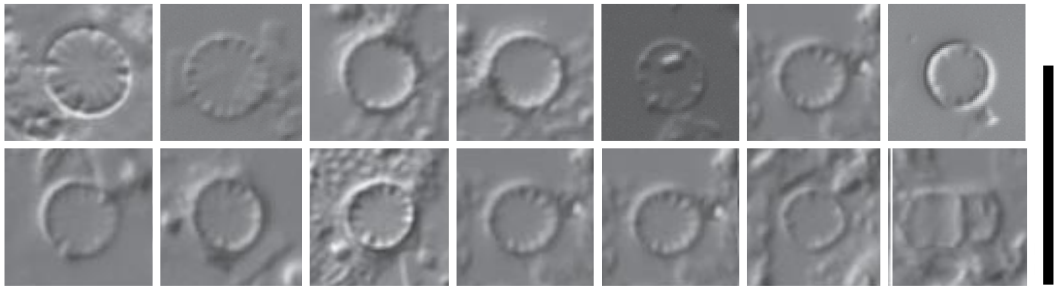
15 - 18

Plate 51 (Scale bars: Figs 1-14=10 µm; Figs 15-21=1 µm)

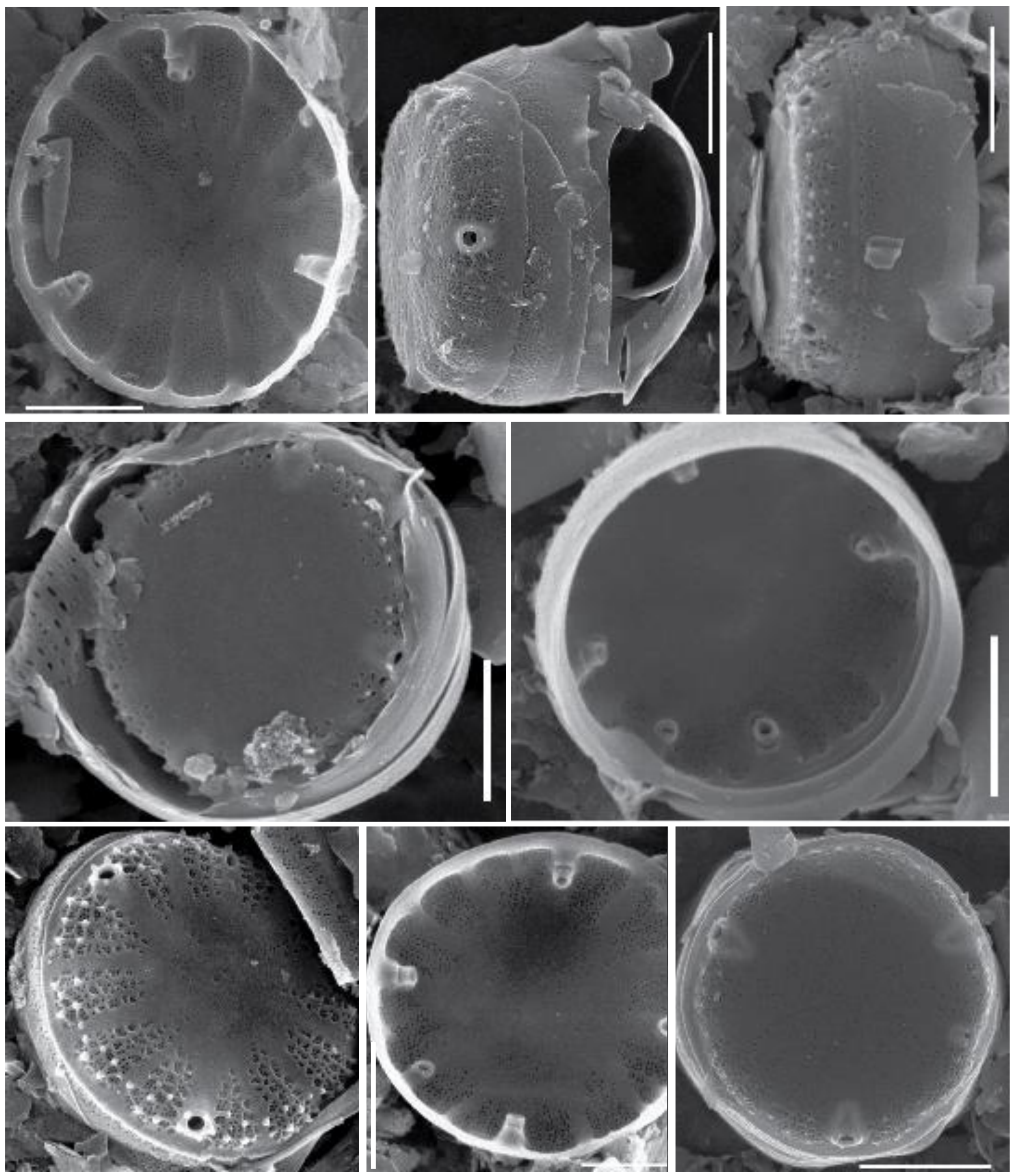
Cyclotella marina Takano

Lit.: Takano 1981

Figs 1-2,6,8-12, 15,17: Sample COAST071, North East, NJ shore.
Figs 3-4: Sample BB0069, Barnegat Bay, NJ.
Fig. 5: Sample BBDC0002, Barnegat Bay, NJ.
Fig. 7: Sample COAST003, Peconic Bay, NY.
Figs 13-14: Sample RUTG807, Cape May, NJ.
Fig. 16: Sample RUTG0811, Cape May, NJ.
Figs 18-19: Sample COAST031, Hempstead Bay, NY.
Figs 20-21: Sample COAST073, North East, NJ shore.
Fig. 22: Sample RUTG0803, Cape May, NJ.



1 - 14



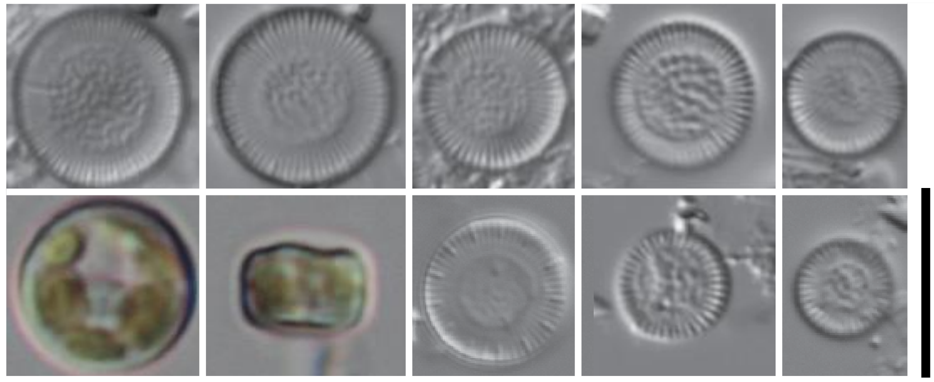
10 - 14

Plate 52 (Scale bars: Figs 1-10=10 µm; Figs 11-15=1 µm)

Cyclotella choctawacheeana Genkal & Kiss

Lit.: Genkal & Kiss 1993, p. 42, figs 10-16, p. 43, figs 17-19

Fig. 1: Sample COAST089, Sea Isle City, NJ.
Figs 2-5,9-10: Sample BBDC0044, Barnegat Bay, NJ.
Figs 6-7: Barnegat Bay, NJ.
Fig. 8: Sample BBDC0051, Barnegat Bay, NJ.
Fig. 11: Sample BBDC0028, Barnegat Bay, NJ.
Figs 12-15: Sample BBDC0030, Barnegat Bay, NJ.



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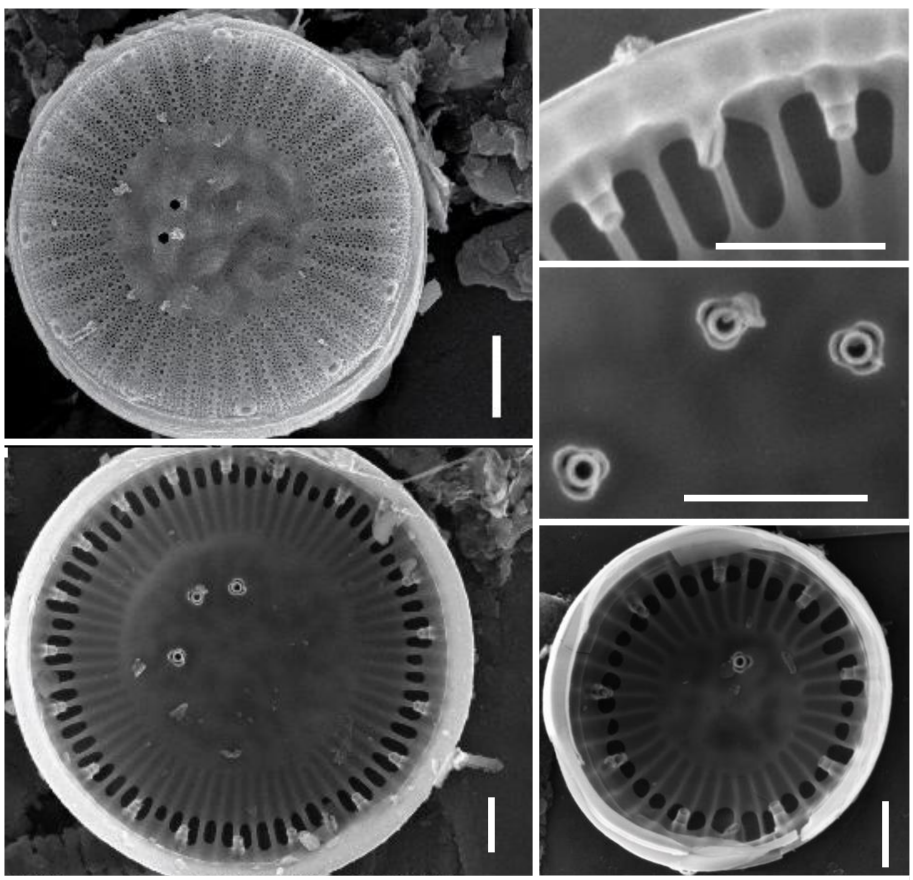


11 - 15

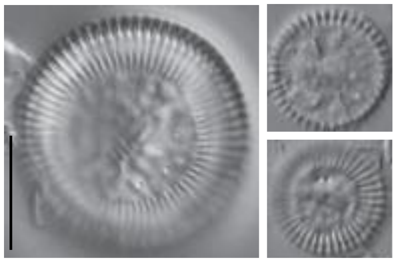
Plate 53 (Scale bar: Figs 18-20=10 μm; Fig. 26=1 μm)

Figs 18-20: ***Cyclotella striata*** (Kützing) Grunow in Cleve & Grunow
Lit.: Cleve & Grunow 1880, p. 119
Basionym: *Coscinodiscus striatus* Kützing 1844
Figs 18-20: Sample BBDC0044, Barnegat Bay, NJ.

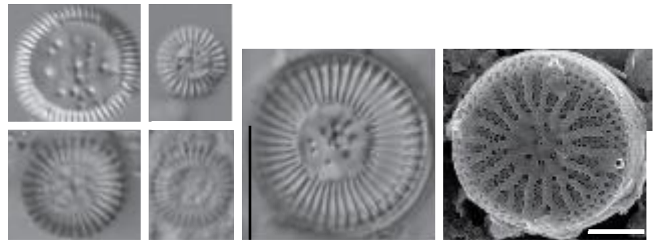
Figs 21-26**: *Cyclotella* sp. 5**
Fig. 21: Sample BBDC0044, Barnegat Bay, NJ.
Fig. 22: Sample BBDC0091, Barnegat Bay, NJ.
Fig. 23: Sample BBDC0080, Barnegat Bay, NJ.
Fig. 24: Sample BBDC0041, Barnegat Bay, NJ.
Fig. 25: Sample BBDC0076, Barnegat Bay, NJ.
Fig. 26: Sample COAST070, North East, NJ shore.

Figs 27-33: ***Cyclotella meneghiniana*** Kützing
Lit.: Kützing 1844, p. 50; pl. 30, fig. 68
Synonyms: *Surirella melosiroides* Meneghini ms. in Kützing 1844
Cyclotella kutzingiana var. *meneghiniana* (Kützing) Brun 1880
Fig. 27: Sample BBDC0001, Barnegat Bay, NJ.
Fig. 28: Sample BBDC0004, Barnegat Bay, NJ.
Fig. 29: Sample BBDC0006, Barnegat Bay, NJ.
Fig. 30: Sample BBDC0046, Barnegat Bay, NJ.
Fig. 31: Sample BBDC0069, Barnegat Bay, NJ.
Fig. 32: Sample BBDC0009, Barnegat Bay, NJ.
Fig. 33: Sample BBDC0007, Barnegat Bay, NJ.

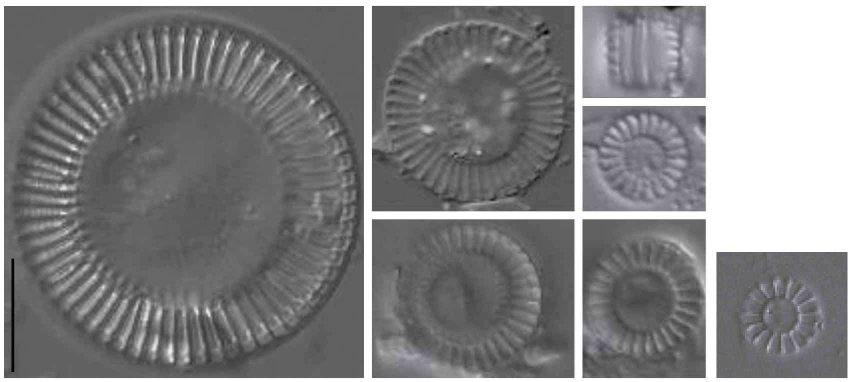
Figs 34-35: ***Discostella stelligera*** (Cleve et Grunow) Houk & Klee
Basionym: *Cyclotella meneghiniana* var. *stelligera* Cleve & Grunow in Cleve 1881
Synonym: *Cyclotella stelligera* (Cleve & Grunow in Cleve) Van Heurck 1882
Lit.: Houk & Klee 2004, p. 208
Fig. 34: Sample BBDC0005, Barnegat Bay, NJ.
Fig. 35: Sample BBDC0065, Barnegat Bay, NJ.



18 - 20



21 - 26



27 - 33

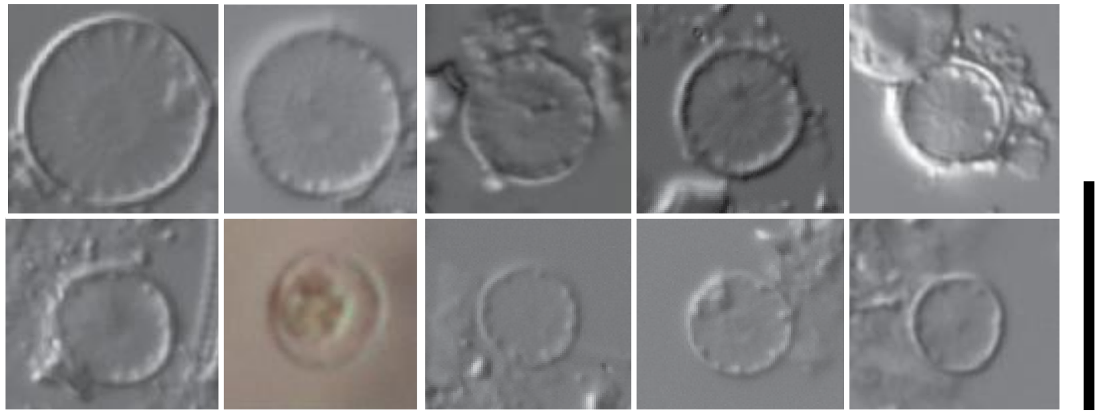
34 - 35

Plate 54 (Scale bars: Figs 1-10=10 µm; Fig 11-16=1 µm)

Cyclotella* aff. *katiana Sala & Ramírez

Lit.: Sala & Ramírez. 2008, p. 149; fig. 2-12

Figs 1-2,6,7-12,14-16: Sample RUTG0803, Cape May, NJ.
Fig. 3: Sample RUTG0131, Cape May, NJ.
Fig. 4: Sample RUTG0111, Cape May, NJ.
Fig. 5: Sample RUTG0076, Cape May, NJ.
Fig. 13: Sample RUTG0811, Cape May, NJ.



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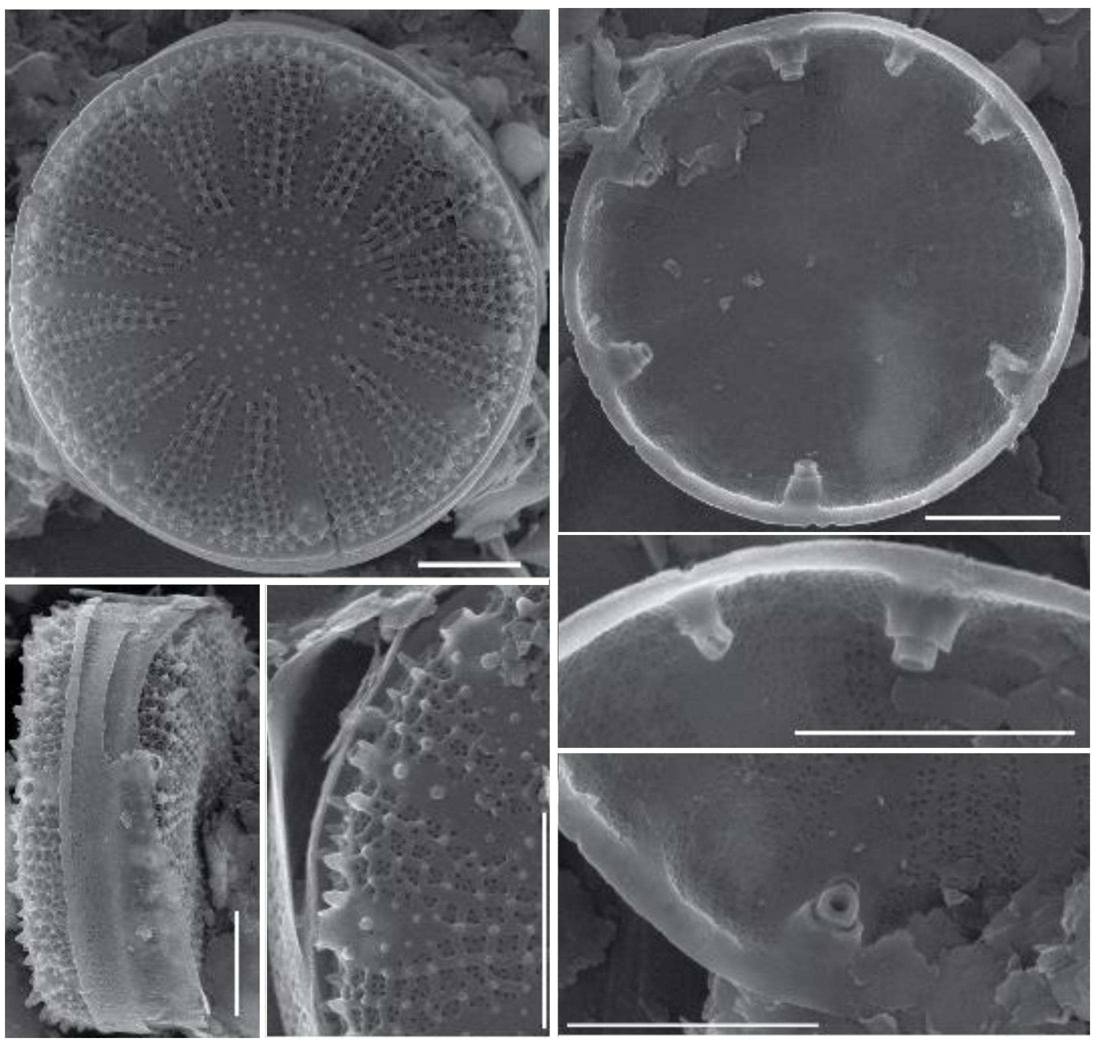
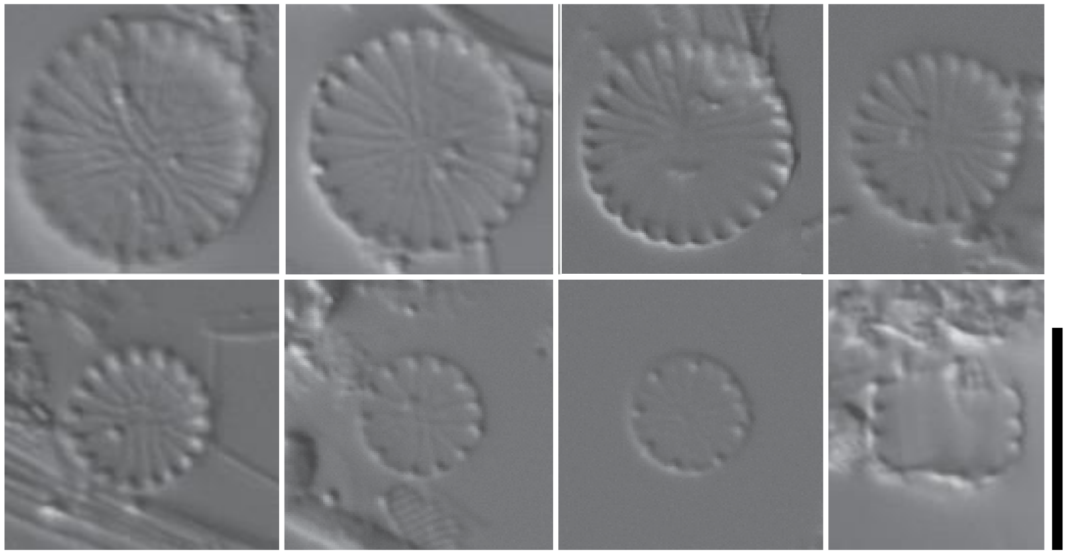


11 - 16

Plate 55 (Scale bars: Figs 1-8=10 µm; Fig 9-13=1 µm)

Cyclotella* cf. *katiana

Figs 1-13: Sample BBDC0031, Barnegat Bay, NJ.



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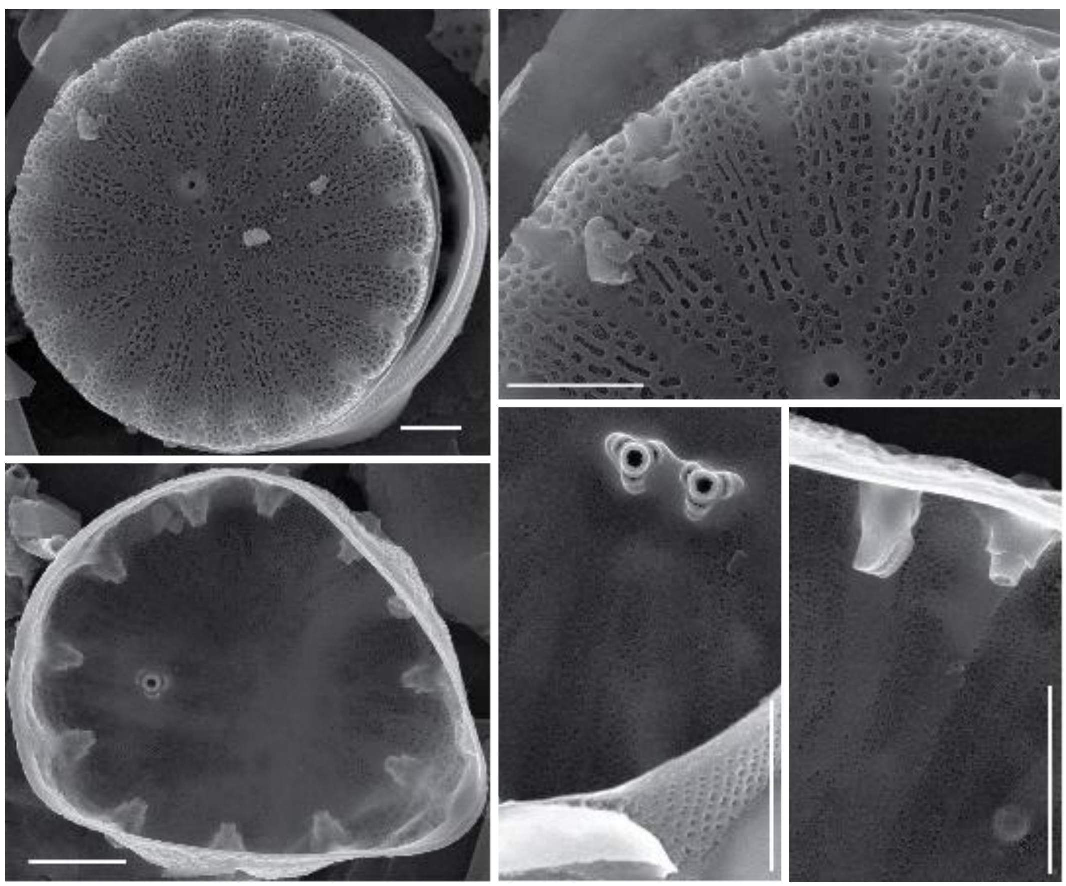
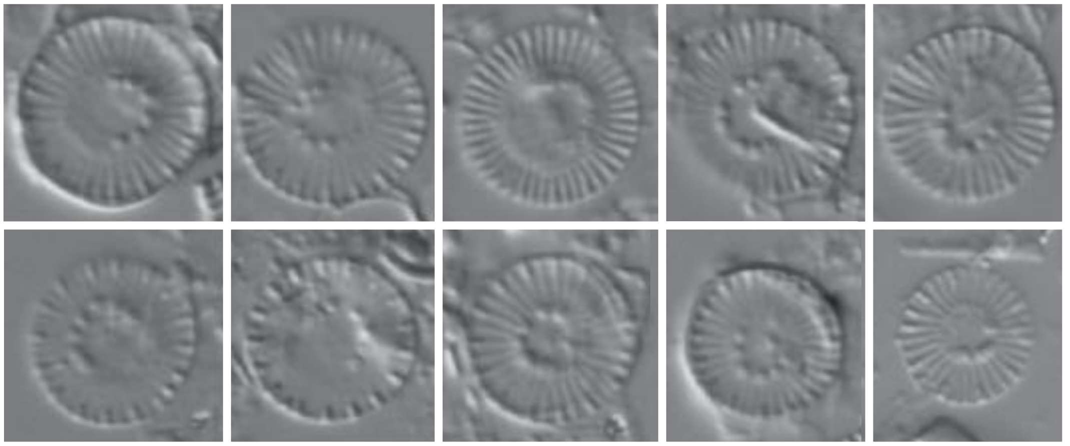


9 - 13

Plate 56 (Scale bars: Figs 1-10=10 μm; Fig 11-16=1 μm)

Cyclotella sp. 1

Figs 1-10: Sample COAST071, North East, NJ shore.
Fig. 10: Sample COAST004, Flanders Bay, NY.
Figs 11-16: Sample COAST071, North East, NJ shore.



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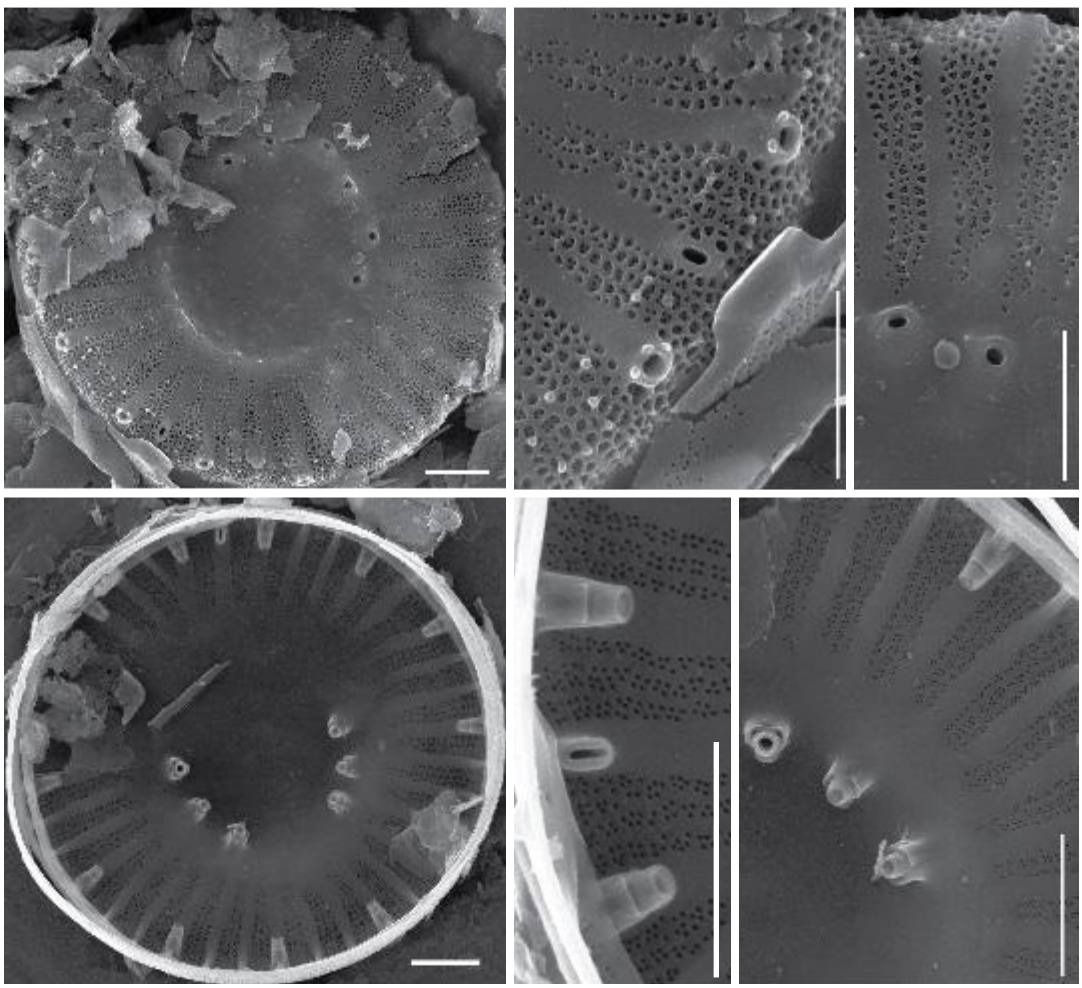
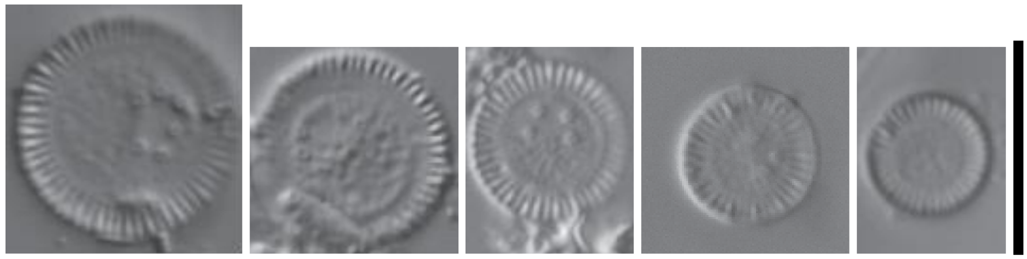


11 - 16

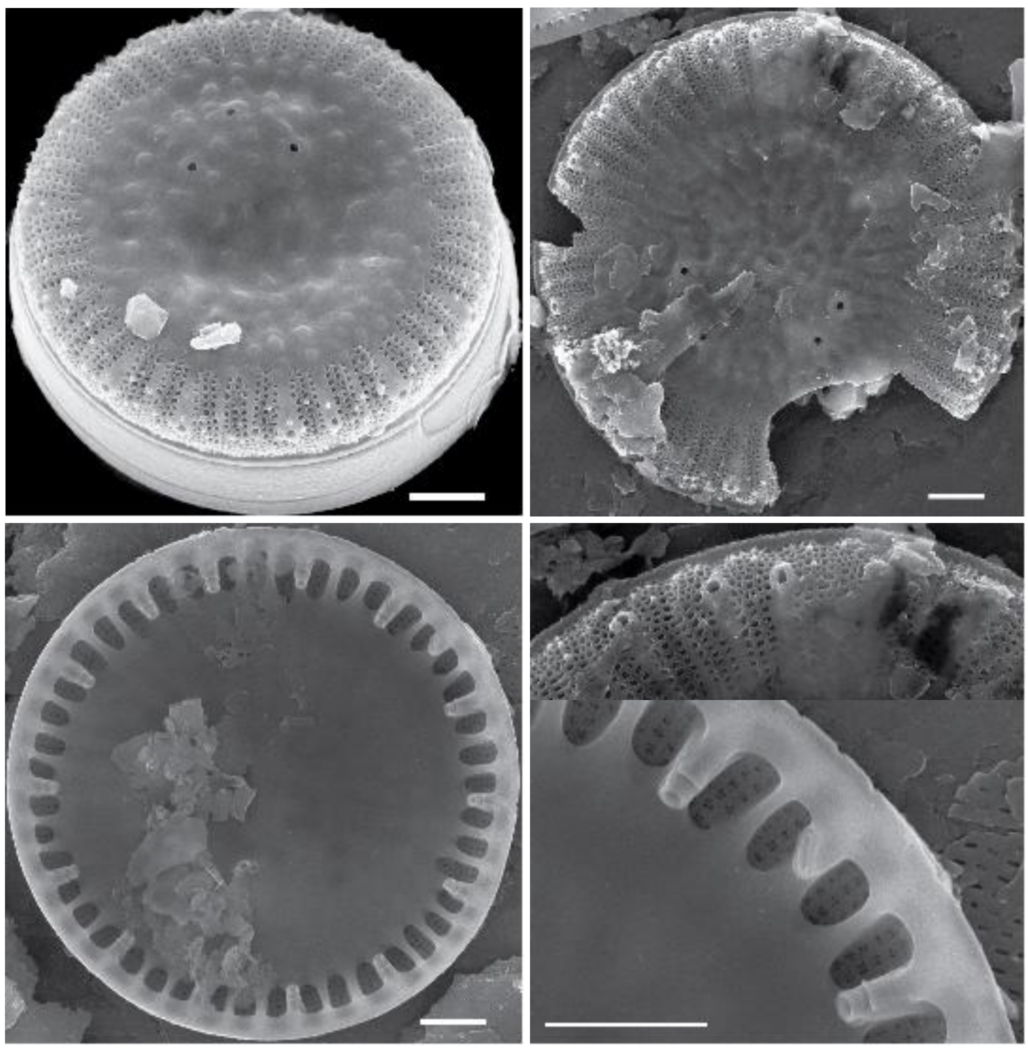
Plate 57 (Scale bars: Figs 1-5=10 µm; Fig 6-10=1 µm)

Cyclotella sp. 2

Fig. 1: Sample RUTG0842, Leeds Point, NJ.
Fig. 2: Sample BBDC0051, Barnegat Bay, NJ.
Fig. 3: Sample BBDC0074, Barnegat Bay, NJ.
Fig. 4: Sample RUTG0805, Cape May, NJ.
Fig. 5: Sample BBDC0044, Barnegat Bay, NJ.
Fig. 6: Sample BBDC0051, Barnegat Bay, NJ.
Figs 7-10: Sample COAST071, North East, NJ shore.



1 - 5



6 - 10

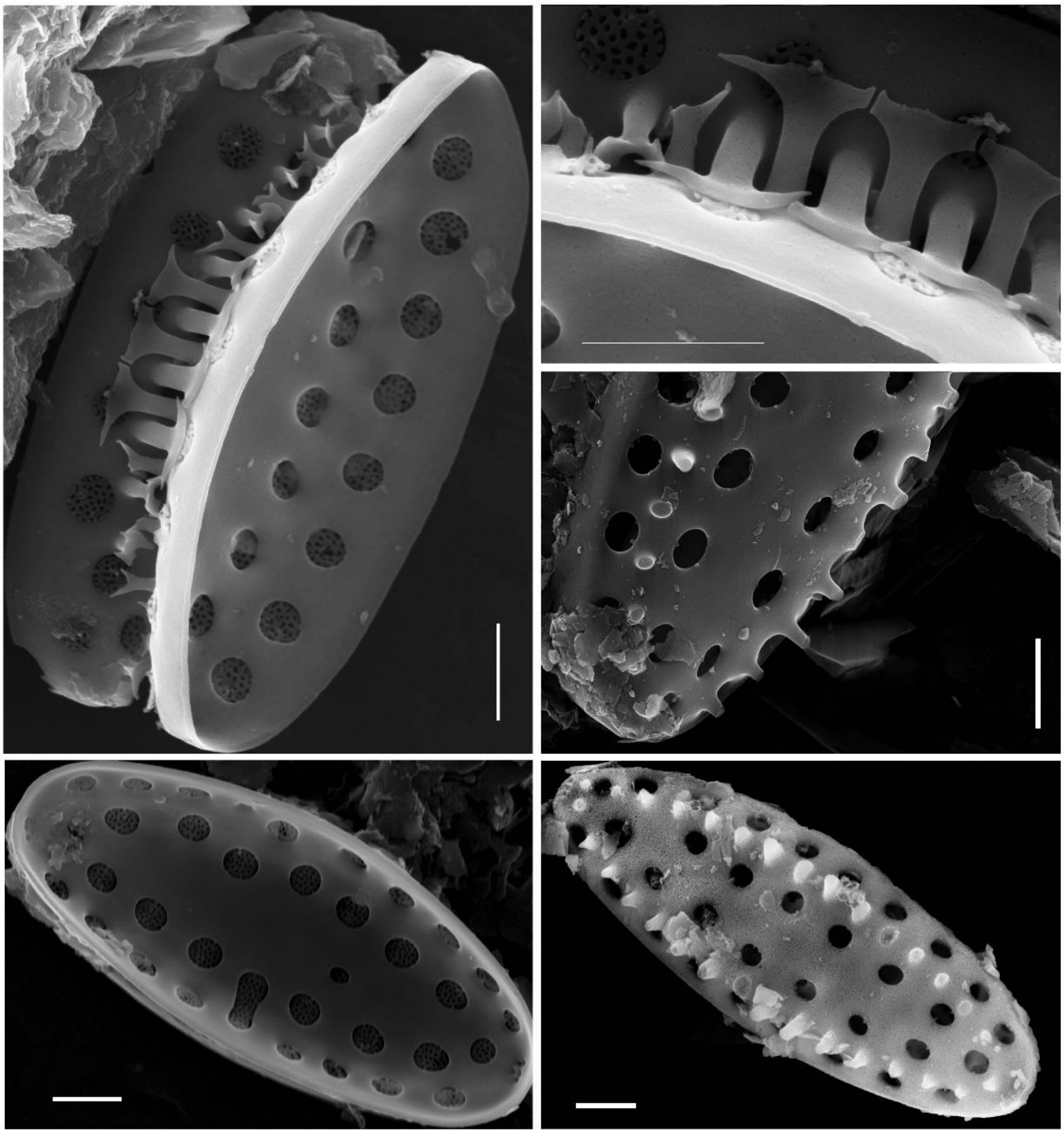
Plate 58 (Scale bars: Figs 1-8=10 µm; Figs 9-10=1 µm)

Cymatosira belgica Grunow in Van Heurck

Lit.: Van Heurck 1881, pl. 45, fig. 38-41

Fig. 1: Sample BB0068, Barnegat Bay, NJ.
Figs 2,4: Sample BB0075, Barnegat Bay, NJ.
Fig. 3: Sample BB0074, Barnegat Bay, NJ.
Fig. 5: Sample BB0065, Barnegat Bay, NJ.
Fig. 6: Sample BBDC0048, Barnegat Bay, NJ.
Fig. 2: Sample BB0069, Barnegat Bay, NJ.
Fig. 2: Sample BB0075, Barnegat Bay, NJ.
Fig. 2: Sample BB0062, Barnegat Bay, NJ.

1 - 8



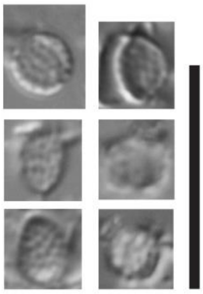
9 - 12

Plate 59 (Scale bars: Figs 1-6=10 µm; Figs 7-11=1 µm)

Cymatosira minutissima Sabbe & Muylaert

Lit.: Sabbe et al. 2010, p. 246; fig. 17-20, 28-31

Figs 1-2: Sample COAST025, Great South Bay, NY.
Figs 3,7-9: Sample BBDC0095, Great Bay, NJ.
Fig. 10: Sample COAST011, Great South Bay, NY.
Fig. 11: Sample COAST062, Western Bay, NY.



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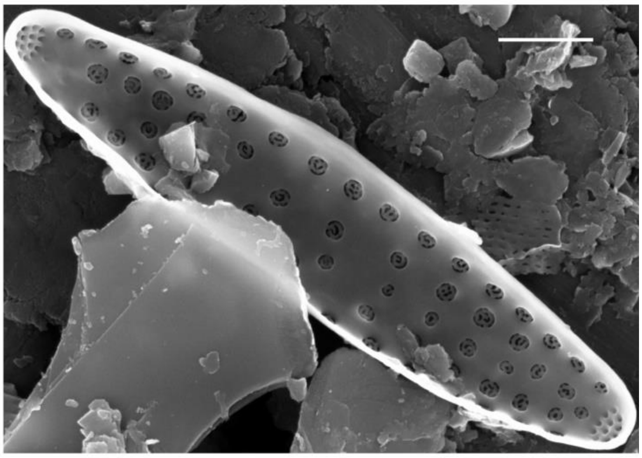
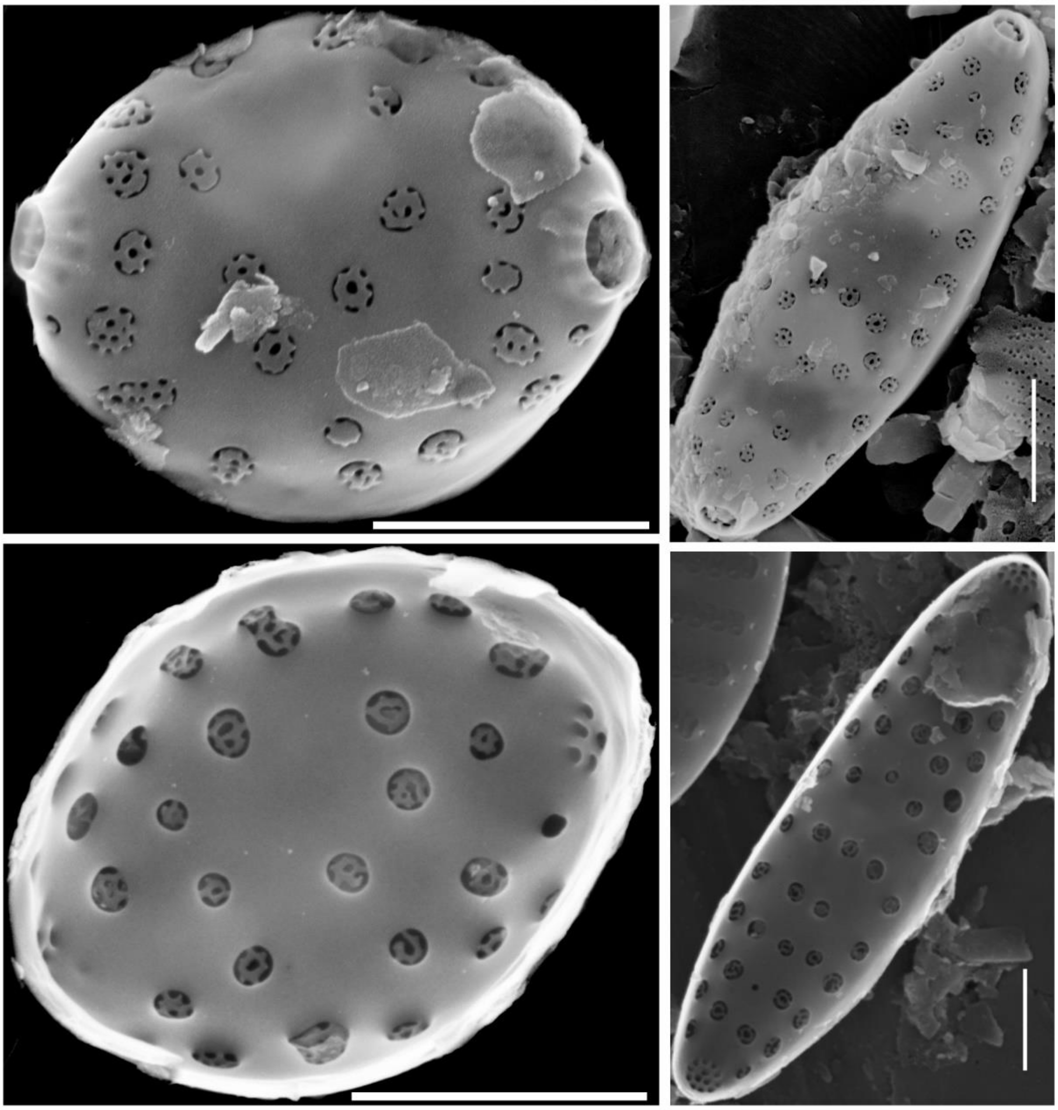




7 - 11

Plate 60(Scale bar: Figs 1-12,14-15,19=10 µm; Figs 13,16-18,20-21=1 µm)

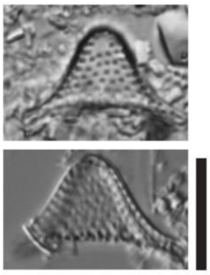
Figs 1-2: ***Campylosira alexandrica*** Salah
Lit.: Salah 1955, p. 92; pl. 1, fig. 17
Fig. 1: Sample RUTG0619, Sea Breeze, NJ.
Fig. 2: Sample RUTG0541, Fortescue, NJ.

Figs 3-4: ***Campylosira cymbelliformis*** (Schmidt) Grunow in Van Heurck
Lit.: Van Heurck 1881, pl. 45, fig. 43
Basionyms: *Synedra cymbelliformis* Schmidt 1874
Fig. 3: Sample BB0068, Barnegat Bay, NJ.
Fig. 4: Sample BBDC0095, Great Bay, NJ.

Figs 5-13: ***Brockmaniella brockmanii*** (Hustedt) Hasle, von Stosch & Syvertsen
Lit.: Hasle, von Stosch & Syvertsen 1983, p. 35-38; text fig. 5, fig. 132-155
Basionyms: *Plagiogramma brockmanni* Hustedt 1939
Fig. 5: Sample COAST062, Great Bay, NJ.
Figs 6,10,12-13: Sample BBDC0095, Great Bay, NJ.
Fig. 7: Sample BBDC0003, Barnegat Bay, NJ.
Fig. 8: Sample BBDC0048, Barnegat Bay, NJ.
Fig. 9: Sample BBDC0045, Barnegat Bay, NJ.
Fig. 11: Sample COAST062, Western Bay, NY.

Figs 14-18: ***Extubocellulus* sp. 1**
Figs 14-17: Sample BBDC0095, Great Bay, NJ.
Fig. 18: Sample COAST015, Great South Bay, NY.

Figs 19-21: ***Minutocellus polymorphus*** (Hargraves & Guillard) Hasle, Stosch, & Syvertsen
Lit.: Hasle, Stosch, & Syvertsen 1983: 38, text figs 6, 8, figs 156-189, 220-242
Basionyms: *Bellerochea polymorpha* Hargraves & Guillard 1974
Figs 19,21: Barnegat Bay, NJ.
Fig. 20: Sample COAST096, Cape May Peninsula, NJ.



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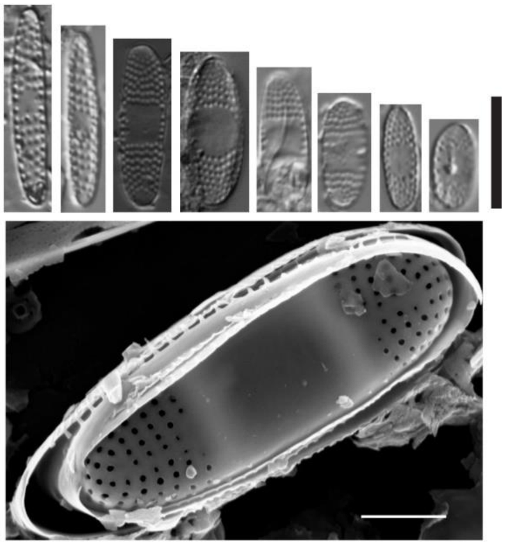
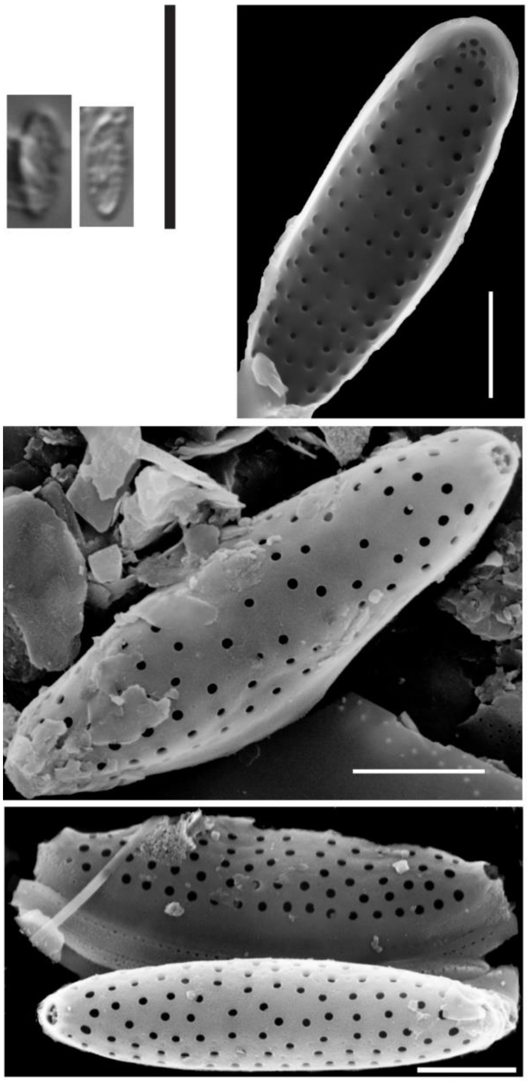
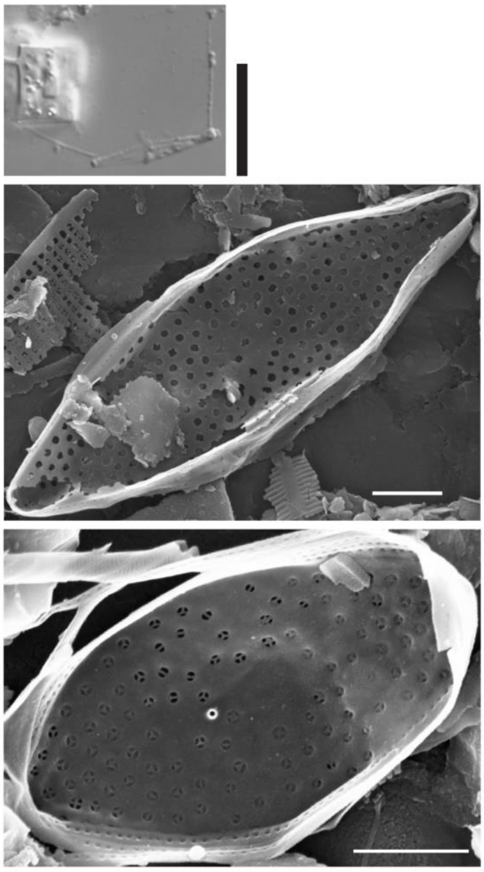
3 - 4



5 - 13



14 - 18



19 - 21

Plate 61 (Scale bars: Figs 1-2=10 µm; Figs 3-9=1 µm)

Arcocellulus cornucervis Hasle, von Stosch & Syvertsen

Lit.: Hasle, von Stosch & Syvertsen 1983, p. 59-63; text fig. 11, fig. 301-333, 408-414

Fig. 1: Sample BBDC00109, Great Bay, NJ.

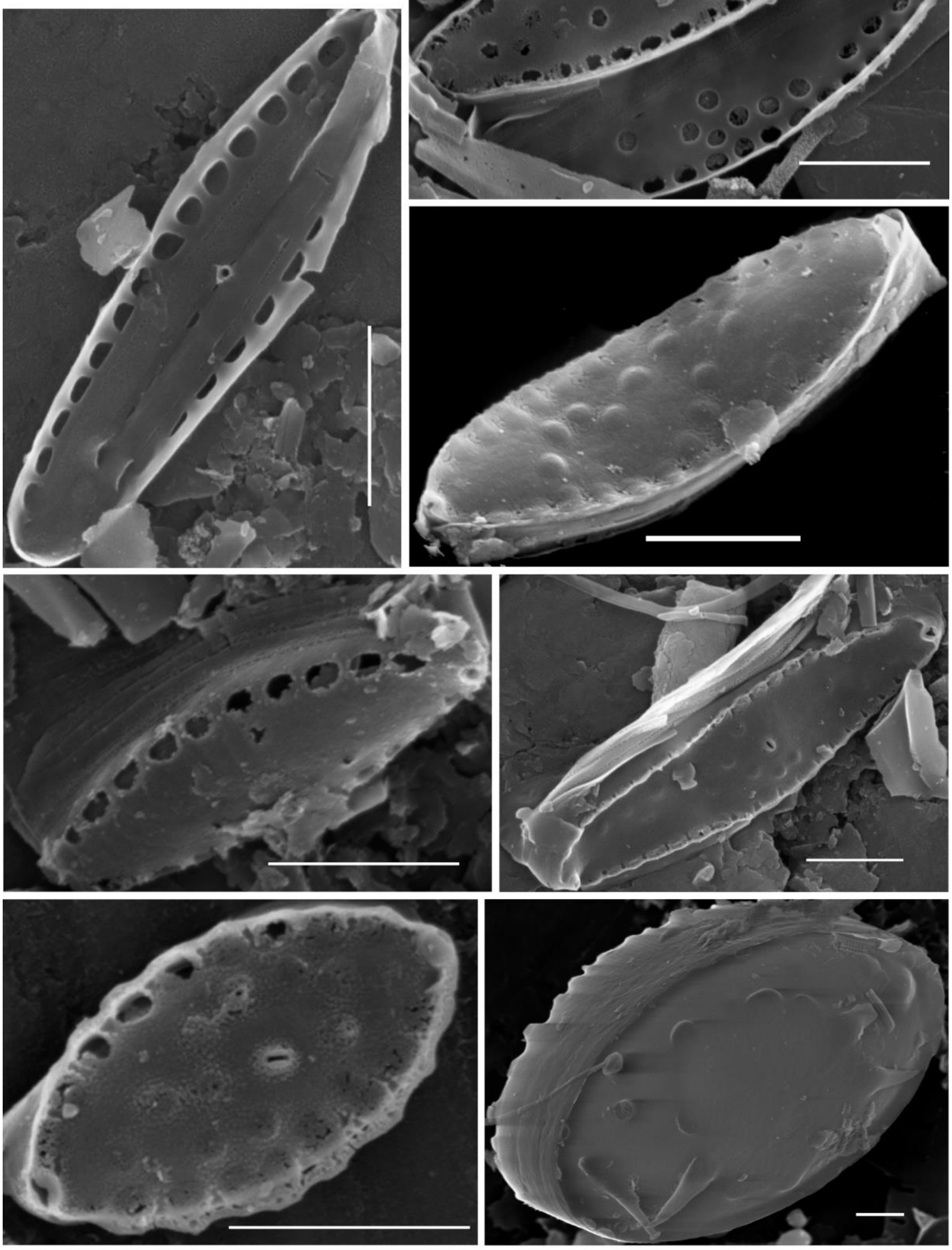
Fig. 2: Sample BB0029, Barnegat Bay, NJ.

Figs 3,8: Sample COAST015, Great South Bay, NY.

Figs 4,7,9: Sample COAST054, Barnegat Bay, NJ.

Figs 5-6: Sample COAST096, Cape May Peninsula, NJ.

1 - 2



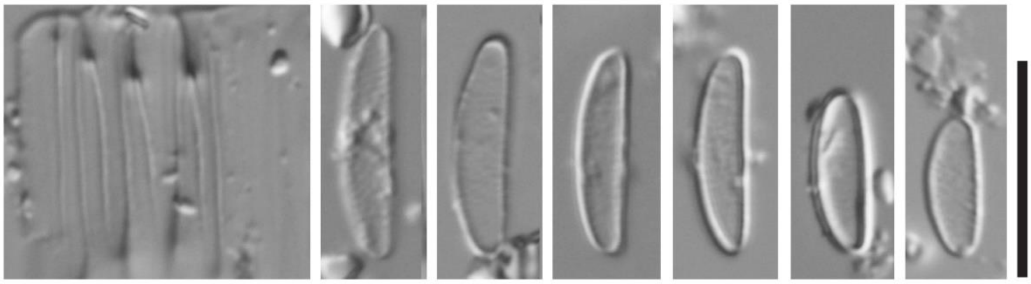
3 - 9

Plate 62 (Scale bars: Figs 1-7=10 µm; Figs 8-10=1 µm)

Pierrecomperia catenuloides Sabbe, Vyverman & Ribeiro

Lit.: Sabbe et al. 2010, p. 251; fig. 21-27, 37-38, 40-42, 45-47

Figs 1-10: Sample BBDC0095, Great Bay, NJ.



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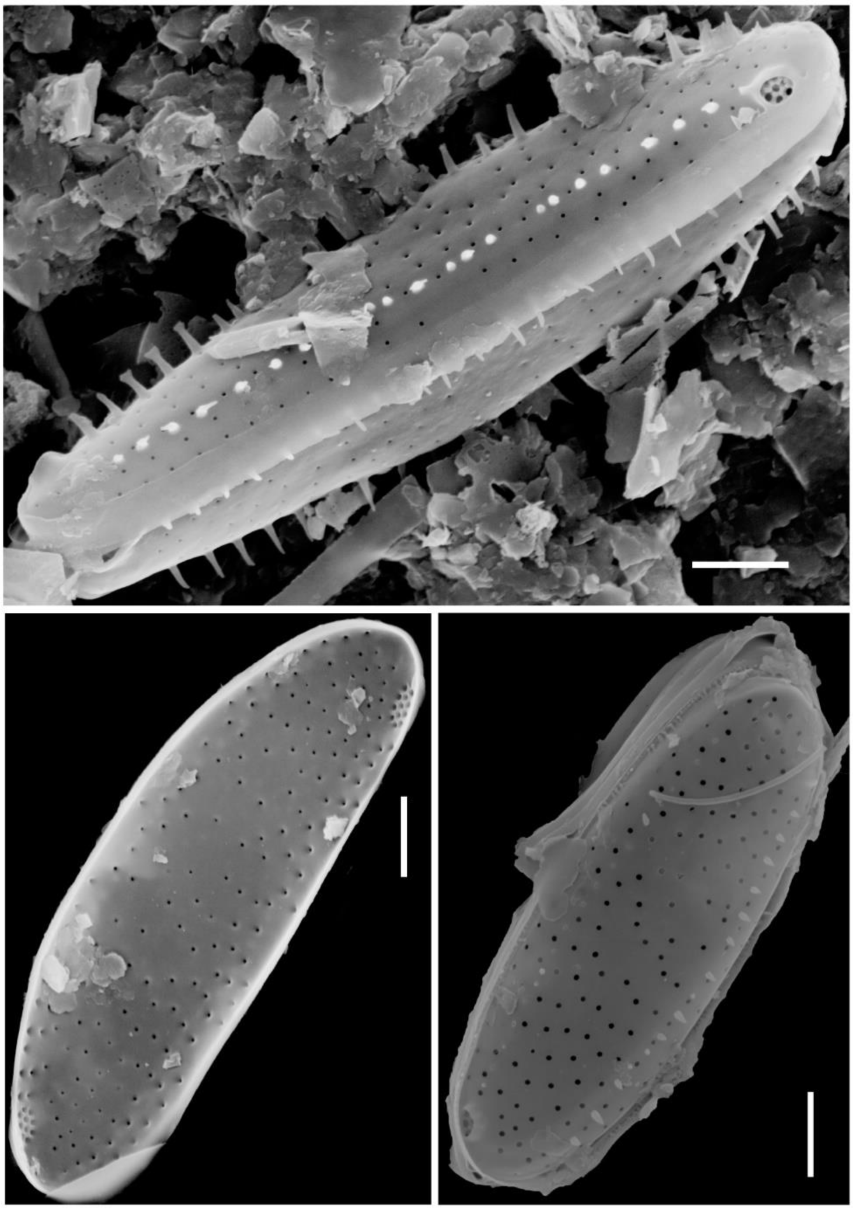


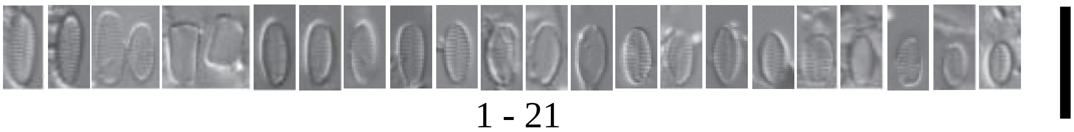
8 - 10

Plate 63 (Scale bars: Figs 1-21; 27-46=10 µm; Figs 22-26; 47-48=1 µm)

Figs 1-26: ***Fragilaria amicorum*** Witkowski et Lange-Bertalot
Lit.: Witkowski et Lange-Bertalot 1993, v. 23 (1): p. 62; fig. 3a-k

Fig. 1: Sample BBDC0095, Great Bay, NJ.
Figs 2,7,10,12-13,15,19-20: Sample BBEDC098, Cattus Island, NJ.
Figs 3,14,16-17: Sample BBDC0016, Barnegat Bay, NJ.
Fig. 4: Sample BB0001, Barnegat Bay, NJ.
Figs 5,8: Sample BBEDC058, Cattus Island, NJ.
Figs 6,21,25: Sample BB0054, Barnegat Bay, NJ.
Fig. 9: Sample BBDC0018, Barnegat Bay, NJ.
Fig. 11: Sample BB0032, Barnegat Bay, NJ.
Fig. 18: Sample BB0060, Barnegat Bay, NJ.
Figs 22,24: Sample COAST015, Great South Bay, NY.
Figs 23: Sample BBDC0028, Barnegat Bay, NJ.

Figs 27-48: ***Fragilaria* sp. 10**
Figs 27-28,30-32,44: Sample BBEDC098, Cattus Island, NJ.
Figs 29,35-38,40-41,46-48: Sample BBDC0016, Barnegat Bay, NJ.
Figs 33,39,45: Sample BBEDC059, Cattus Island, NJ.
Figs 34: Sample COAST015, Great South Bay, NY.
Fig. 42: Sample BB0071, Barnegat Bay, NJ.
Figs 43: Sample BBEDC058, Cattus Island, NJ.



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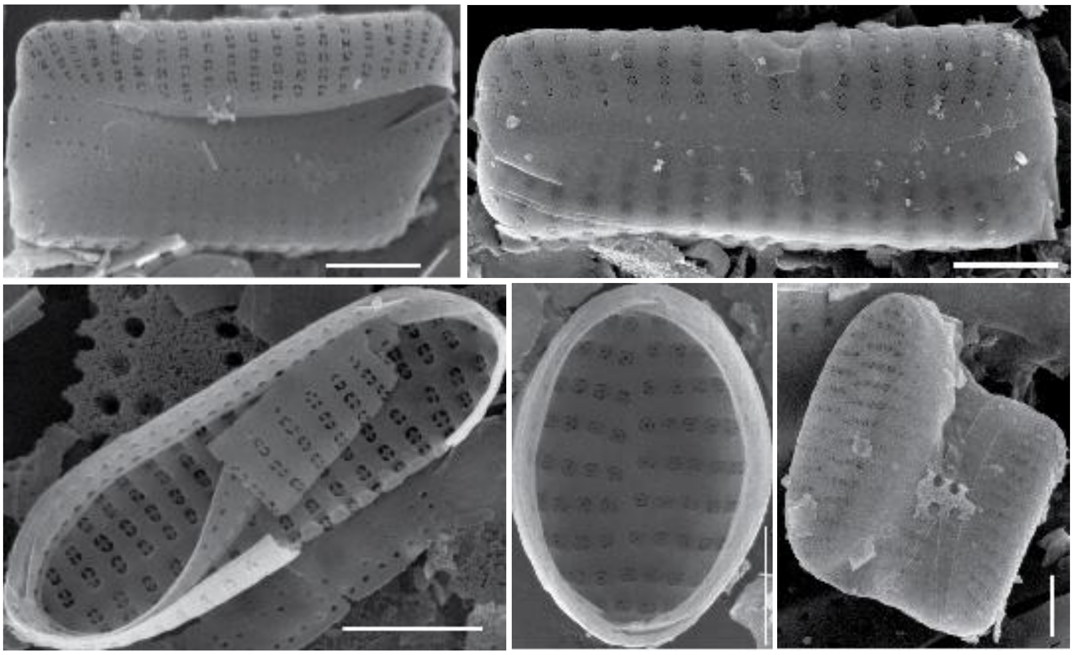
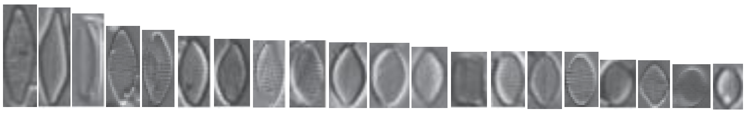
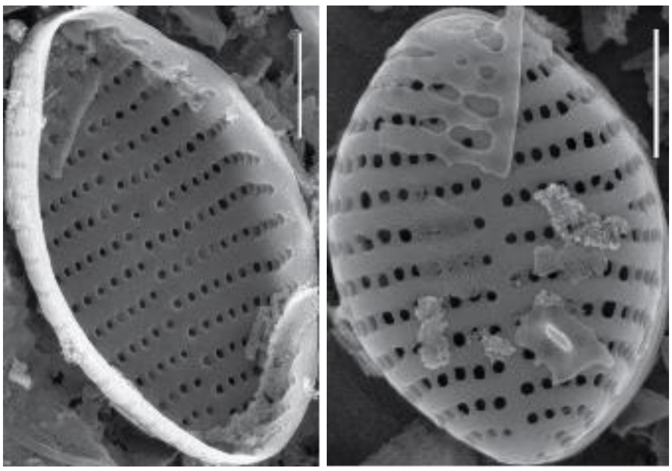


22 - 26



27 - 46



47 - 48

Plate 64 (Scale bars: Figs 1-9; 14-19; 21-39=10 µm; Figs 10-13; 20; 40-41=1 µm)

Figs 1-13: ***Fragilaria bronkei*** Witkowski, Lange-Bertalot & Metzeltin
Lit.: Witkowski, Lange-Bertalot & Metzeltin 2000, p. 48, 427; pl. 12, fig. 1-12

Figs 1,3,5,8-12: Sample COAST062, Great Bay, NJ.
Figs 2: Sample COAST022, Great South Bay, NY.
Figs 4: Sample COAST015, Great South Bay, NY.
Figs 6,13: Sample BBDC0095, Great Bay, NJ.
Fig. 7: Sample BB0008, Barnegat Bay, NJ.

Figs 14-20: ***Pseudostaurosira* cf. *brevistriata***
Figs 14-20: Sample BBDC00028, Barnegat Bay, NJ.

Figs 21-24: ***Fragilaria* sp. 3**
Fig. 21: Sample BBDC00038, Barnegat Bay, NJ.
Fig. 22: Sample BBDC00018, Barnegat Bay, NJ.
Fig. 23: Sample BB0070, Barnegat Bay, NJ.
Fig. 24: Sample BBDC0095, Great Bay, NJ.

Figs 25-41: ***Tabularia waernii*** Snoeijs
Lit.: Snoeijs & Kuylenstierna 1991, p. 352; fig. 1-34

Figs 25-26: Sample COAST019, Great South Bay, NY.
Figs 27,29-30,35,37: Sample BBDC0095, Great Bay, NJ.
Fig. 28: Sample BBDC00015, Barnegat Bay, NJ.
Figs 31,33-34,40-41: Sample COAST015, Great South Bay, NY.
Fig. 32: Sample BBDC00016, Barnegat Bay, NJ.
Figs 36,39: Sample BBEDC098, Cattus Island, NJ.
Fig. 38: Sample BBDC00028, Barnegat Bay, NJ.

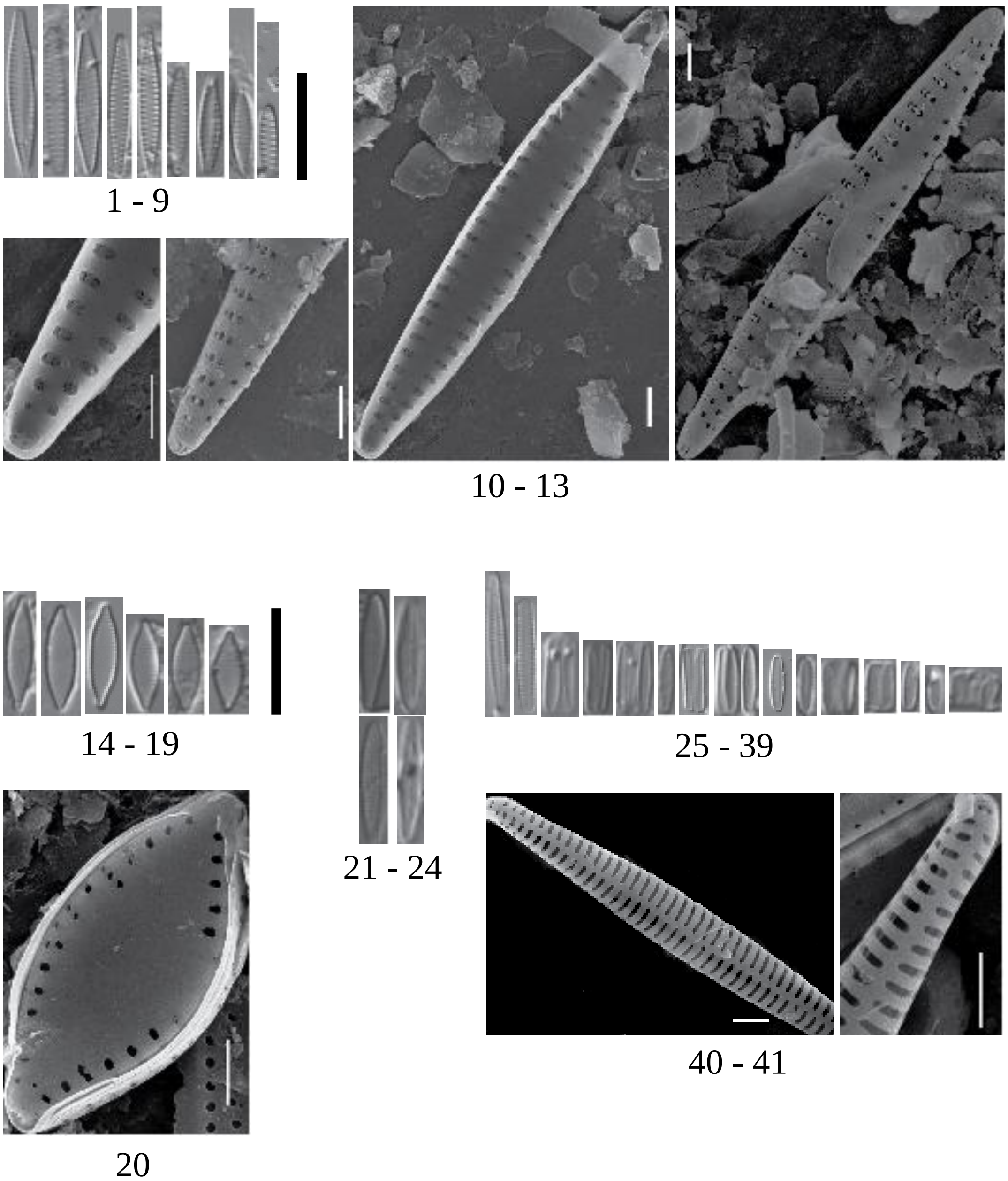
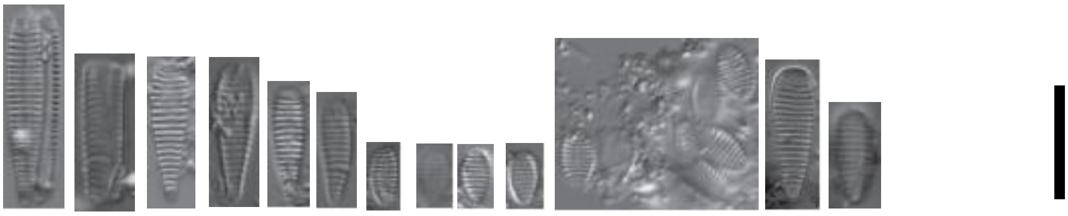

1 - 9
10 - 13
14 - 19
21 - 24
25 - 39
40 - 41
20

Plate 65 (Scale bar: Figs 1-13=10 µm; Figs 1-13=10 µm)

Fragilaria cassubica Witkowski et Lange-Bertalot

Lit.: Witkowski et Lange-Bertalot 1993, v. 23 (1): p. 65; fig. 4a-m

Figs 1,8: Sample BBDC00029, Barnegat Bay, NJ.
Figs 2,4: Sample BBDC00001, Barnegat Bay, NJ.
Fig. 3: Sample COAST051, Barnegat Bay, NY.
Fig. 5: Sample BB0067, Barnegat Bay, NJ.
Figs 6,13: Sample BBDC00002, Barnegat Bay, NJ.
Fig. 7: Sample BB0058, Barnegat Bay, NJ.
Figs 9-10,16: Sample BB0054, Barnegat Bay, NJ.
Fig. 11: Sample BB0009, Barnegat Bay, NJ.
Fig. 12: Sample BBDC00007, Barnegat Bay, NJ.
Fig. 14: Sample COAST031, Western Bay, NY.
Fig. 15: Sample BB0029, Barnegat Bay, NJ.



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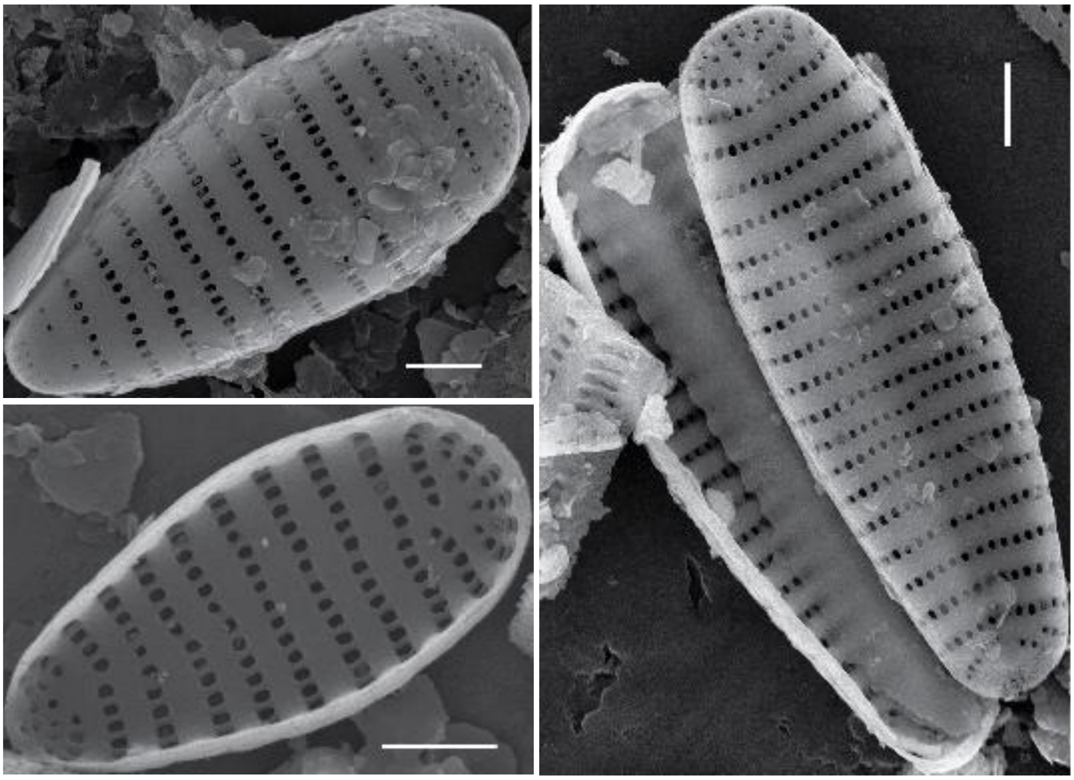


14 - 16

Plate 66 (Scale bars: Figs 1-2=10 µm; Figs 3-7=1 µm)

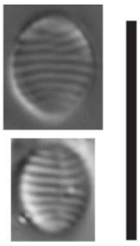
Martyana atomus (Hustedt) Snoeijs

Lit.: Snoeijs, Hallfors & Leskinen 1991, p. 166; fig. 1-18, 23-25

Basionyms: *Fragilaria atomus* Hustedt 1931

Figs 1-6: Sample BBDC00028, Barnegat Bay, NJ.

Fig. 7: Sample BBDC00016, Barnegat Bay, NJ.



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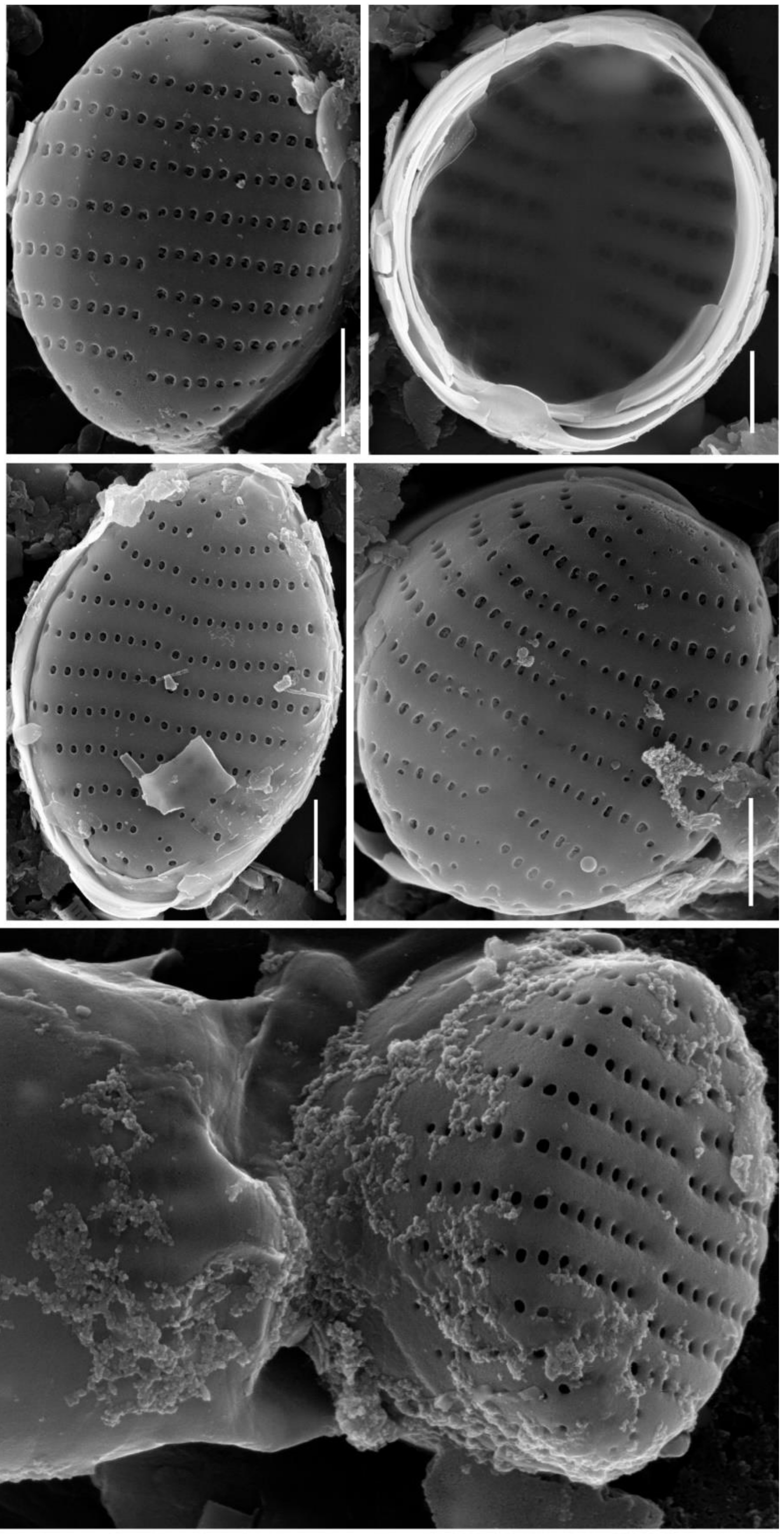
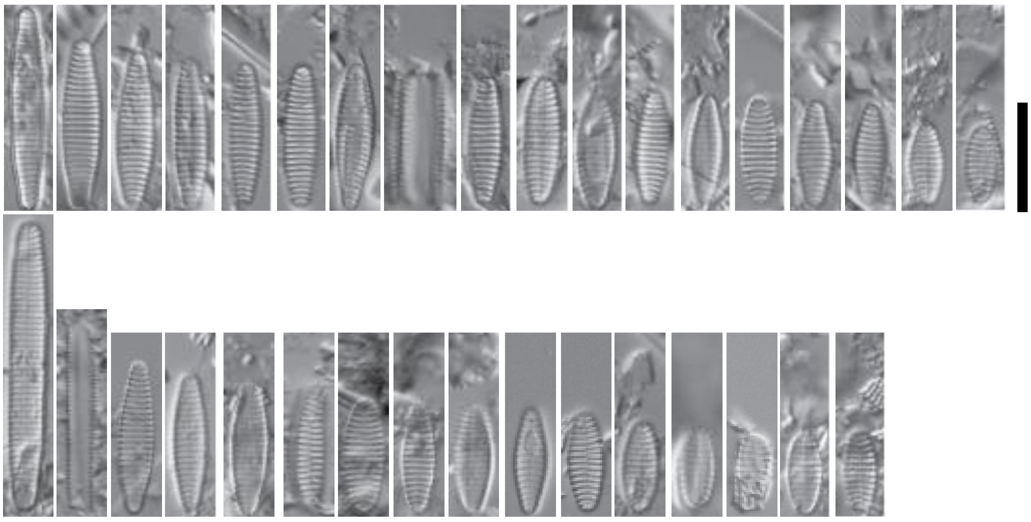


3 - 7

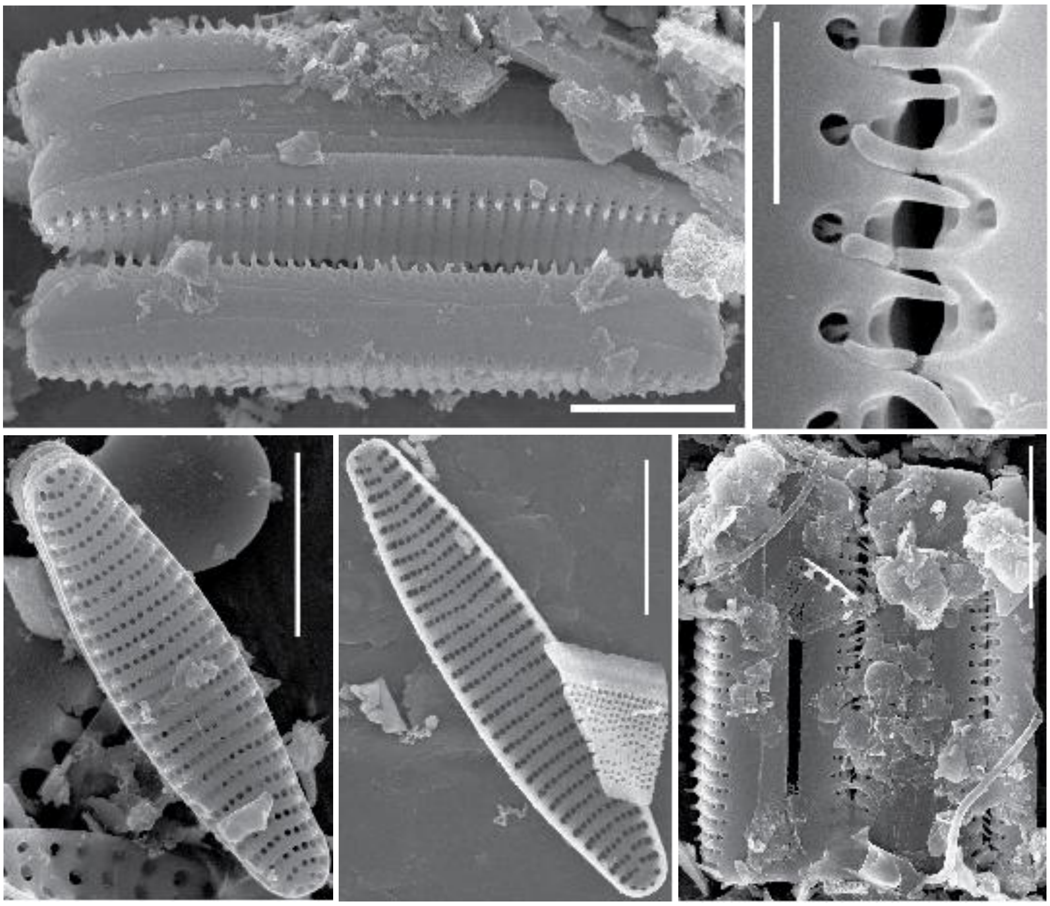
Plate 67 (Scale bars: Figs 1-34=10 µm; Figs 35-39=1 µm)

Stauroforma exiguiformis (Lange-Bertalot) Flower, Jones & Round
Lit.: Flower, Jones & Round 1996, p. 53-54; fig. 16-22
Basionyms: *Fragilaria exiguiformis* Lange-Bertalot 1993

Fig. 1: Sample BB0054, Barnegat Bay, NJ.
Figs 2-18,37-38: Sample BB0032, Barnegat Bay, NJ.
Figs 19-35: Sample BB0031, Barnegat Bay, NJ.
Figs 36,39: Sample BBDC00028, Barnegat Bay, NJ.



1 - 34



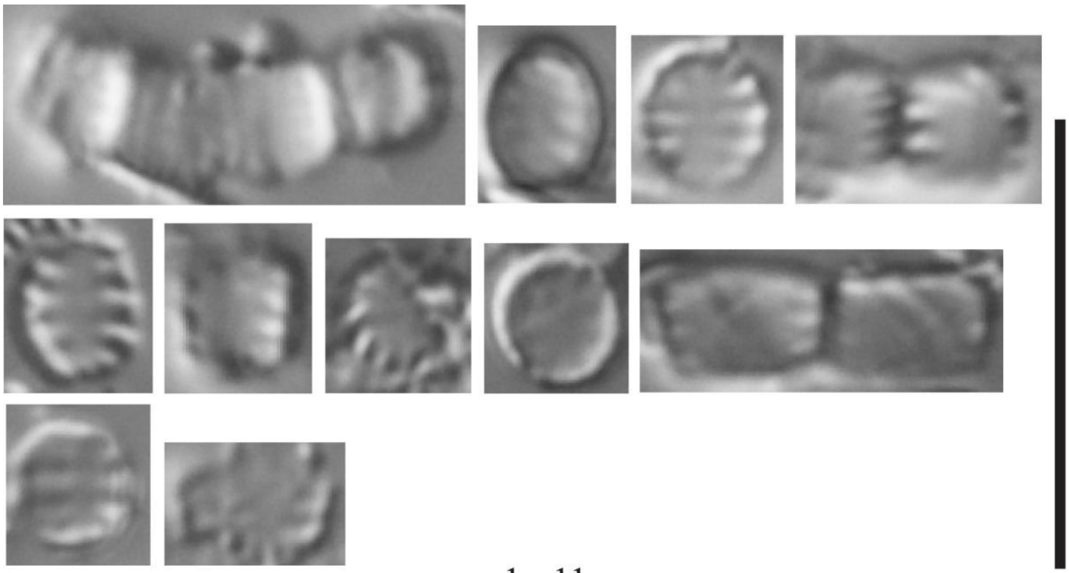
35 - 39

Plate 68 (Scale bars: Figs 1-11=10 µm; Figs 12-15=1 µm)

Staurosira punctiformis Witkowski, Metzeltin & Lange-Bertalot

Lit.: Witkowski, Lange-Bertalot & Metzeltin 2000, p. 78, 441; pl. 24, fig. 51-58, pl. 26, fig. 1-2

Figs 1-15: Sample BBDC00016, Barnegat Bay, NJ.



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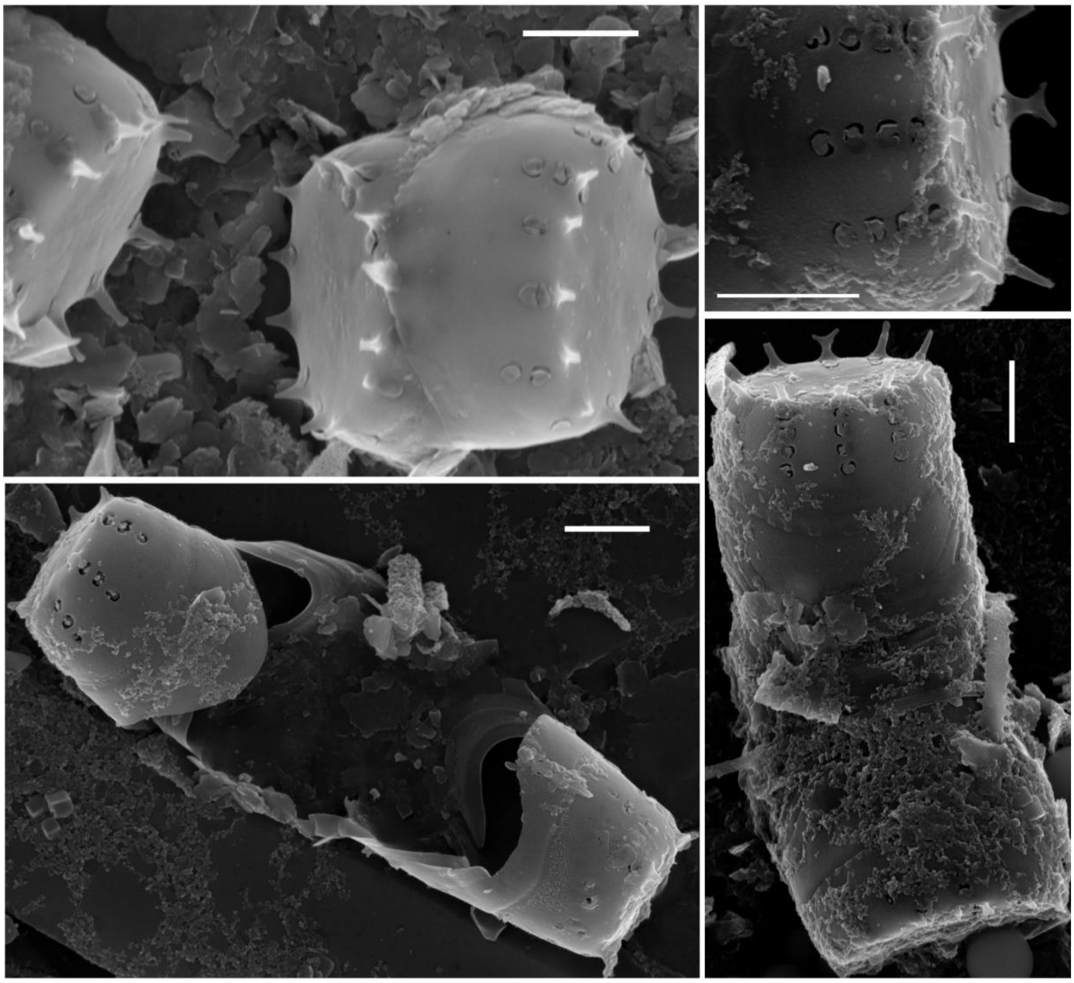


12 - 15

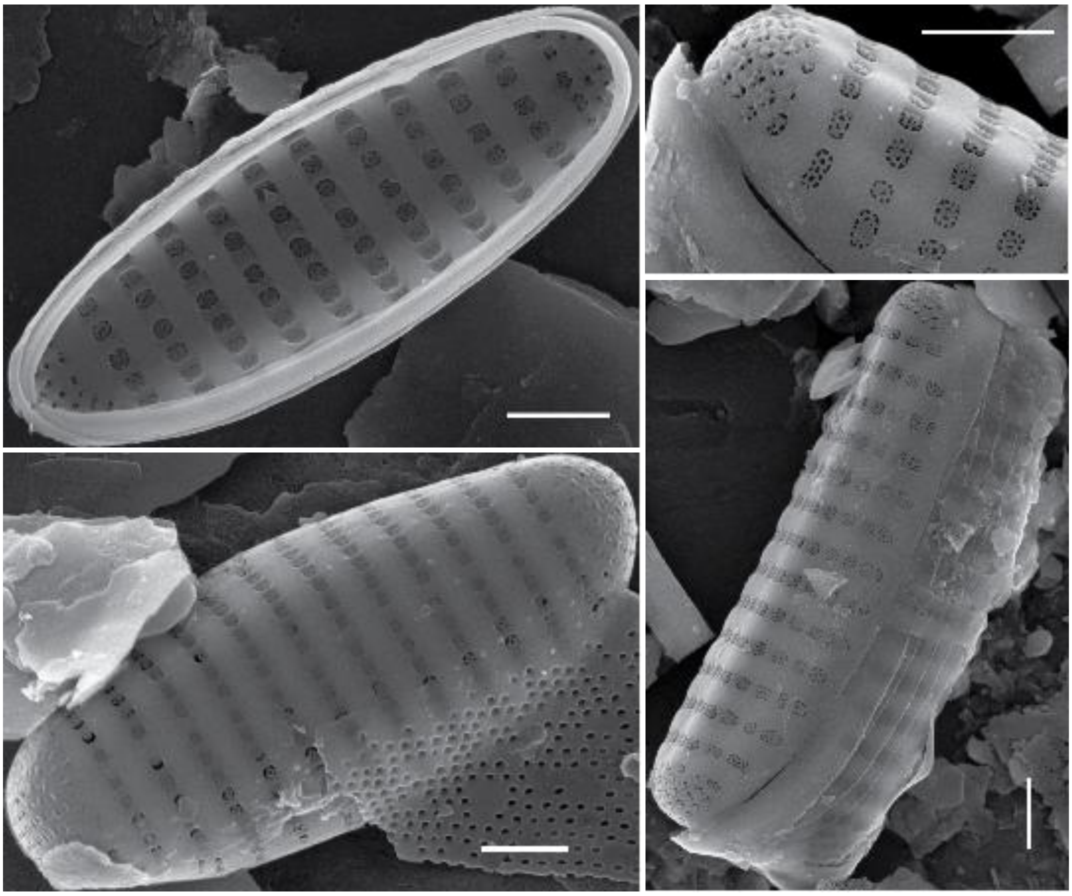
Plate 69 (Scale bar: Figs 1-20=10 µm)

Psammogramma vigoense Sato & Medlin

Lit.: Sato et al. 2008, p. 258; fig. 1-19

Figs 1-3,5-14,16-21,23,25: Sample BBDC0095, Great Bay, NJ.
Fig. 15: Sample BBDC00036, Barnegat Bay, NJ.
Figs 22: Sample COAST062, Great Bay, NY.
Figs 24: Sample COAST013, Great South Bay, NY.

1 - 21



22 - 25

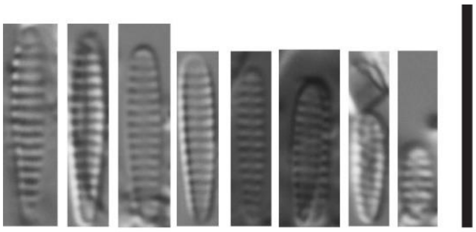
Plate 70(Scale bars: Figs 1-7,11-14=10 µm; Figs 8-10,15-16=1 µm)

Figs 1-10: ***Fragilaria gedanensis*** Witkowski
Lit.: Witkowski 1993, v. 56 (3-4): p. 498; fig. 1-18

Fig. 1: Sample BBDC0029, Barnegat Bay, NJ.
Figs 2,7-8: Sample BBDC0095, Great Bay, NJ.
Fig. 3: Sample BBDC00054, Barnegat Bay, NJ.
Fig. 4: Sample BB0055, Barnegat Bay, NJ.
Fig. 5: Sample BBDC0036, Barnegat Bay, NJ.
Fig. 6: Sample BBDC0002, Barnegat Bay, NJ.
Figs 9-11: Sample COAST022, Great South Bay, NY.

Figs 11-16: ***Fragilaria* sp. 1**

Figs 12-15,17: Sample BBDC0018, Barnegat Bay, NJ.
Fig. 16: Sample BBDC0016, Barnegat Bay, NJ.



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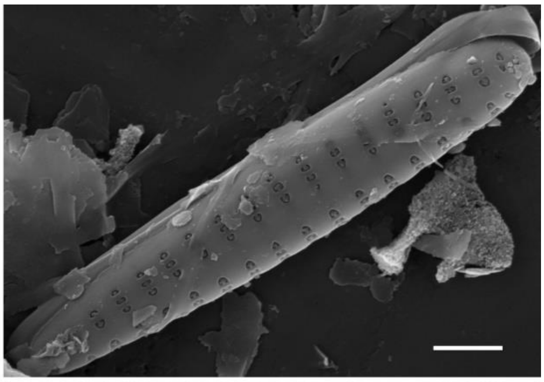
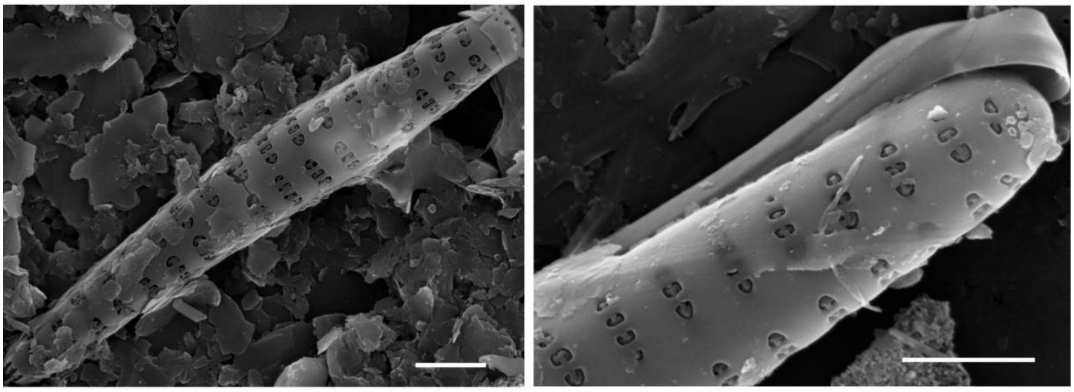
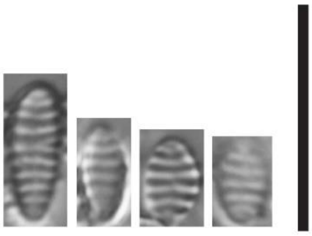
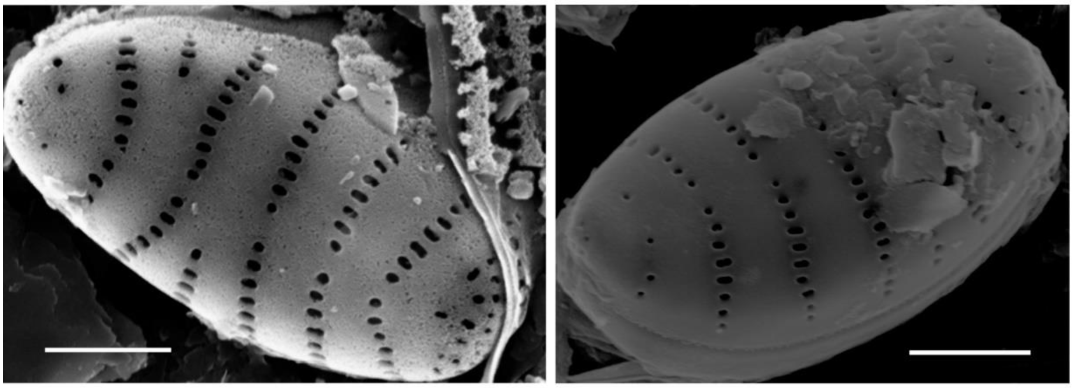




9 - 11



12 - 15



16 - 17

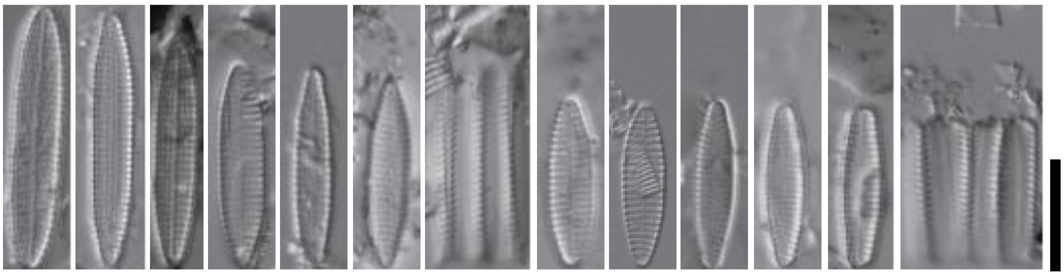
Plate 71 (Scale bars: Figs 1-13=10 µm; Figs 14-18=1 µm)

Pseudostaurosira subsalina (Hustedt) Morales

Lit.: Morales 2005, p. 115

Basionym: *Fragilaria construens* var. *subsalina* Hustedt 1925
Synonyms: *Fragilaria construens* f. *subsalina* (Hustedt) Hustedt 1957
Staurosira construens f. *subsalina* (Hustedt) Bukhtiyarova 1995

Fig. 1: Sample BB0065, Barnegat Bay, NJ.
Fig. 2: Sample BB0027, Barnegat Bay, NJ.
Fig. 3: Sample BB0071, Barnegat Bay, NJ.
Figs 4,6-8,10,13: Sample BB0031, Barnegat Bay, NJ.
Figs 11-12: Sample BB0032, Barnegat Bay, NJ.
Fig. 5: Sample BBDC0095, Great Bay, NJ.
Fig. 9: Sample BBDC00028, Barnegat Bay, NJ.
Figs 14-18: Sample BB0029, Barnegat Bay, NJ.



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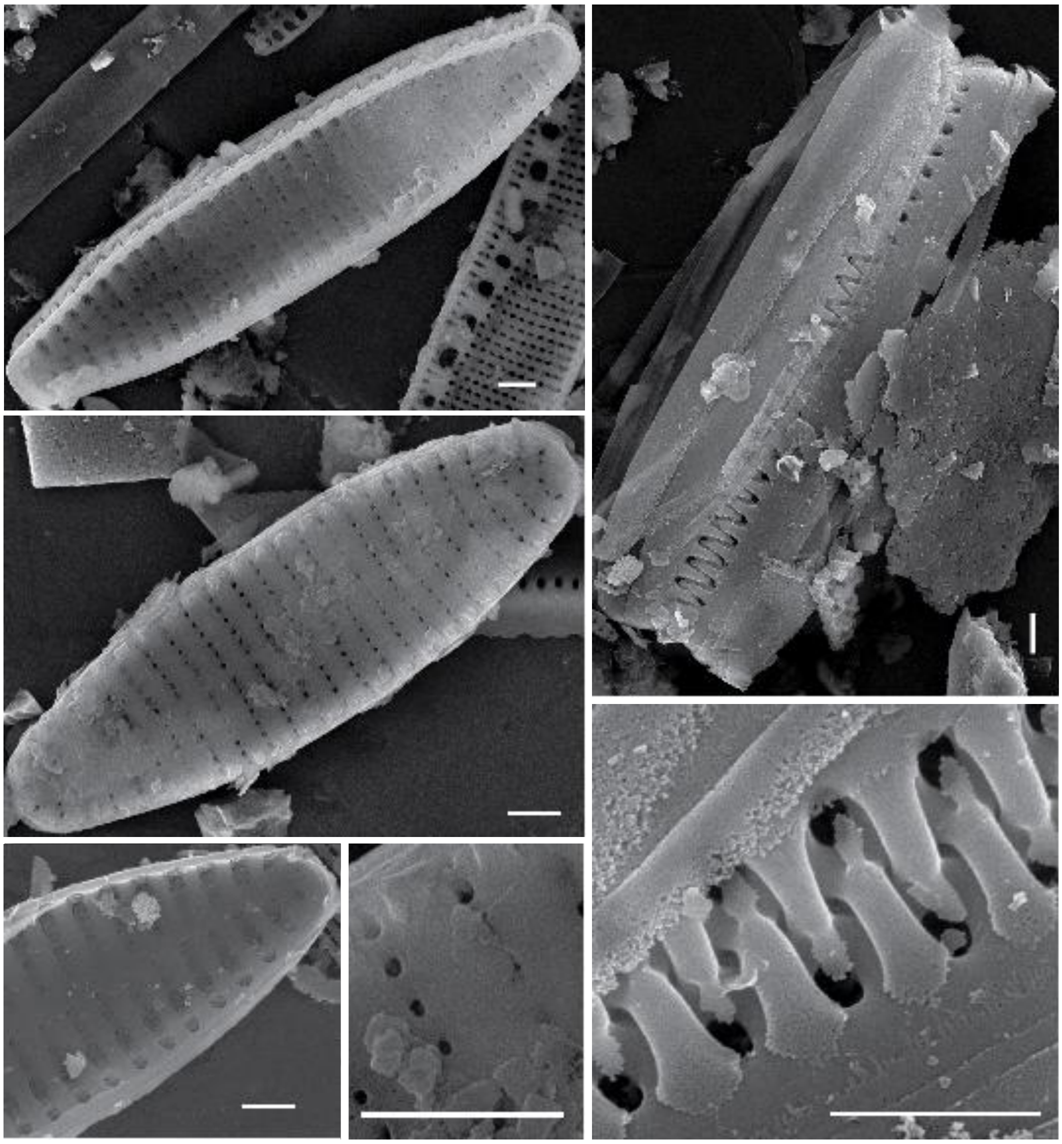


14 - 18

Plate 72 (Scale bars: Figs 1-21=10 µm; Figs 22-25=1 µm)

Pseudostaurosira perminuta (Grunow) Sabbe & Vyverman

Lit.: Sabbe & Vyverman 1995, p. 237; fig. 1-12, 54-60

Basionym: *Sceptroneis marina* var. *perminuta* Grunow in Van Heurck 1881

Synonyms: *Grunoviella (Grunowiella) perminuta* (Grunow in Van Heurck) Peragallo & Peragallo 1901

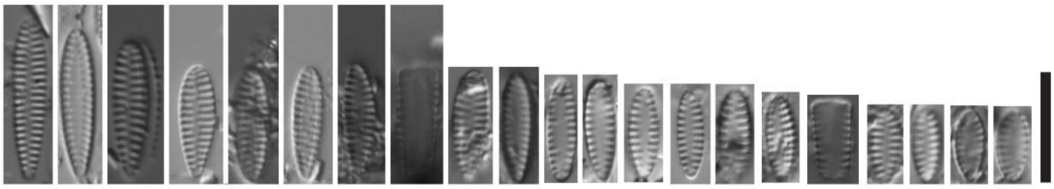
Opephora marina var. *perminuta* (Grunow in Van Heurck) Proschkina-Lavrenko 1950

Opephora perminuta (Grunow in Van Heurck) Frenguelli 1938

Sceptroneis marina var. *perminuta* Grunow in Van Heurck 1881

Grunovia perminuta (Grunow) H. Peragallo & M. Peragallo 1901

Figs 1,3,5,7-8: Sample BBDC00002, Barnegat Bay, NJ.
Fig. 2: Sample COAST029, Western Bay, NY.
Figs 4,6,23-25: Sample COAST031, Western Bay, NY.
Figs 9,18-19: Sample BBDC0095, Great Bay, NJ.
Figs 10,17: Sample BBDC00003, Barnegat Bay, NJ.
Figs 11,13,21: Sample BB0032, Barnegat Bay, NJ.
Fig. 12: Sample COAST062, Great Bay, NY.
Fig. 14: Sample COAST025, Great South Bay, NY.
Fig. 15: Sample BB0060, Barnegat Bay, NJ.
Fig. 16: Sample BB0054, Barnegat Bay, NJ.
Fig. 20: Sample BB0001, Barnegat Bay, NJ.
Fig. 22: Sample COAST010, Great South Bay, NY.



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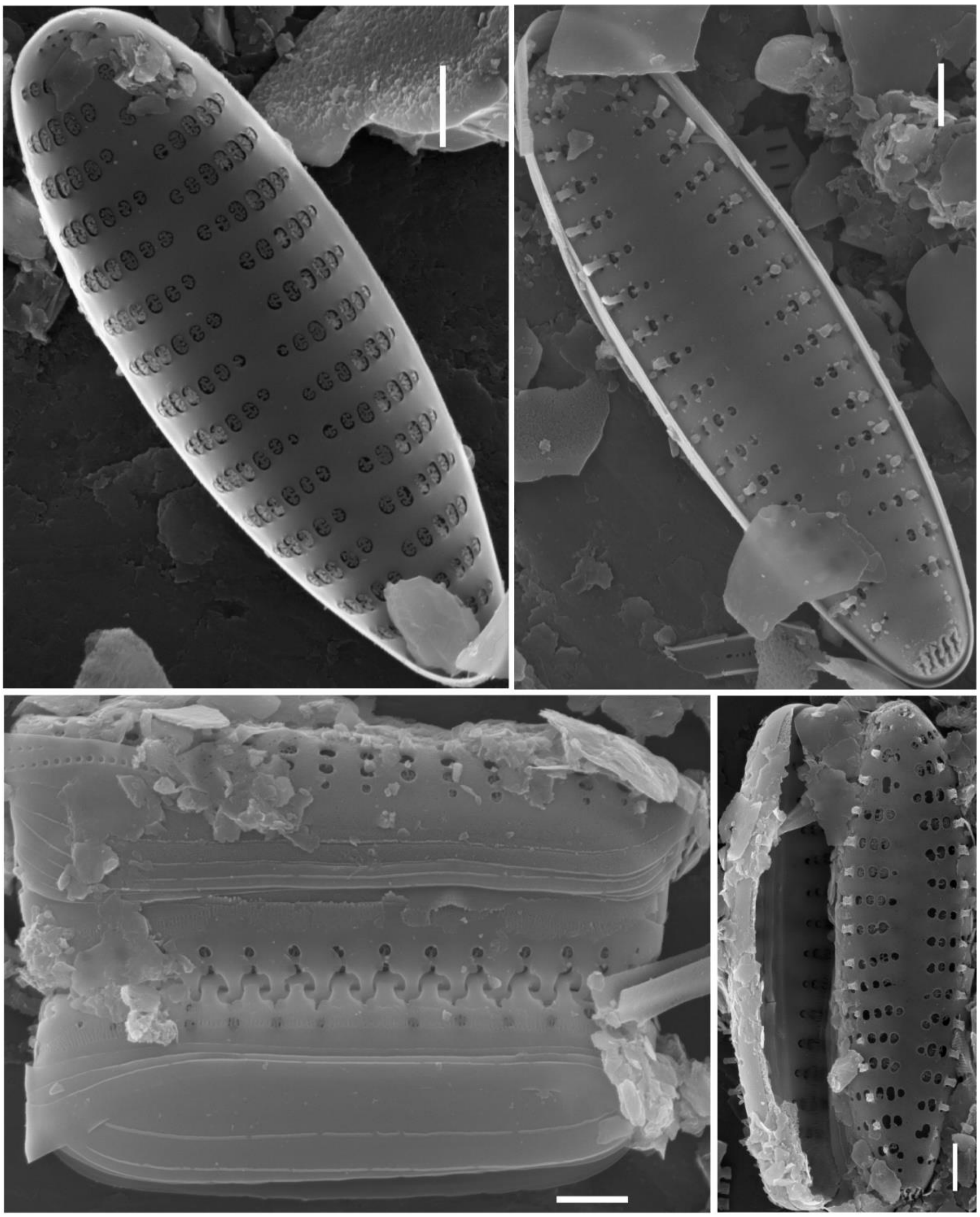


22 - 25

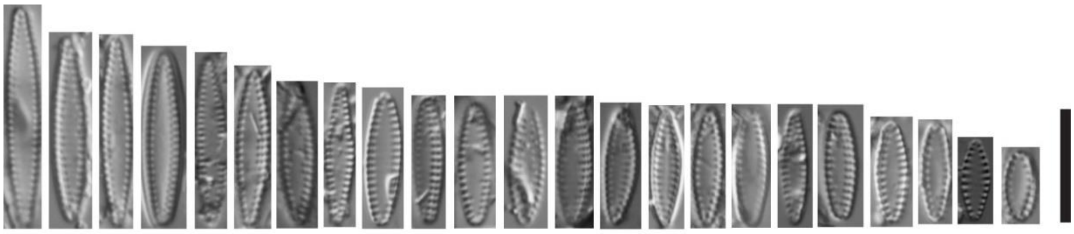
Plate 73 (Scale bars: Figs 1-23=10 µm; Figs 24-29=1 µm)

Pseudostaurosira medliniae Williams & Morales

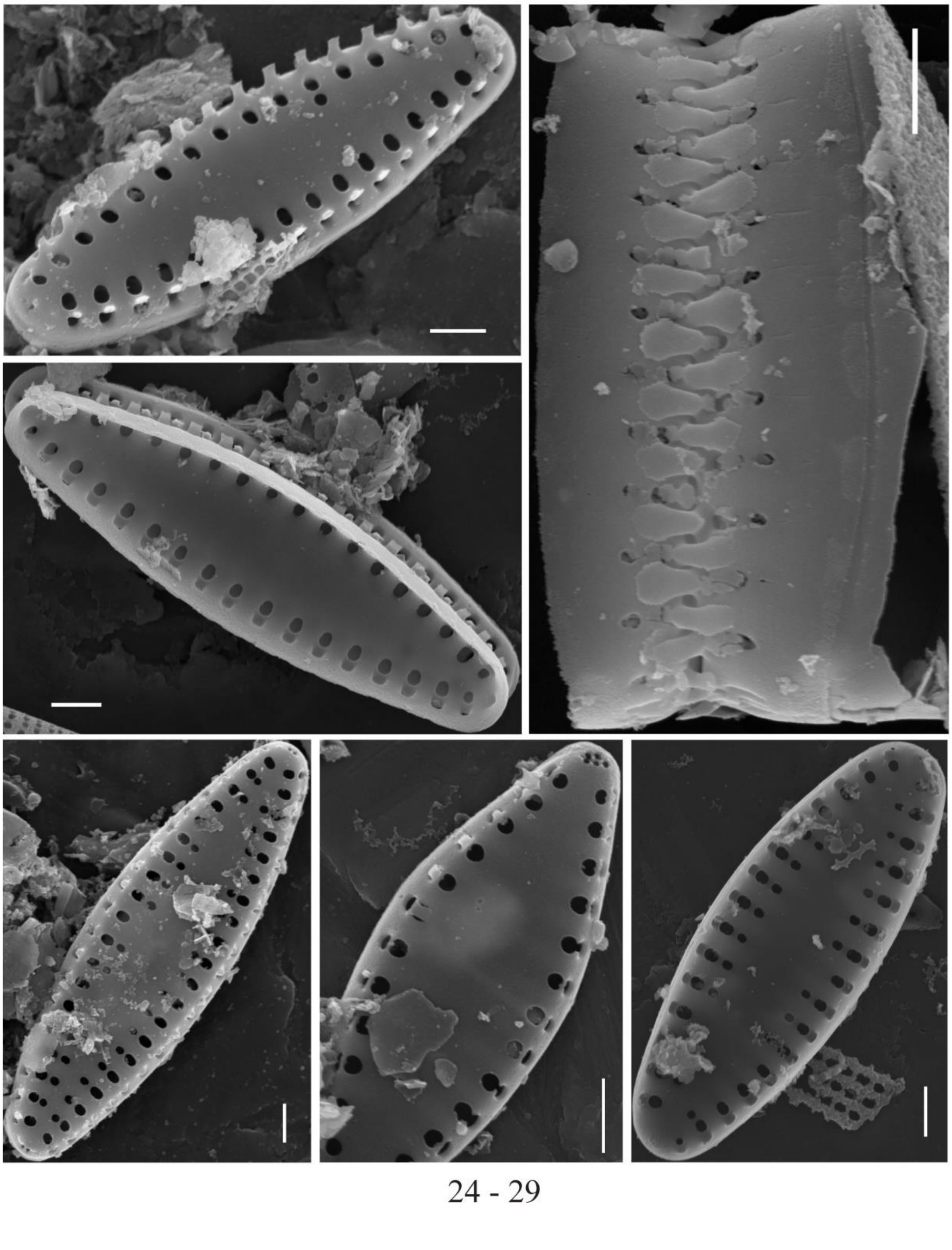
Lit.: Williams & Morales 2010, p. 226-226

Synonyms: *Fragilaria zeilleri* var. *elliptica* Gasse 1980
Pseudostaurosira elliptica (F. Gasse) I. Jung & L.K. Medlin in L. Medlin et al. 2008
Pseudostaurosira zeilleri var. *elliptica* (F. Gasse) Kulikovskiy 2008

Figs 1,3,6,8-11,16-17,19-21,25-28: Sample BB0032, Barnegat Bay, NJ.
Fig. 2: Sample BBDC0095, Great Bay, NJ.
Figs 4,15: Sample COAST053, Barnegat Bay, NJ.
Fig. 5: Sample BB0067, Barnegat Bay, NJ.
Figs 7,13: Sample BB0069, Barnegat Bay, NJ.
Fig. 12: Sample BBDC00029, Barnegat Bay, NJ.
Fig. 14: Sample BBEDC061, Cattus Island, NJ.
Fig. 18: Sample BBDC00001, Barnegat Bay, NJ.
Figs 22-23: Sample BBDC00004, Barnegat Bay, NJ.
Figs 24,29: Sample BB0031, Barnegat Bay, NJ.



1 - 23

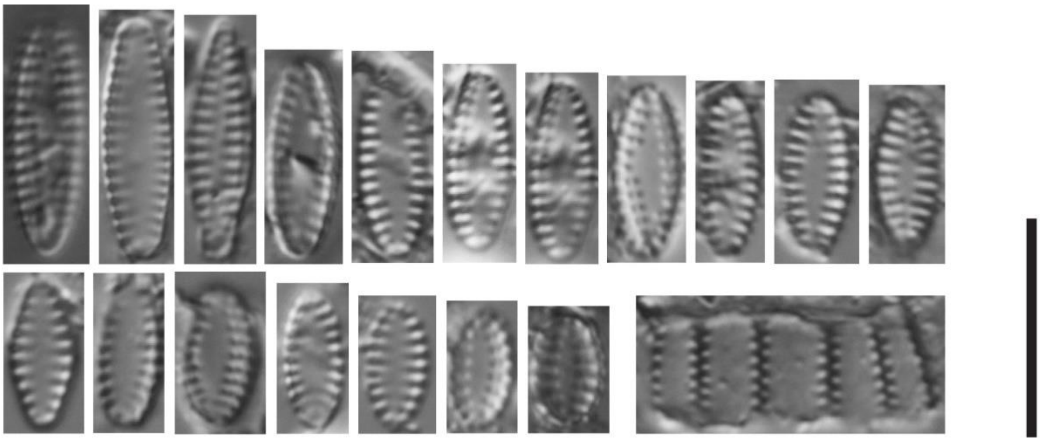


24 - 29

Plate 74 (Scale bars: Figs 1-12=10 µm; Figs 13-15=1 µm)

Pseudostaurosira sp. 1

Figs 1: Sample BBDC00003, Barnegat Bay, NJ.
Fig. 2-11,13,15,17: Sample BB0032, Barnegat Bay, NJ.
Fig. 3: Sample BBDC0095, Great Bay, NJ.
Figs 12,16,20,22-23: Sample BBDC00016, Barnegat Bay, NJ.
Fig. 14: Sample BB0069, Barnegat Bay, NJ.
Fig. 18: Sample BB0054, Barnegat Bay, NJ.
Fig. 19: Sample BBDC00017, Barnegat Bay, NJ.
Fig. 21: Sample BBDC00018, Barnegat Bay, NJ.



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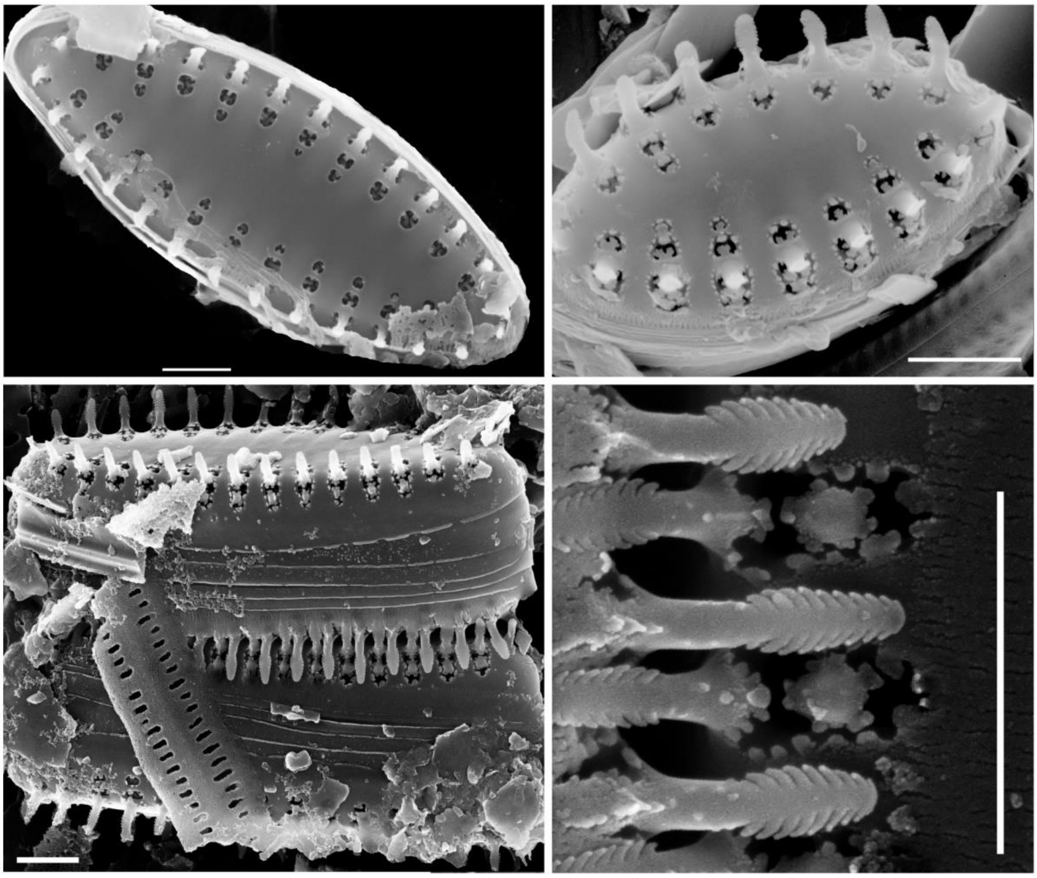


20 - 23

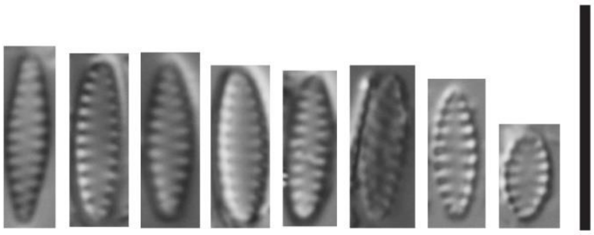
Plate 75 (Scale bars: Figs 1-8; 12-14=10 µm; Figs 9-11; 15-16=1 µm)

Figs 1-11: ***Pseudostaurosira* sp. 2** Williams & Morales

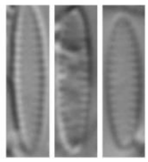
Figs 1,6: Sample BBDC00029, Barnegat Bay, NJ.
Fig. 2: Sample BBEDC058, Cattus Island, NJ.
Figs 3,7,9-11: Sample BBDC00016, Barnegat Bay, NJ.
Fig. 4: Sample BBDC00018, Barnegat Bay, NJ.
Fig. 5: Sample BBDC0095, Great Bay, NJ.
Fig. 8: Sample COAST053, Barnegat Bay, NY.

Figs 12-16: ***Pseudostaurosiropsis* sp. 1**

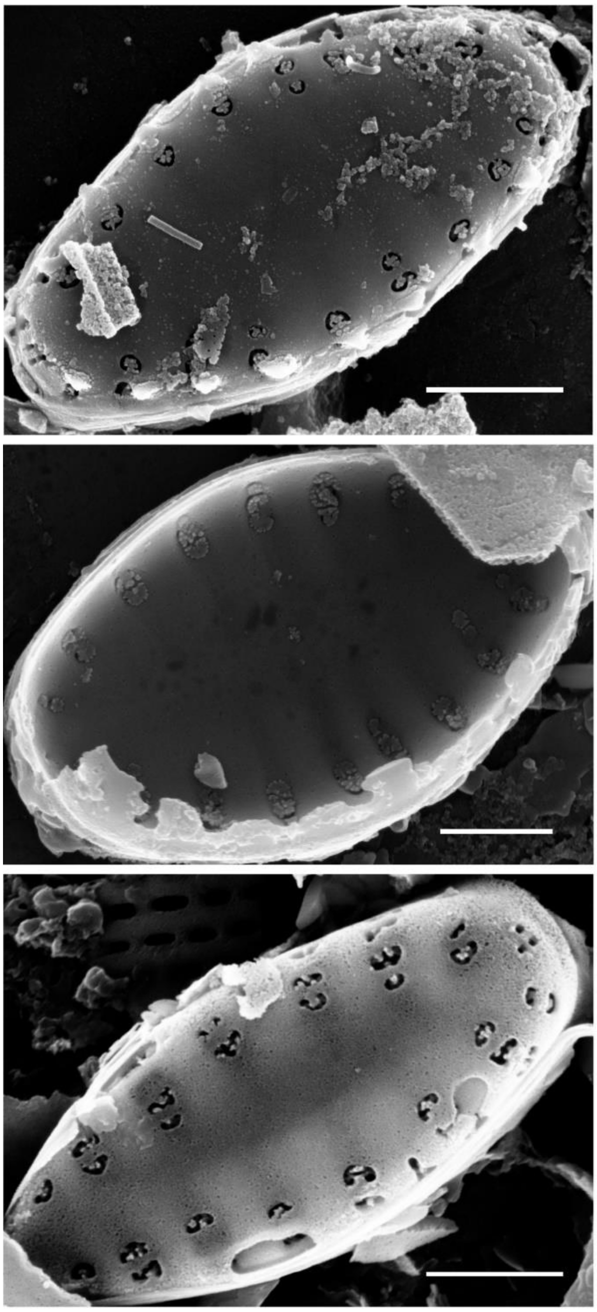
Figs 12,14: Sample COAST022, Great South Bay, NY.
Fig. 13: Sample BBDC0095, Great Bay, NJ.
Fig. 15: Sample BBDC00028, Barnegat Bay, NJ.
Fig. 16: Sample BBDC00038, Barnegat Bay, NJ.



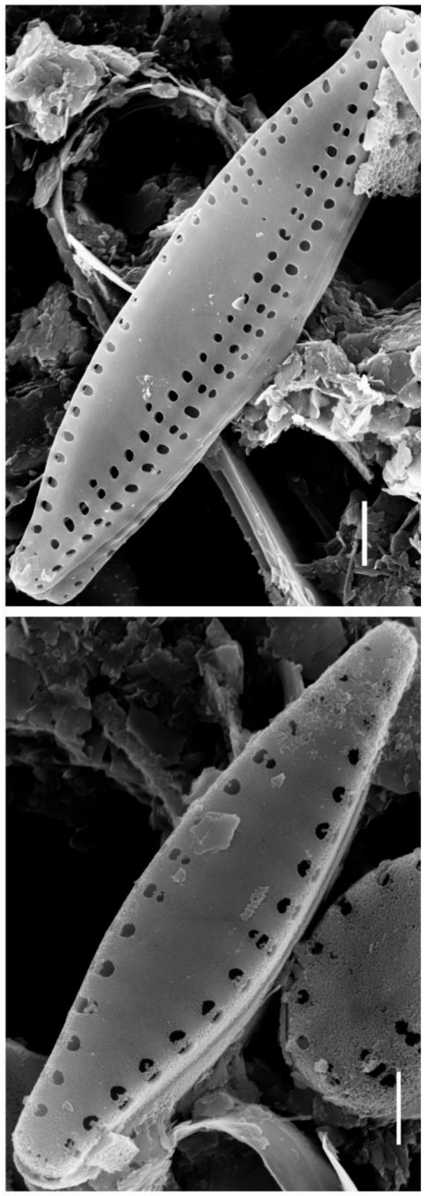
1 - 8



12 - 14



9 - 11

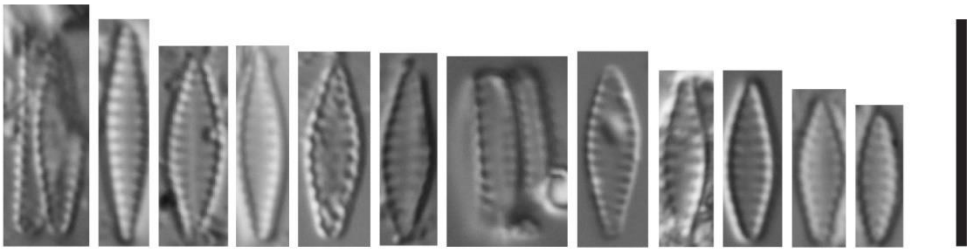


15 - 16

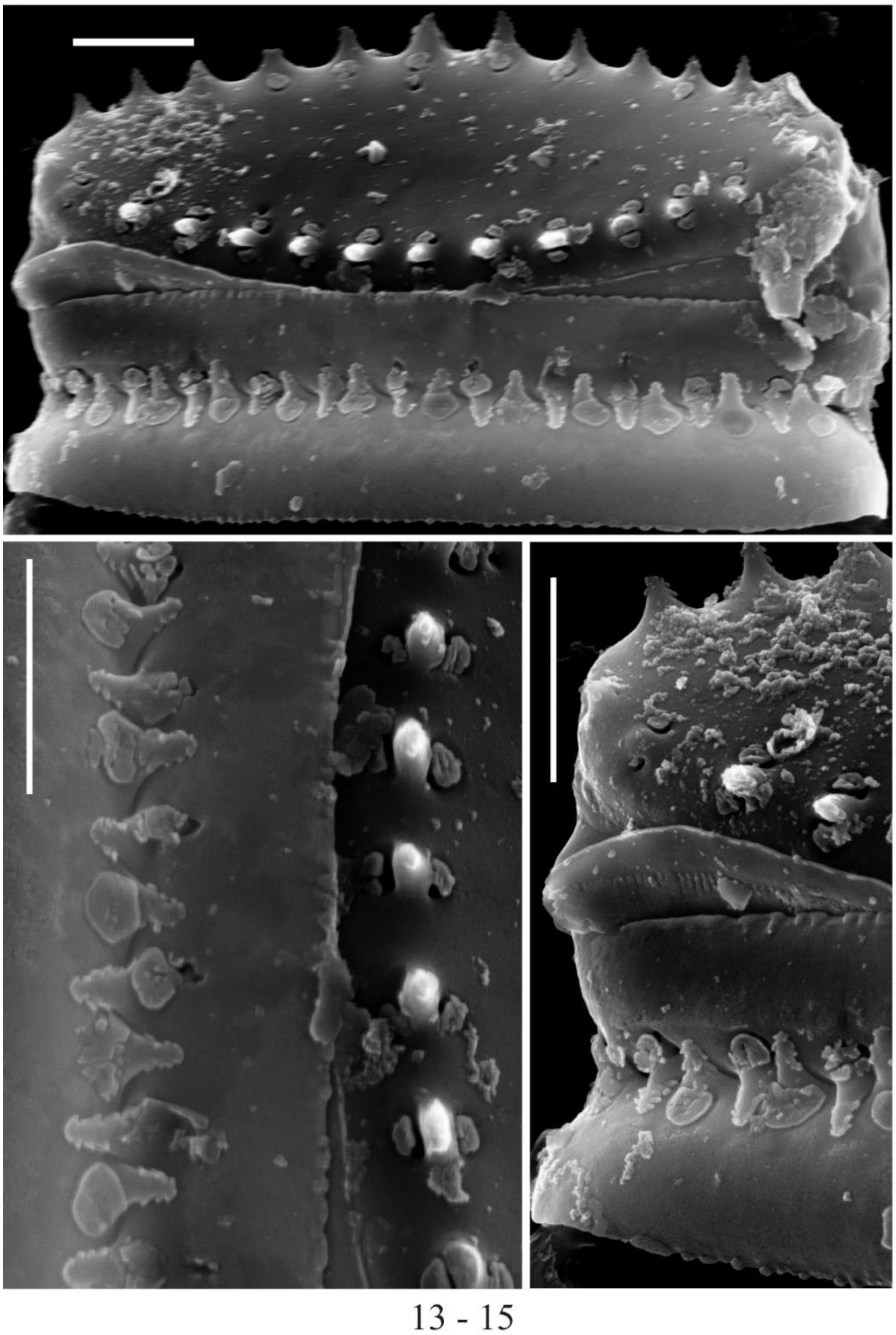
Plate 76 (Scale bars: Figs 1-12=10 µm; Figs 13-15=1 µm)

***Pseudostaurosiropsis* sp. 2**

Fig. 1: Sample BB0065, Barnegat Bay, NJ.
Fig. 2: Sample BBDC00029, Barnegat Bay, NJ.
Figs 3,9: Sample BB0032, Barnegat Bay, NJ.
Fig. 4: Sample BB0009, Barnegat Bay, NJ.
Fig. 5: Sample BB0010, Barnegat Bay, NJ.
Fig. 6: Sample BBDC00018, Barnegat Bay, NJ.
Figs 7,11,13-15: Sample BBDC00016, Barnegat Bay, NJ.
Fig. 8: Sample BBDC0095, Great Bay, NJ.
Fig. 10: Sample BBDC00017, Barnegat Bay, NJ.
Fig. 12: Sample BB0055, Barnegat Bay, NJ.



1 - 12

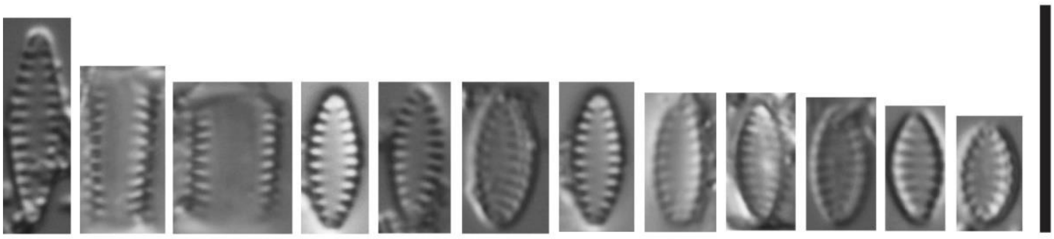


13 - 15

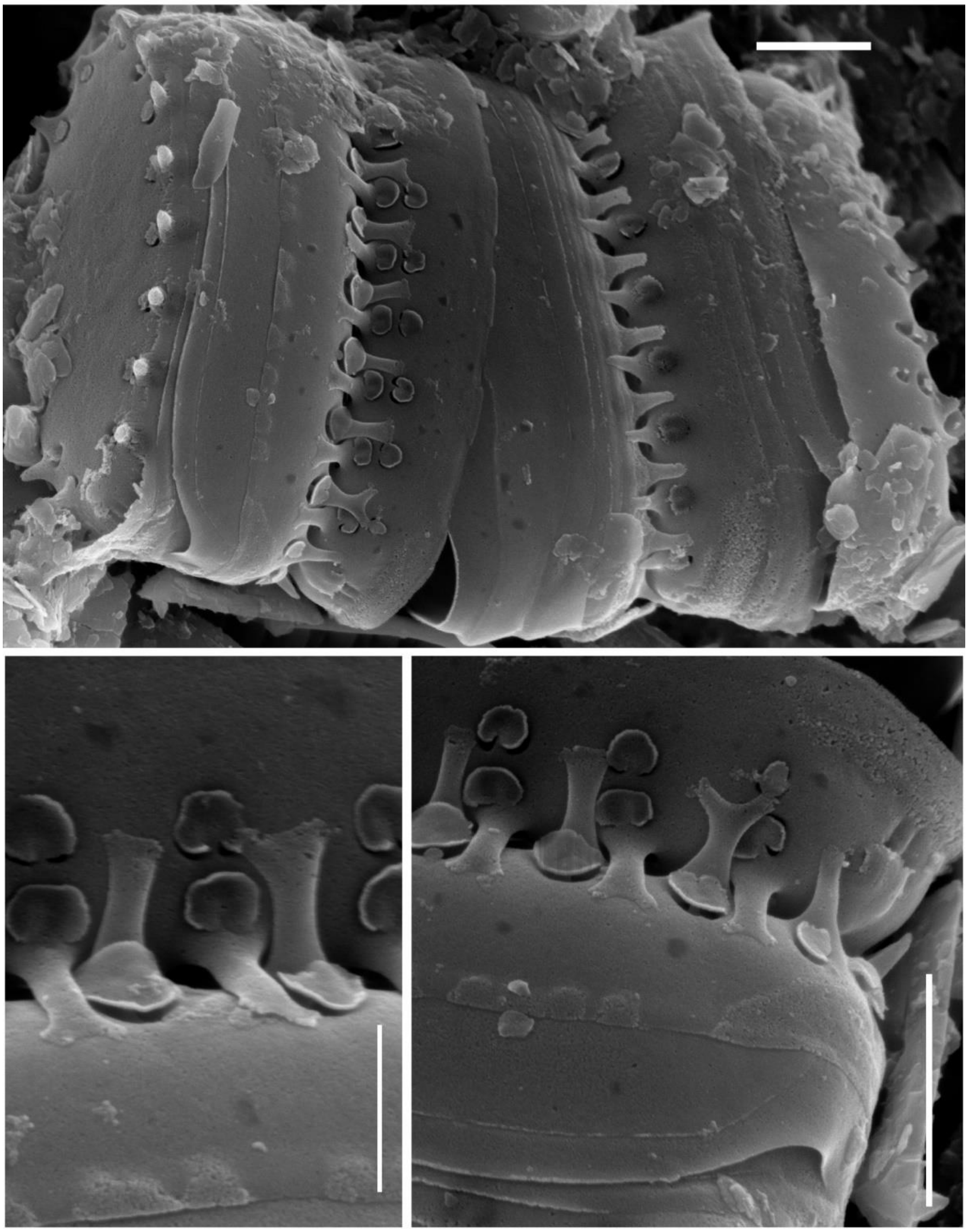
Plate 77 (Scale bars: Figs 1-12=10 µm; Figs 13-15=1 µm)

***Pseudostaurosiropsis* sp. 4**

Fig. 1: Sample BBEDC058, Cattus Island, NJ.
Figs 2-3,9: Sample BB0001, Barnegat Bay, NJ.
Figs 4,7-8,11: Sample BBDC00016, Barnegat Bay, NJ.
Figs 5,10: Sample BBEDC059, Cattus Island, NJ.
Fig. 6: Sample BBEDC061, Cattus Island, NJ.
Fig. 12: Sample BBEDC098, Cattus Island, NJ.
Figs 13-15: Sample BBDC00038, Barnegat Bay, NJ.



1 - 12



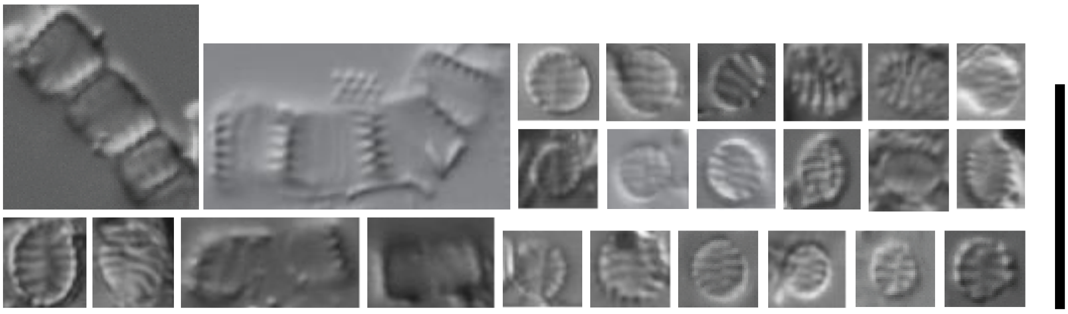
13 - 15

Plate 78 (Scale bars: Figs 1-24=10 μm; Figs 25-27=1 μm)

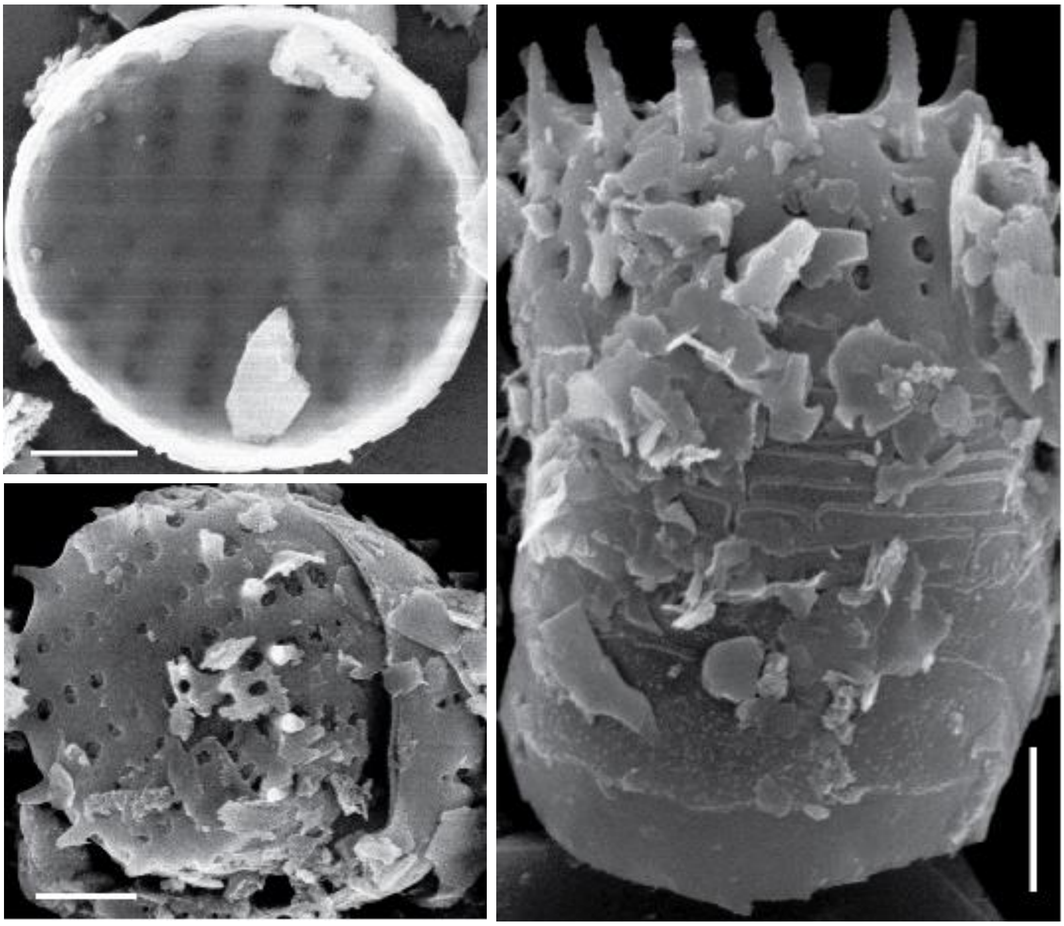
Pseudostaurosira trainorii Morales

Lit.: Morales 2001, p. 113; fig. 6:a-l

Figs 1,17,19,24: Sample BBDC00016, Barnegat Bay, NJ.
Figs 2-4,10: Sample BBDC00046, Barnegat Bay, NJ.
Fig. 5: Sample BB0073, Barnegat Bay, NJ.
Fig. 6: Sample BB0072, Barnegat Bay, NJ.
Fig. 7: Sample BB0067, Barnegat Bay, NJ.
Fig. 8: Sample BB0002, Barnegat Bay, NJ.
Fig. 9: Sample BBEDC058, Cattus Island, NJ.
Fig. 11: Sample BBDC00051, Barnegat Bay, NJ.
Fig. 12: Sample BBDC00052, Barnegat Bay, NJ.
Fig. 13: Sample BB0064, Barnegat Bay, NJ.
Fig. 14: Sample BB0009, Barnegat Bay, NJ.
Fig. 15: Sample BB0052, Barnegat Bay, NJ.
Fig. 16: Sample BB0060, Barnegat Bay, NJ.
Fig. 18: Sample BBEDC059, Cattus Island, NJ.
Fig. 20: Sample BB0008, Barnegat Bay, NJ.
Figs 21,25-27: Sample BB0001, Barnegat Bay, NJ.
Fig. 22: Sample COAST051, Barnegat Bay, NY.
Fig. 23: Sample BB0055, Barnegat Bay, NJ.



1 - 24

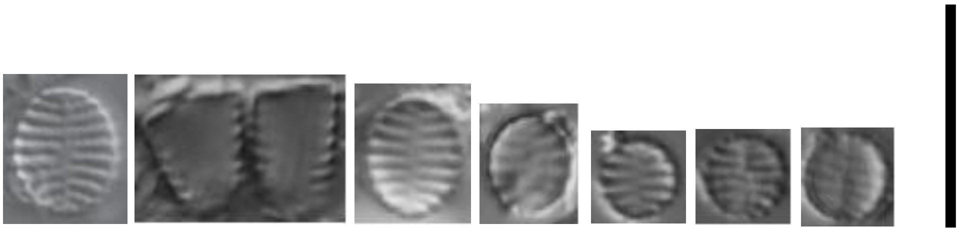


25 - 27

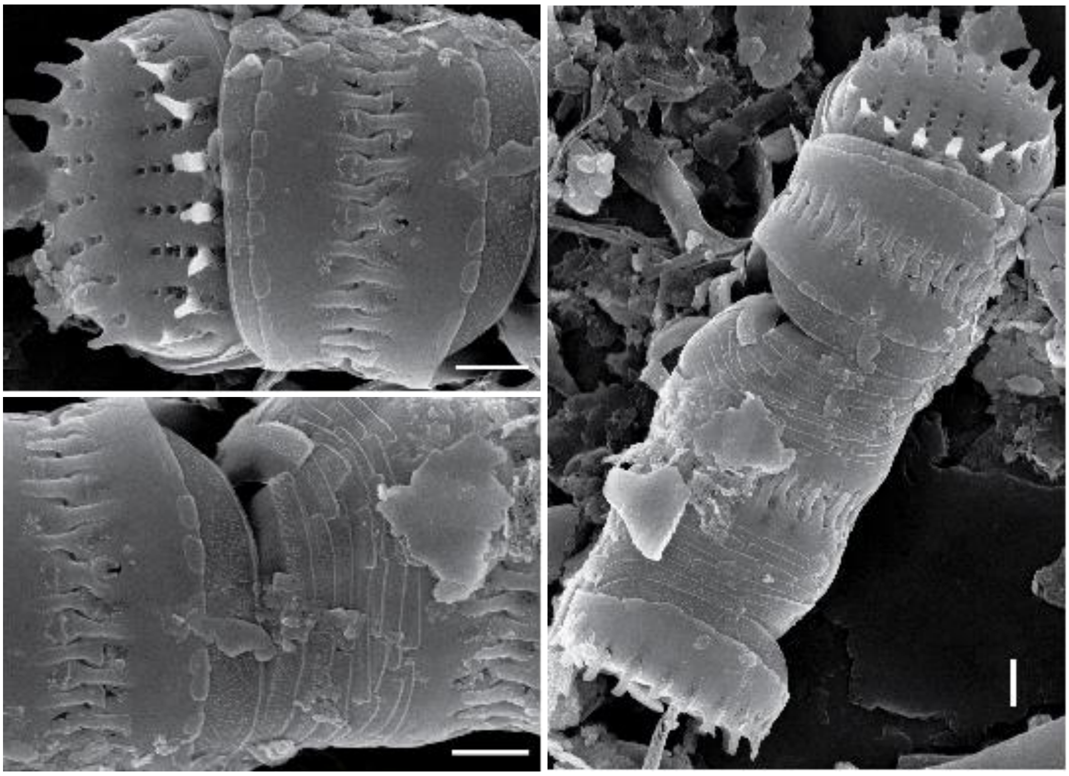
Plate 79 (Scale bars: Figs 1-7=10 µm, Figs 8-10=1 µm)

Fragilaria sopotensis Witkowski & Lange-Bertalot
Lit.: Witkowski & Lange-Bertalot 1993, v. 23 (1): p. 67; fig. 6a-p

Fig. 1: Sample BB0002, Barnegat Bay, NJ.
Figs 2,6: Sample BBDC00003, Barnegat Bay, NJ.
Figs 3,4: Sample BB0001, Barnegat Bay, NJ.
Fig. 5: Sample BBEDC098, Cattus Island, NJ.
Fig. 7: Sample BBEDC059, Cattus Island, NJ.
Figs 8-10: Sample BBDC00028, Barnegat Bay, NJ.



1 - 7



8 - 10

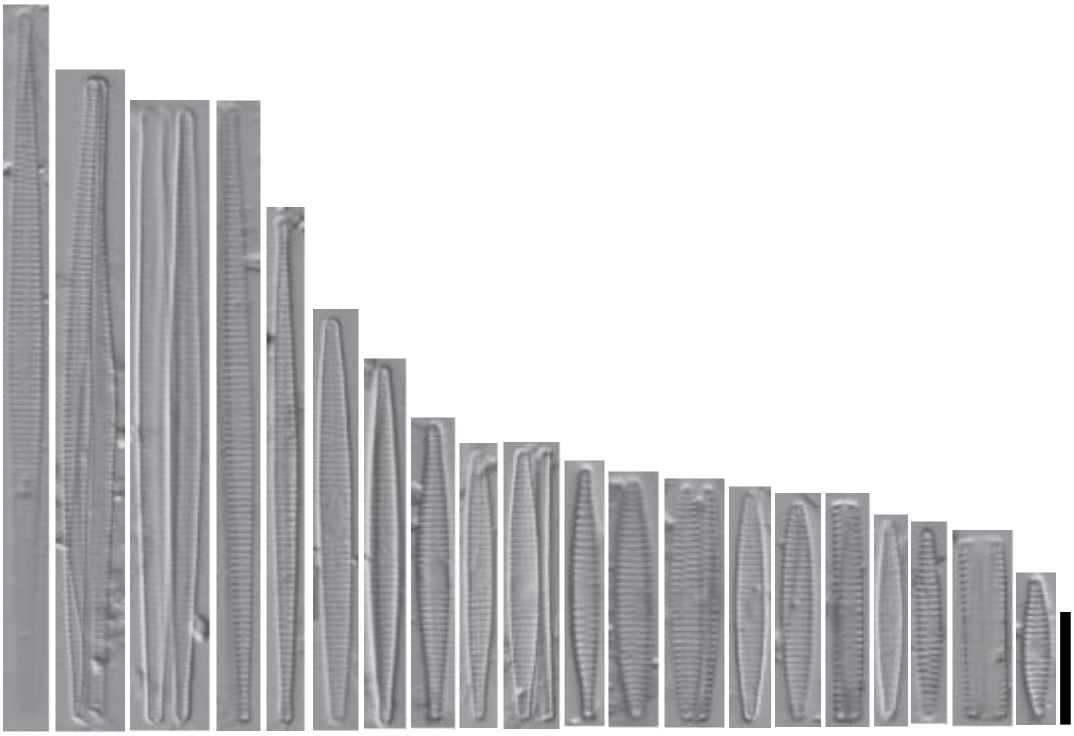
Plate 80 (Scale bar: Figs 1-20=10 µm)

Synedra famelica Kützing

Lit.: Kützing 1844, p. 64; pl. 14/8, fig. 1

Synonyms: *Nitzschia palea* f. *famelica* (Kützing) Rabenhorst 1864
Nitzschia palea var. *famelica* (Kützing) M. Peragallo 1903
Fragilaria famelica (Kützing) Lange-Bertalot 1980
Nitzschia famelica (Kützing) Rabenhorst 1863

Figs 1-20: Sample RUTG0795, Tuckerton Bay, NJ.



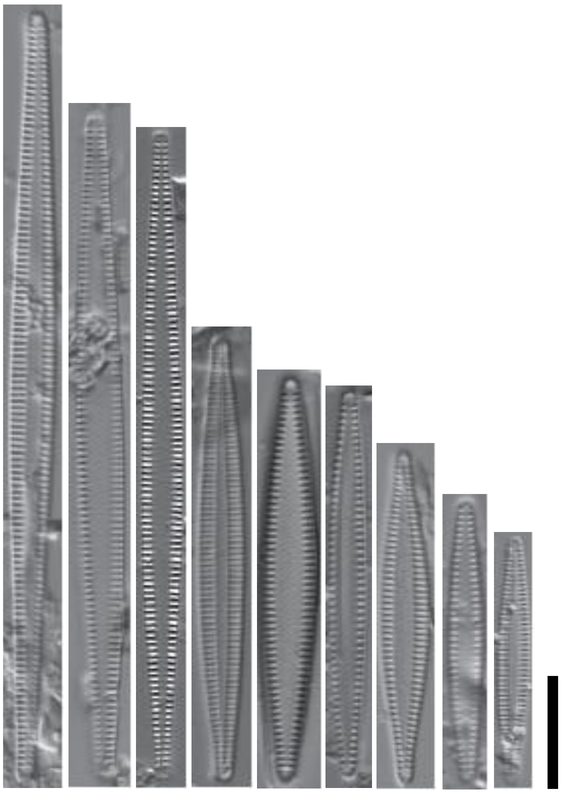
1 - 20

Plate 81 (Scale bars: Figs 1-9=10 µm; 10=1 µm)

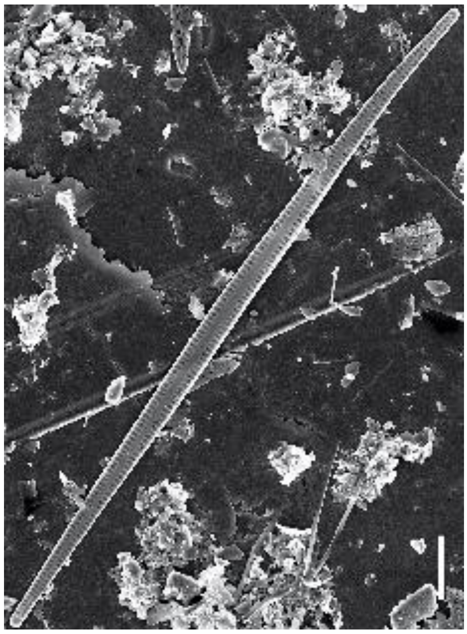
Tabularia fasciculata (Agardh) Williams & Round
Lit.: Williams & Round 1986, p. 326; fig. 46-52

Synonyms: *Ctenophora pulchella* var. *fasciculata* (Agardh ex specim., Kützing) Schonfeldt 1907
Exilaria fasciculata Kützing 1833
Echinella fasciculata (Agardh) Jurgens 1816-1822
Fragilaria fasciculata (Agardh) Lange-Bertalot 1980
Exilaria fasciculata (Agardh) Greville 1827
Lyngbyea fasciculata (Agardh) Sommerfelt 1826
Diatoma fasciculata Agardh 1812

Figs 1,5: Sample BBDC00044, Barnegat Bay, NJ.
Fig. 2: Sample BBDC00047, Barnegat Bay, NJ.
Fig. 3: Sample BBDC00048, Barnegat Bay, NJ.
Fig. 4: Tuckerton Bay, NJ.
Fig. 6: Sample BBDC00008, Barnegat Bay, NJ.
Fig. 7: Sample BBDC00051, Barnegat Bay, NJ.
Fig. 8: Sample BB0009, Barnegat Bay, NJ.
Figs 9-10: Sample BBDC00052, Barnegat Bay, NJ.



1 - 9

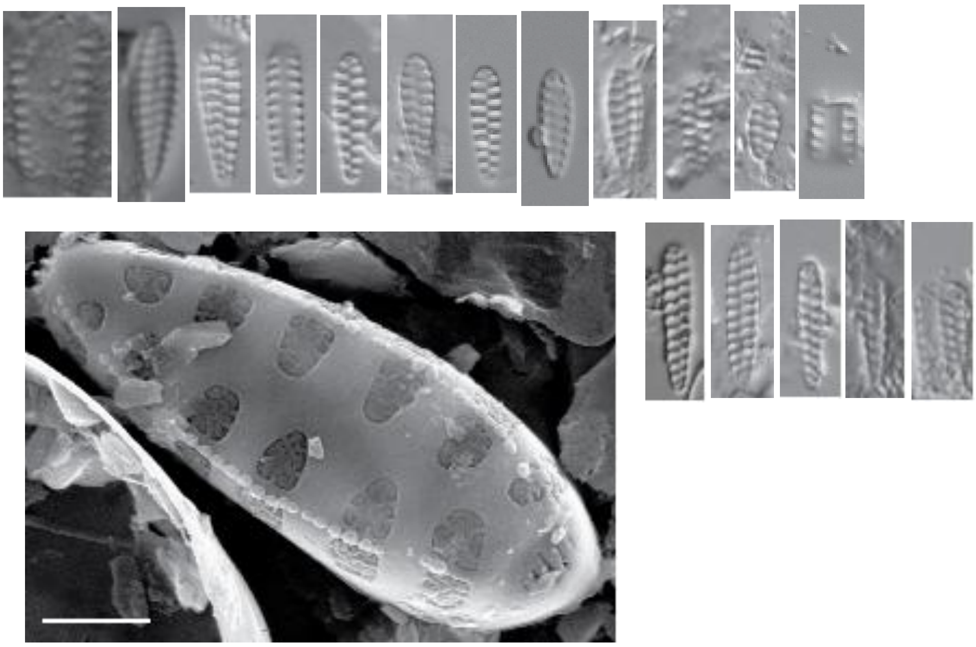


10

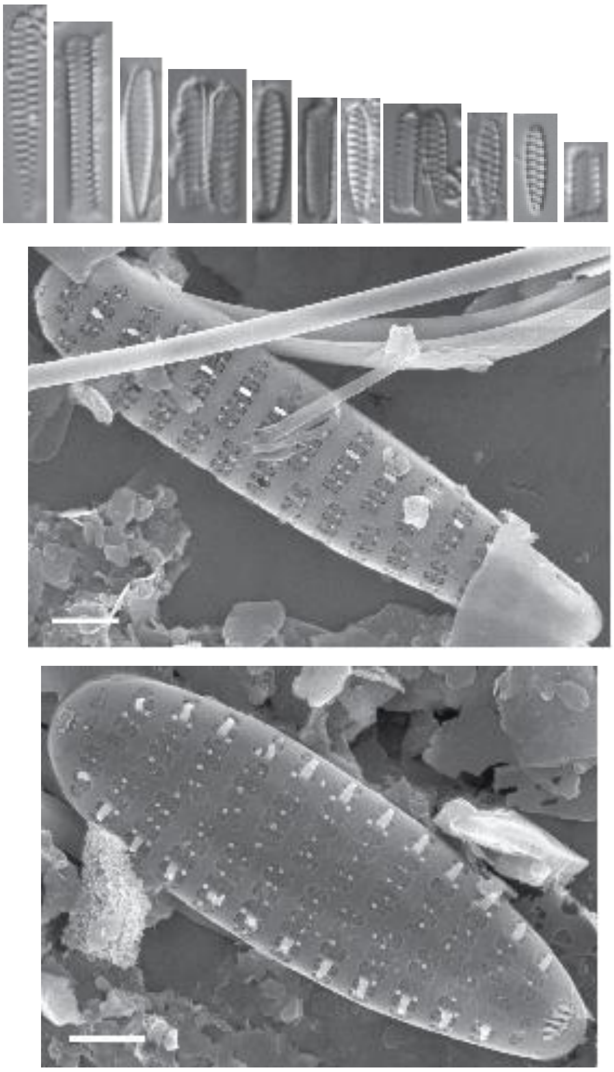
Plate 82 (Scale bars: Figs 1-16; 19-35=10 µm; Figs 18; 36-37=1 µm)

Figs 1-18: ***Opephora* sp. 2**

Figs 19-37: ***Opephora* sp. 8**



1 - 17

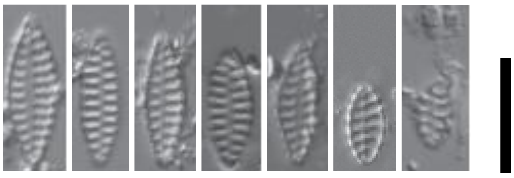


19 - 37

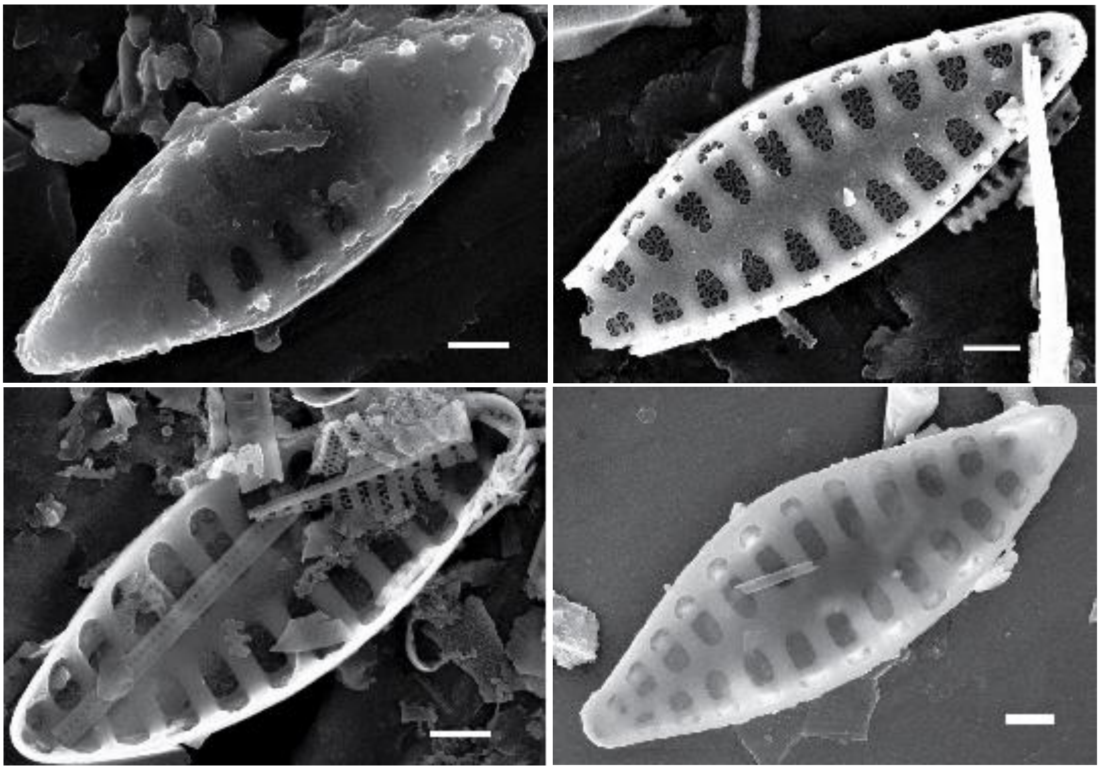
Plate 83 (Scale bars: Figs 1-7=10 µm; Figs 9-11=1 µm)

Opephora sp. 13

Fig. 1: Sample BBDC00109, Great Bay, NJ.
Fig. 2: Sample BB0029, Barnegat Bay, NJ.
Figs 3,8: Sample COAST015, Great South Bay, NY.
Figs 4,7,9: Sample COAST054, Barnegat Bay, NY.
Figs 5-6: Sample COAST096, Cape May Peninsula, NJ.



1 - 7

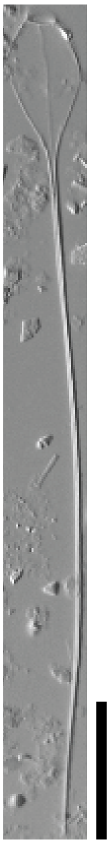


9 - 11

Plate 84 (Scale bars: Figs 1-6=10 µm)

Asterionellopsis glacialis (Castracane) Round
Lit.: Round, Crawford & Mann 1990, p. 664

Fig. 1: Sample BBDC00109, Great Bay, NJ.
Fig. 2: Sample BB0029, Barnegat Bay, NJ.
Figs 3,8: Sample COAST015, Great South Bay, NY.
Figs 4,7,9: Sample COAST054, Barnegat Bay, NY.
Figs 5-6: Sample COAST096, Cape May Peninsula, NJ.



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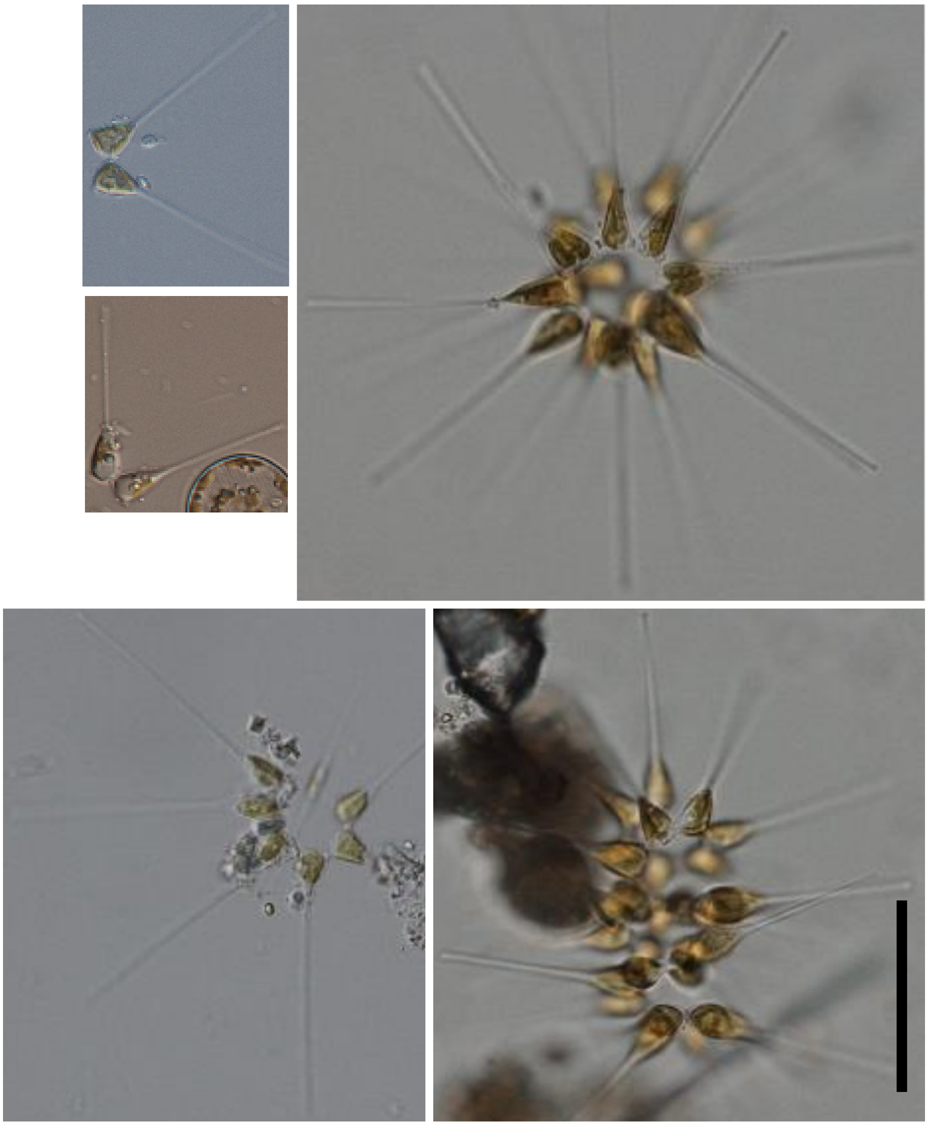


2- 6

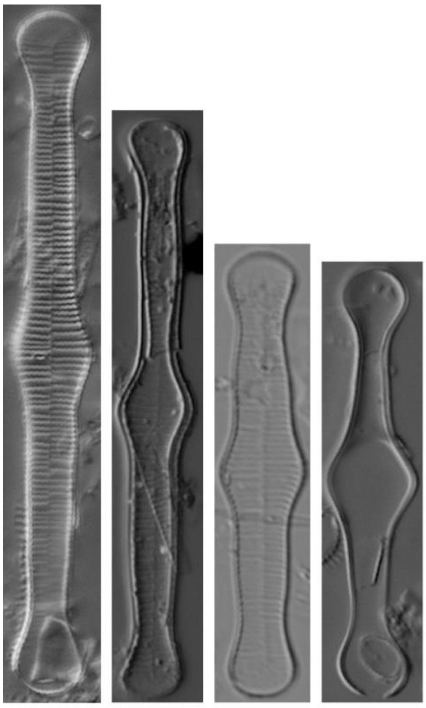
Plate 85 (Scale bars: Figs 1-8=10 μm)

Figs 1-4: ***Tabellaria fenestrata*** (Lyngbye) Kützing
Lit.: Kützing 1844, p. 127; pl. 17, fig. 22, pl. 18, fig. 2
Basionym: *Diatoma fenestratum* Lyngbye 1819
Synonyms: *Striatella fenestrata* (Lyngbye) Kuntze 1898
Tabellaria flocculosa var. *fenestrata* (Lyngbye) Rabenhorst 1847
Figs 1,4: Sample BBDC00007, Barnegat Bay, NJ.
Fig. 2: Sample BBDC00004, Barnegat Bay, NJ.
Fig. 3: Sample BBDC00028, Barnegat Bay, NJ.

Fig. 5: ***Tabellaria flocculosa*** (Roth) Kützing
Lit.: Kützing 1844, p. 127; pl. 17, fig. 21
Basionym: *Conferva flocculosa* Roth 1797
Synonyms: *Bacillaria flocculosa* (Roth) Ehrenberg 1832
Bacillaria tabellaris Ehrenberg 1835
Striatella flocculosa (Roth) Kuntze 1898
Tabellaria flocculosa (Roth) Knudson 1952
Bacillaria flocculosa (Roth) Leiblein 1827
Candollella flocculosa (Roth) Gaillon 1833
Fig. 5: Sample BBDC00059, Barnegat Bay, NJ.

Figs 6-7: ***Licmophora grandis*** (Kützing) Grunow
Lit.: Van Heurck 1881, pl. 48, fig. 2, 3
Basionym: *Rhipidophora grandis* Kützing 1844
Synonyms: *Licmophora gracilis* f. *grandis* (Kützing) Grunow 1867
Stylaria grandis (Kützing) Trevisan 1848
Styllaria grandis (Kützing) Trevisan 1848
Fig. 6: Sample BBDC00001, Barnegat Bay, NJ.
Fig. 7: Sample BBDC00002, Barnegat Bay, NJ.

Fig. 8: ***Licmophora paradoxa* var. *tincta*** (Agardh) Hustedt
Lit.: Hustedt 1931, p. 77; fig. 607
Basionym: *Gomphonema tinctum* Agardh 1831
Synonyms: *Licmophora tincta* (Agardh) Grunow 1867
Rhipidophora tincta (Agardh) Ralfs in Pritchard 1861
Fig. 8: Sample BBDC00048, Barnegat Bay, NJ.



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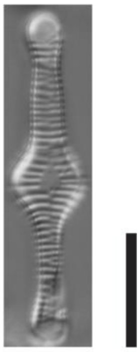

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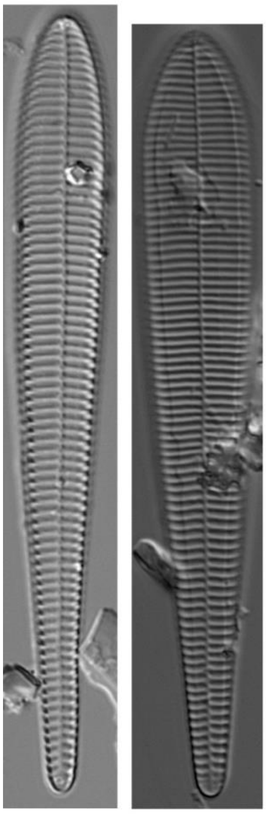
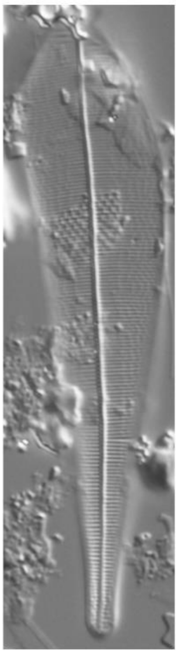


6 - 7



8

Plate 86 (Scale bars: Figs 1-4=10 µm; Figs 5-10=10 µm)

Licmophora abbreviata Agardh

Lit.: Agardh 1831, p. 42

Synonyms: *Licmophora lyngbyei* f. *abbreviata* (Agardh) Frenguelli 1930

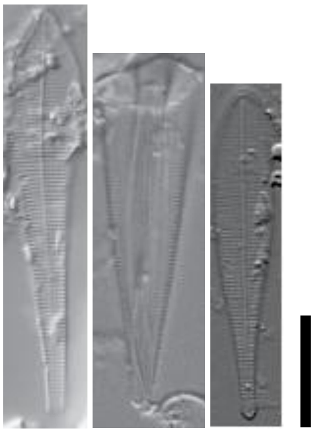
Fig. 1: Sample BBDC00109, Great Bay, NJ.

Fig. 2: Sample BB0029, Barnegat Bay, NJ.

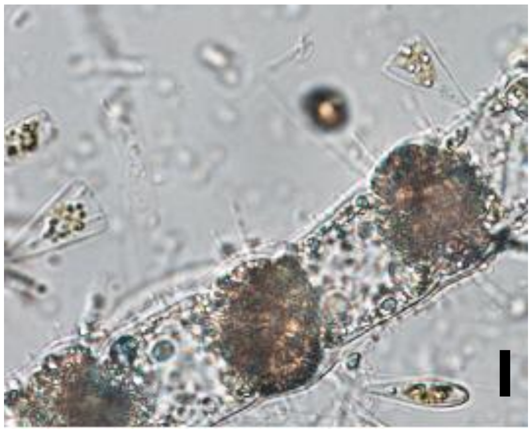
Figs 3,8: Sample COAST015, Great South Bay, NY.

Figs 4,7,9: Sample COAST054, Barnegat Bay, NY.

Figs 5-6: Sample COAST096, Cape May Peninsula, NJ.



1 - 3



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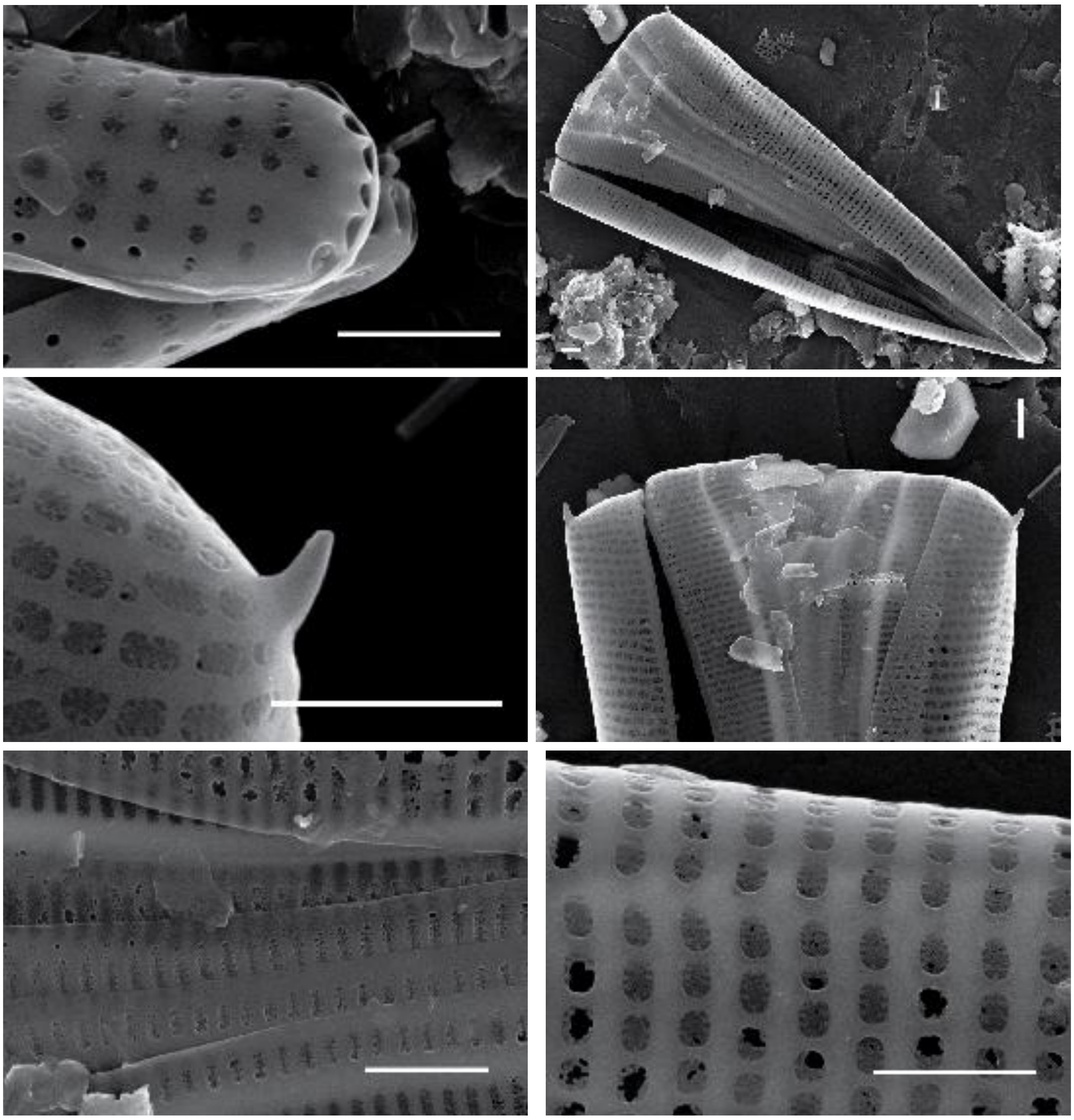


5 - 10

Plate 87 (Scale bars: Figs 1-9=10 µm; Figs 10-11=1 µm)

Rhaphoneis amphiceros (Ehrenberg) Ehrenberg

Lit.: Ehrenberg 1844, p. 87

Basionym: *Cocconeis amphiceros* Ehrenberg 1840

Synonyms: *Fragilaria amphiceros* (Ehrenberg) Ehrenberg 1843

Nematoplata (Nematoplate) amphiceros (Ehrenberg) Kuntze 1898

Odontidium amphiceros (Ehrenberg) Kützing 1849

Doryphora amphiceros (Ehrenberg) Kützing 1844

Figs 1,6,9: Barnegat Bay, NJ.

Fig. 2: Sample BBDC00048, Barnegat Bay, NJ.

Fig. 3: Sample BB0085, Barnegat Bay, NJ.

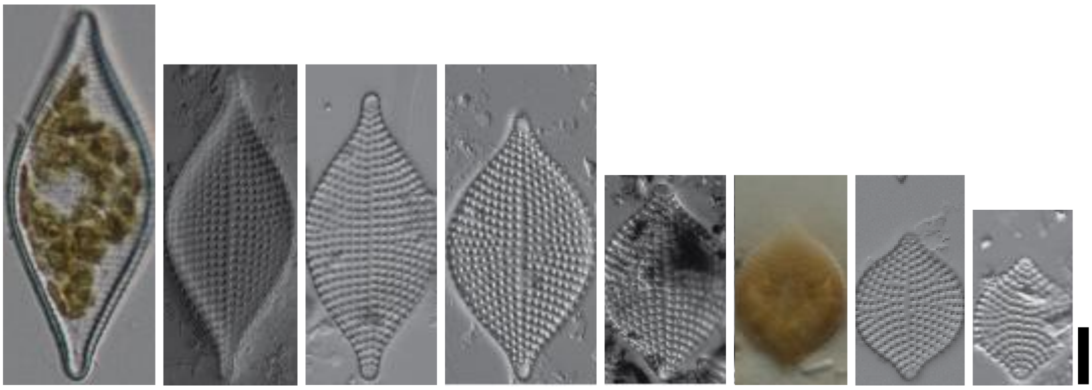
Fig. 4: Sample BBDC0095, Great Bay, NJ.

Fig. 5: Sample BB0071, Barnegat Bay, NJ.

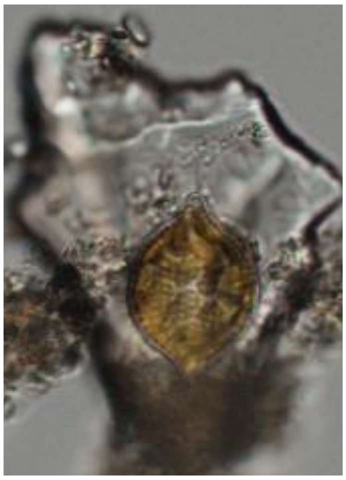
Fig. 7: Sample BBDC0108, Great Bay, NJ.

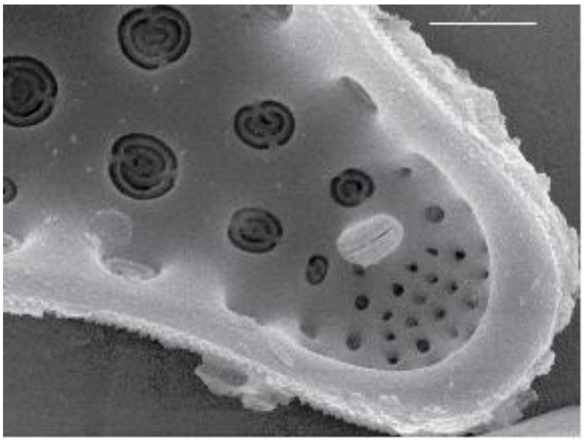
Fig. 8: Sample BBDC00065, Barnegat Bay, NJ.

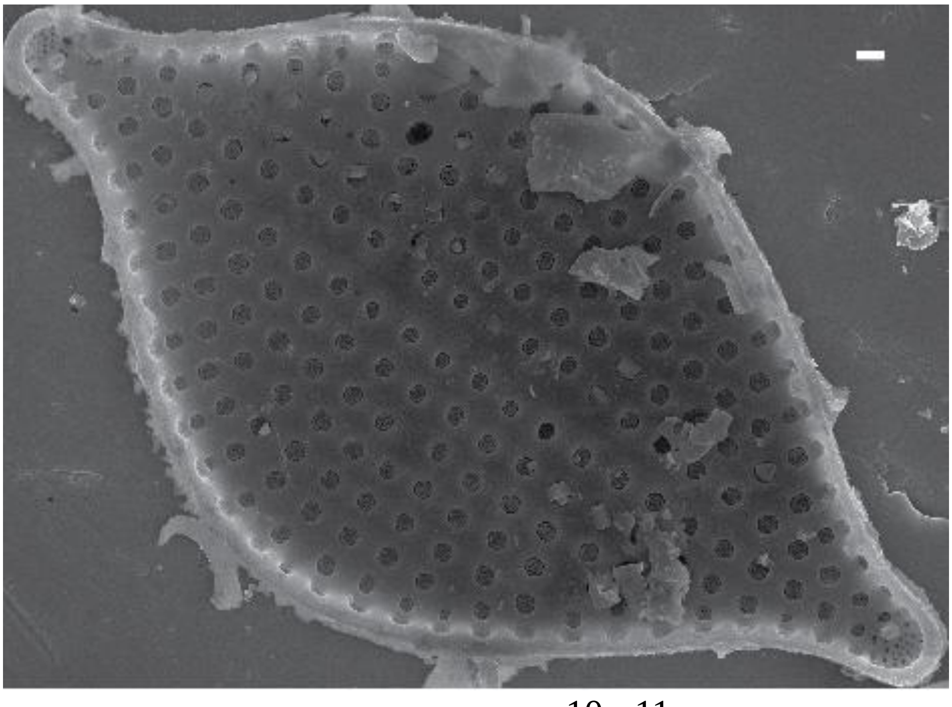
Figs 10-11: Lewes-Rehoboth, DE.



1 - 9







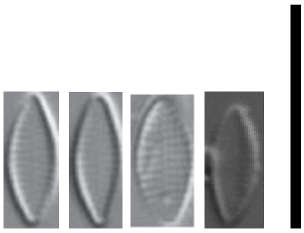
10 - 11

Plate 88 (Scale bars: Figs 1-4=10 µm; Figs 6-8=1 µm)

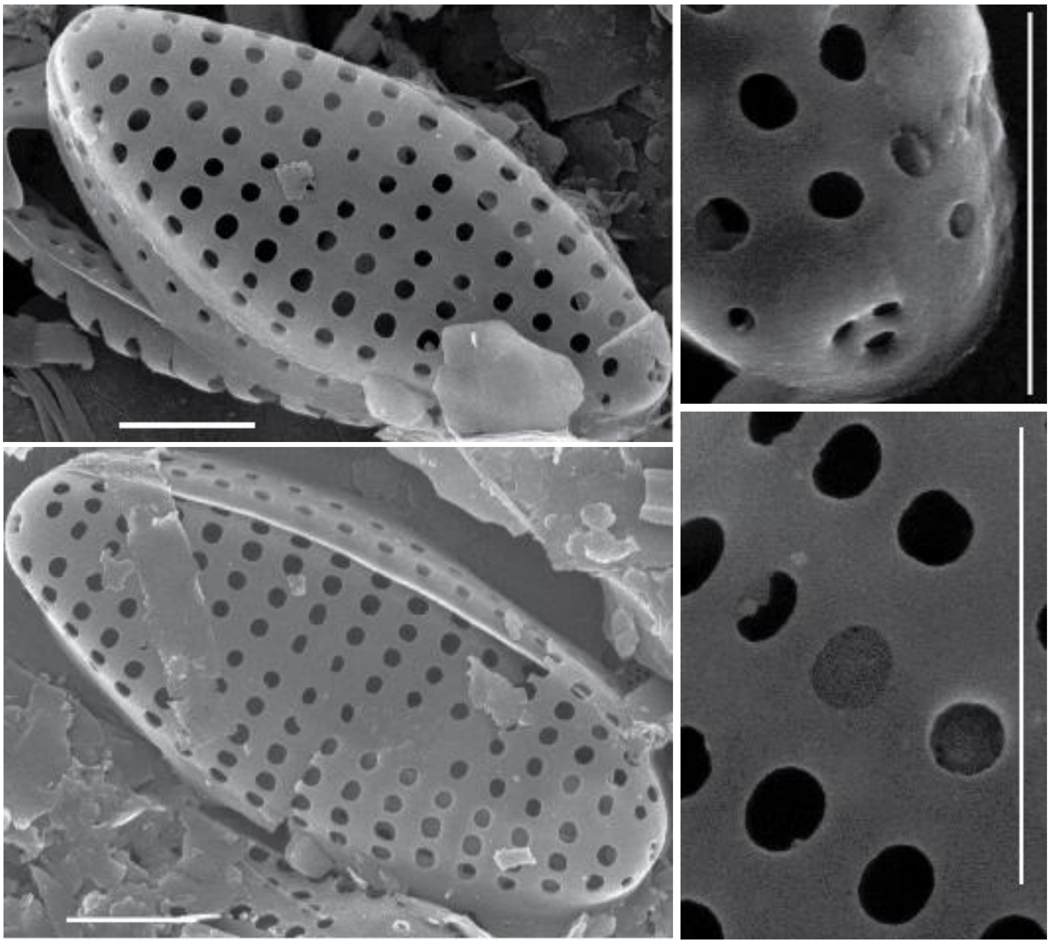
Rhaphoneis crinigera Takano

Lit.: Takano 1983, v. 109: p. 28; fig. 1-20

Fig. 1: Sample COAST015, Great South Bay, NY.
Figs 4,7,8: Sample COAST054, Barnegat Bay, NY.
Figs 5-6: Sample COAST096, Cape May Peninsula, NJ.



1 - 4



6 - 8

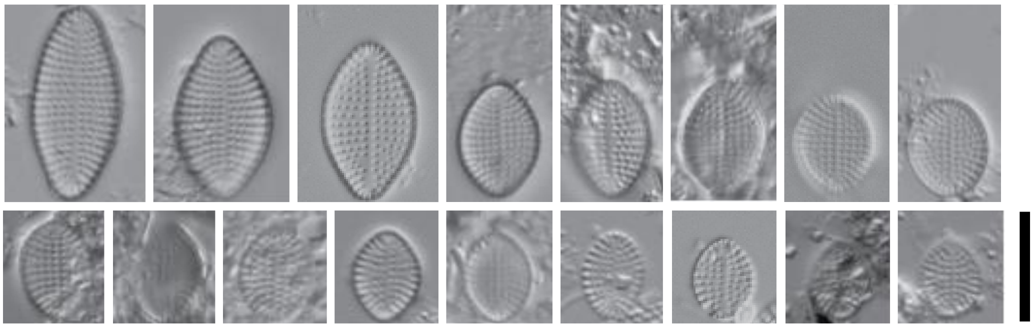
Plate 89 (Scale bars: Figs 1-17=10 µm; Figs 18-21=1 µm)

Delphineis minutissima (Hustedt) Simonsen

Lit.: Simonsen 1987, p. 252

Basionym: *Rhaphoneis* (Raphoneis) *minutissima* Hustedt 1939

Figs 1,18,20: Sample BBDC00080, Barnegat Bay, NJ.
Figs 2-4,12,15: Sample BBDC00044, Barnegat Bay, NJ.
Fig. 5: Sample BB0075, Barnegat Bay, NJ.
Fig. 6: Sample BB0064, Barnegat Bay, NJ.
Figs 7-8: Sample BBDC00074, Barnegat Bay, NJ.
Fig. 9: Sample BB0066, Barnegat Bay, NJ.
Fig. 10: Sample BB0074, Barnegat Bay, NJ.
Fig. 11: Sample BB0092, Tuckerton Bay, NJ.
Fig. 13: Sample BB0089, Tuckerton Bay, NJ.
Fig. 14: Sample BB0061, Barnegat Bay, NJ.
Fig. 16: Sample BB0070, Barnegat Bay, NJ.
Fig. 17: Sample BB0079, Tuckerton Bay, NJ.
Figs 19,21: Sample RUTG0811, Cape May Courthouse, NJ.



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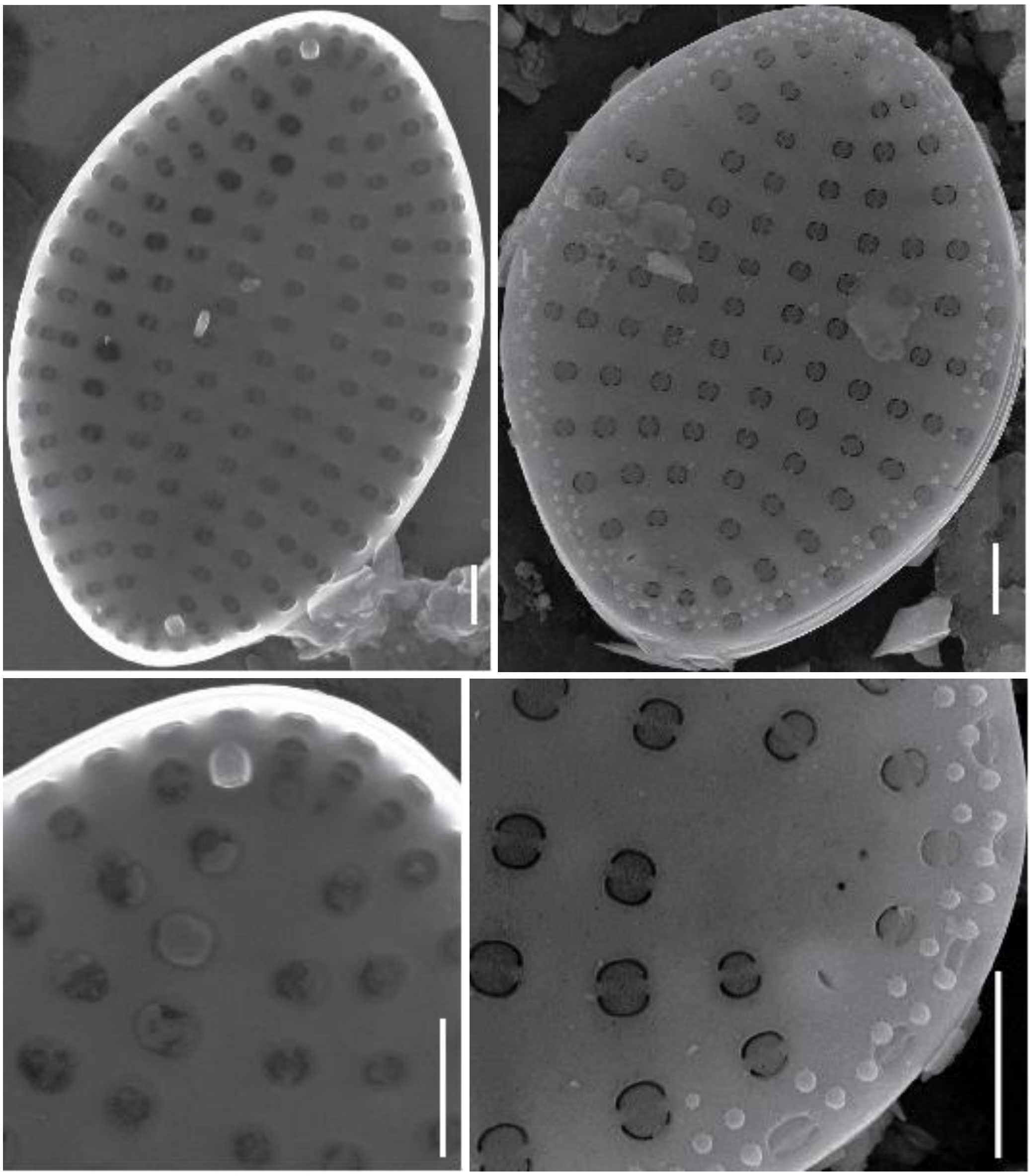
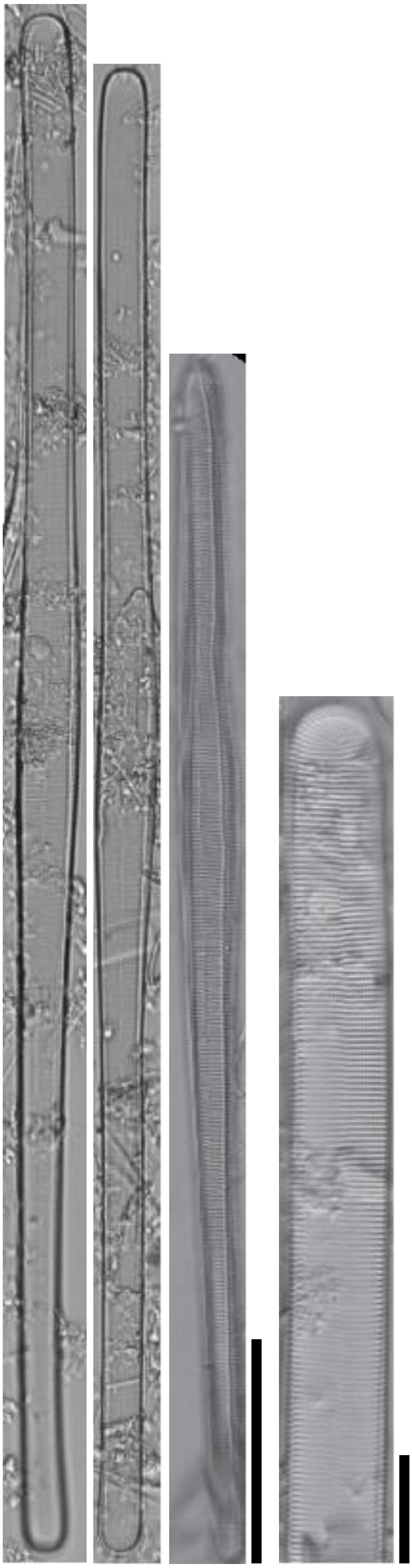


18 - 21

Plate 90 (Scale bar: Figs 1-4=20 μm)

Ardissonea robusta (Ralfs in Pritchard) De Notaris
Lit.: De Notaris & Baglietto 1871, p. 95

Basionym: *Synedra robusta* Ralfs in Pritchard 1861
Synonyms: *Synedra superba* var. *robusta* (Ralfs in Pritchard) Grunow 1862
Figs 1-5: Sample RUTG278, Rutgers Field Station, NJ.



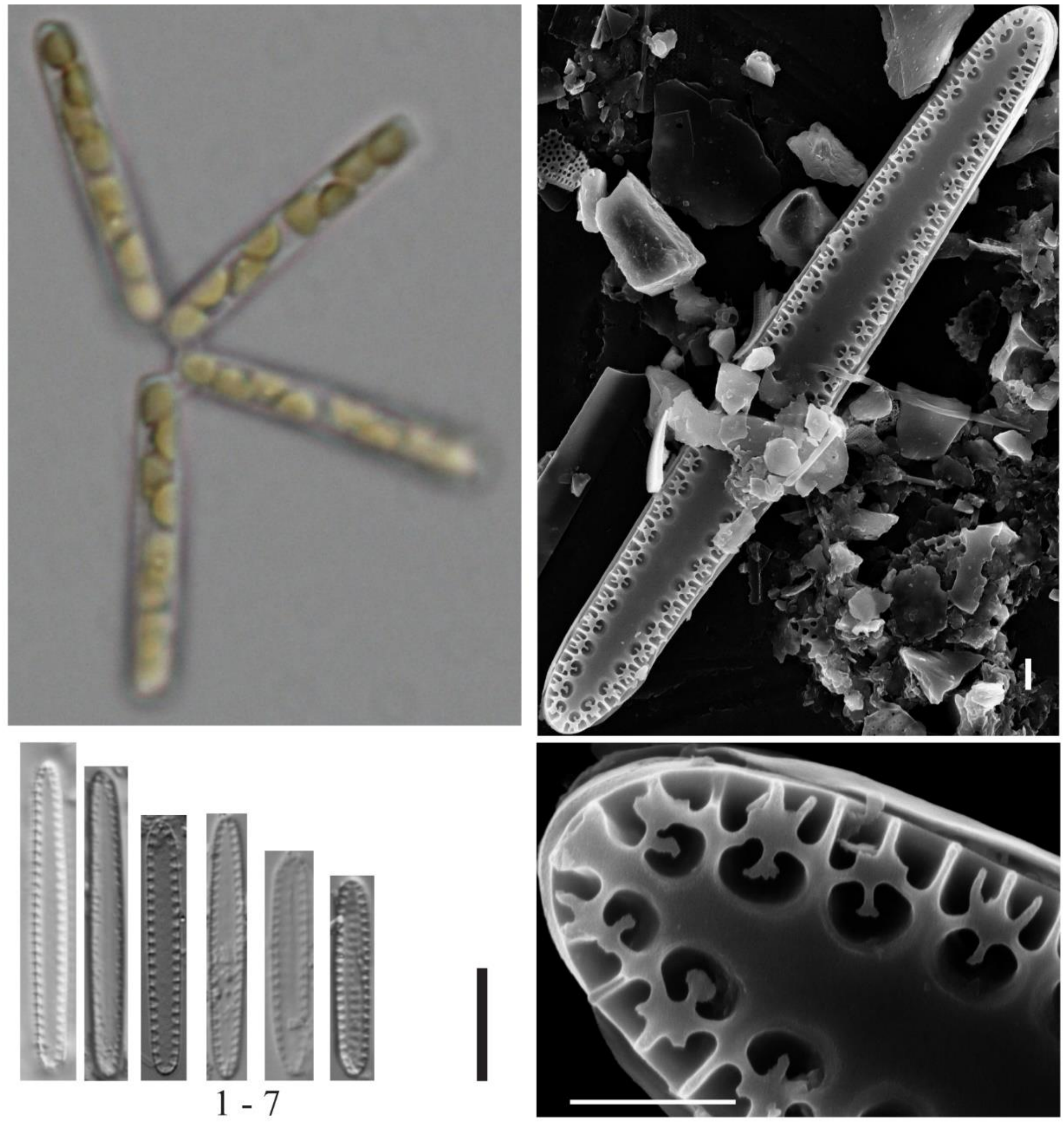
1 - 4

Plate 91 (Scale bars: Figs 1-7=10 µm; Figs 8-11=1 µm)

Thalassionema nitzschioides (Grunow) Van Heurck
Lit.: Van Heurck 1896, p. 319; plate caption for text-fig. 75

Basionym: *Synedra nitzschioides* Grunow 1862
Synonyms: *Thalassiothrix nitzschioides* (Grunow) Grunow in Van Heurck 1881
Thalassionema nitzschioides (Grunow) Mereschkowsky 1902

Fig. 1: Barnegat Bay, NJ.
Figs 2-3,7: Sample BBDC00045, Barnegat Bay, NJ.
Fig. 4: Sample BBDC00012, Barnegat Bay, NJ.
Fig. 5: Sample BBDC00051, Barnegat Bay, NJ.
Fig. 6: Sample BBDC00072, Barnegat Bay, NJ.
Figs 8-9: Sample BBDC00030, Barnegat Bay, NJ.
Figs 10-11: Sample BBDC00080, Barnegat Bay, NJ.



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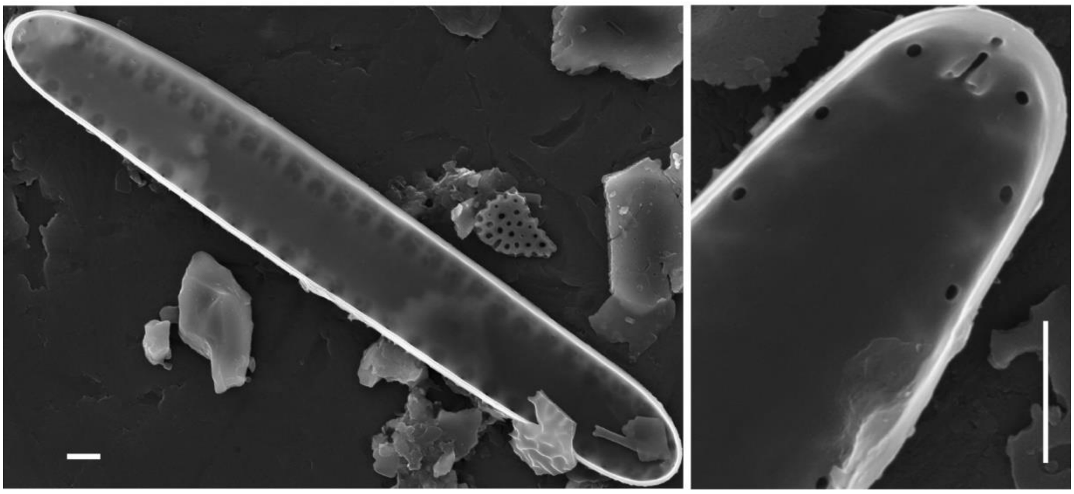


8 - 11

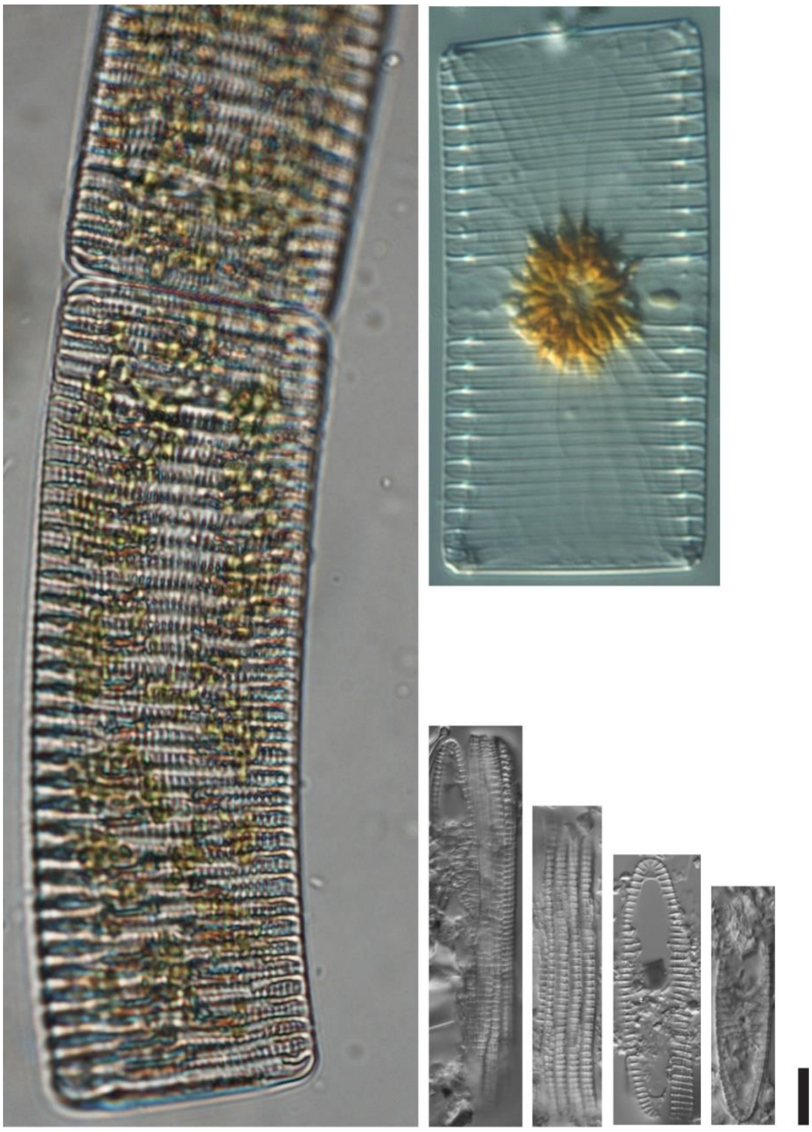
Plate 92 (Scale bars: Figs 1-6=10 µm)

Rhabdonema adriaticum Kützing

Lit.: Kützing 1844, p. 126; pl. 18, fig. 7

Synonyms: *Tessella adriatica* (Kützing) Mann 1907

Fig. 1: Sample RUTG274, Barnegat Light House, NJ.
Fig. 2: Barnegat Bay, NJ.
Fig. 3: Sample BB0063, Barnegat Bay, NJ.
Fig. 4: Sample BB0064, Barnegat Bay, NJ.
Fig. 5: Sample BBDC00048, Barnegat Bay, NJ.
Fig. 6: Sample BB0076, Barnegat Bay, NJ.

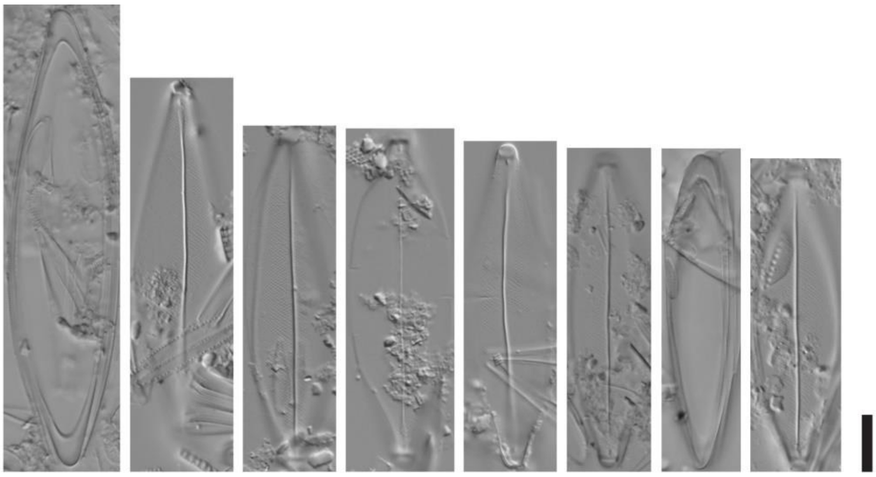


1 - 6

Plate 93 (Scale bar: Figs 1-8=10 µm; Figs 9-10=1 µm)

Striatella unipunctata (Lyngbye) Agardh
Lit.: Agardh 1832, p. 61

Basionym: *Fragilaria unipunctata* Lyngbye 1819
Synonyms: *Achnanthes unipunctata* (Lyngbye) Carmichael ex Greville 1827
Echinella annulata Corda in Sturm 1829
Echinella unipunctata (Lyngbye) Corda apud Sturm 1798-1839
Tabellaria unipunctata (Lyngbye) Schütt 1896
Thaumaleorhabdium unipunctatum (Lyngbye) Trevisan 1848
Diatoma unipunctatum (Lyngbye) Agardh 1824
Candollella unipunctata (Lyngbye) Gaillon 1833
Figs 1-8: Sample RUTG278, Rutgers Field Station, NJ.
Fig. 9-10: Sample RUTG1007, Great Bay, NJ.



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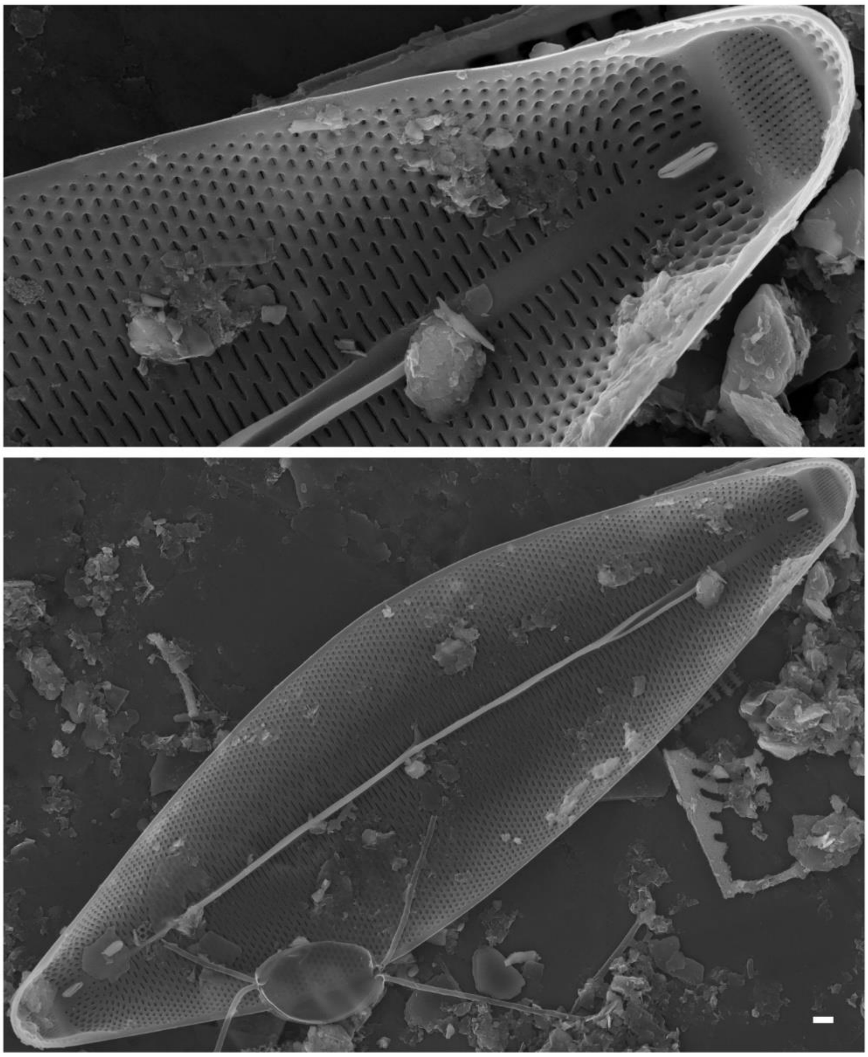
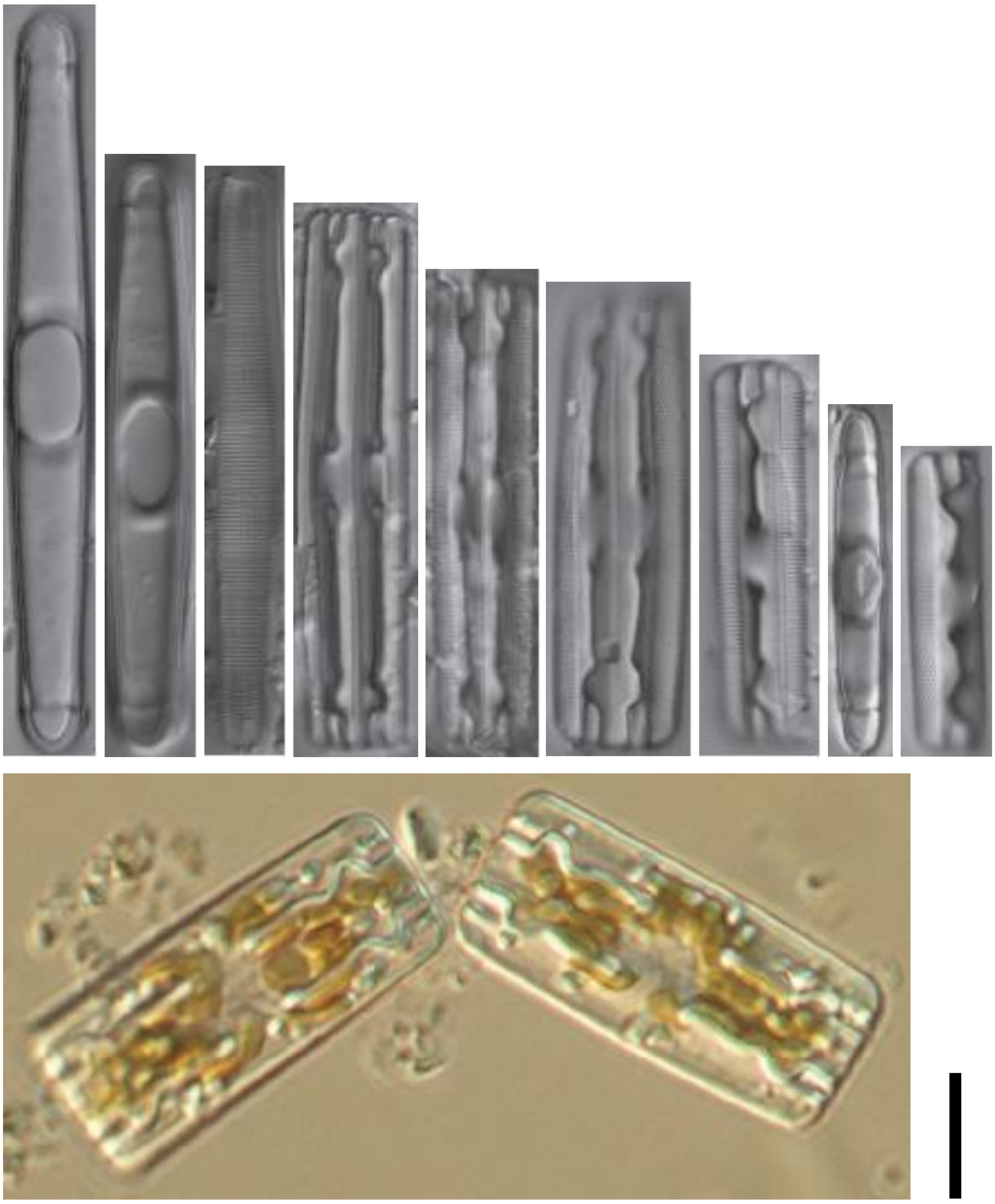


9 - 10

Plate 94 (Scale bar: Figs 1-19=10 µm)

Figs 1-10: ***Grammatophora oceanica*** Ehrenberg
Lit.: Ehrenberg 1840, p. 161

Figs 11-19: ***Grammatophora angulosa*** Ehrenberg
Lit.: Ehrenberg 1840, p. 73 (153)



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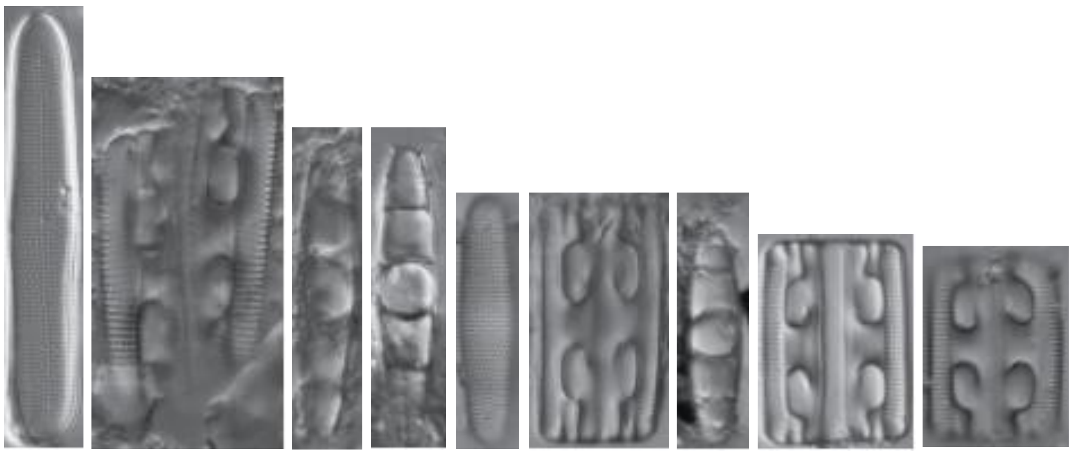


11 - 19

Plate 95 (Scale bar: Figs 1-6=10 µm)

Figs 1-2: ***Eunotia myrmica*** Lange-Bertalot

Lit.: Lange-Bertalot, Bak & Witkowski 2011: 165, pl. 221: figs 10-11; pl. 222: figs 8-13.

Synonyms:

Eunotia formica sensu Hustedt 1924, fig.18:13, Hustedt 1932 partim, fig.775 (specimen right side)

Eunotia formica sensu Mölder & Tynni 1971 et sensu Patrick & Reimer 1966 (fig.10:7) et sensu auct. nonnull.

(?) *Eunotia formica* f. *stricta* A. Berg 1939, p.453, fig.4:148

(?) *Eunotia nodosa* A. Berg 1939, p.453, fig.4:149 (nec *Eunotia nodosa* Ehrenberg1843)

Fig. 1: Sample BBDC0002, Barnegat Bay, NJ.

Fig. 2: Sample BBDC0009, Barnegat Bay, NJ.

Figs 3-4: ***Eunotia glacialis*** Meister

Lit.: Meister 1912, p. 85; pl. 10, fig. 2-3; Krammer & Lange-Bertalot 1991, p.207, fig.150:10; 2000 (2^{nd} ed.), p.594, figs 151A:1,2; Lange-Bertalot, Bak & Witkowski 2011: 112, pl. 206: figs 1-13; pl. 207: figs 1-9.

Fig. 3: Sample BB0070, Barnegat Bay, NJ.

Fig. 4: Sample BB0069, Barnegat Bay, NJ.

Figs 5-6: ***Eunotia naegelii*** Migula

Lit.: Migula 1907, p. 203; Krammer & Lange-Bertalot 2000, p.182, figs 140:1-6; Lange-Bertalot, Bak & Witkowski 2011: 167, pl. 21: figs 1-23; pl. 22: figs 1-13.

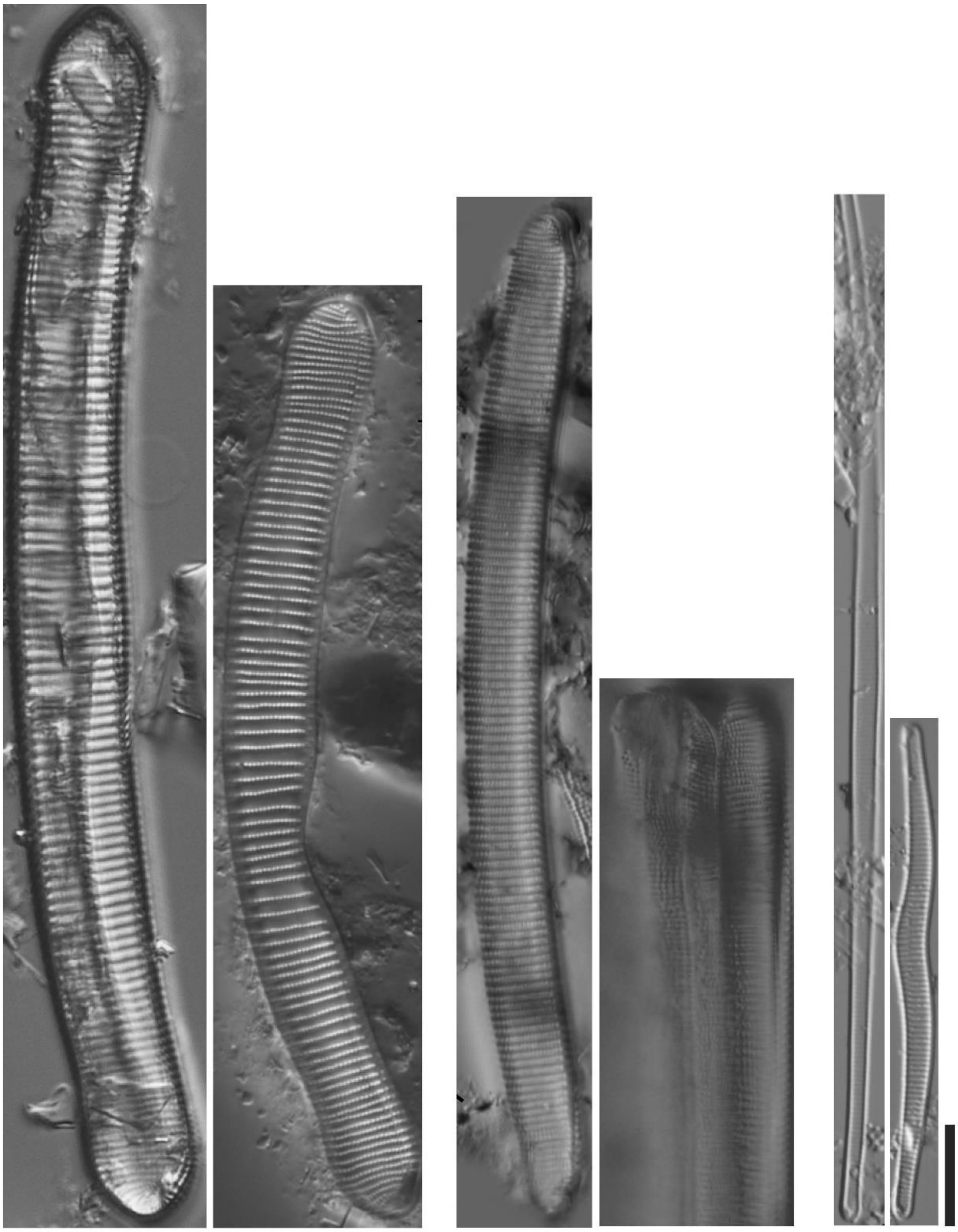
Synonyms:

Synedra alpina Nägeli ex Kützing 1849

Eunotia lunaris var? *alpine* (Nägeli) Grunow in Van Heurck 1881

Fig. 5: Sample BBDC0026, Barnegat Bay, NJ.

Fig. 6: Sample BBDC0029, Barnegat Bay, NJ.



1 - 2 3 - 4 5 - 6

Plate 96 (Scale bar: Figs 1-15=10 µm)

Fig. 1: ***Eunotia serra*** Ehrenberg

Lit.: Ehrenberg 1837, p. 45; Lange-Bertalot, Bak & Witkowski 2011: 219, pl. 107: figs 1-15; pl. 108: figs 1-8.

Synonyms:

Eunotia robusta Ralfs in Pritchard 1861 partim.

Eunotia robusta var. *serra* (Ehrenberg) Meister 1912

Fig. 1: Sample BBDC0028, Barnegat Bay, NJ.

Figs 2-6: ***Eunotia pectinalis*** (Kützing) Rabenhorst

Lit.: Rabenhorst 1864, p. 73; Kützing 1844, p.39, fig.16:11; Tuji & William 2005, p.57-60; Lange-Bertalot, Bak & Witkowski 2011: 193, pl. 166: figs 1-13; pl. 170: figs 4-6.

Basionym: *Himantidium pectinale* Kützing 1844

Synonyms:

Eunotia pectinalis var. *undulata* (Ralfs 1843) Rabenhorst 1864

Temachium pectinale (Dillwyn) Wallroth 1833

Fig. 2: Sample BBDC0006, Barnegat Bay, NJ.

Fig. 3: Sample BBDC0008, Barnegat Bay, NJ.

Fig. 4: Sample BBDC0050, Barnegat Bay, NJ.

Fig. 5: Sample BB0071, Barnegat Bay, NJ.

Fig. 6: Sample BB0069, Barnegat Bay, NJ.

Figs 7-10: ***Eunotia minor*** (Kützing) Grunow

Lit.: Van Heurck 1881, pl. 33, fig. 20-21; Kützing 1844, p.39, fig.16:10; Krammer & Lange-Bertalot 2000, p.196, figs 142:7-15; Lange-Bertalot, Bak & Witkowski 2011: 157, pl. 145: fig.24, pl. 158, figs 14-17, pl.159:1-27; 160:1-6; 161:1-5; 162:1-27; 163:1-28; 164:1-31; 226:6-18.

Basionym: *Himantidium minus* Kützing 1844

Synonyms:

Himantidium pectinale var. *minus* (Kützing) Grunow 1862

Eunotia pectinalis f. *minor* (Kützing) A. Berg 1939

Eunotia pectinalis var. *minor* (Kützing) Rabenhorst 1864

Eunotia pectinalis var. *minus* (Kützing) Rabenhorst 1864

Figs 7-9: Sample RUTG0520, Cheesequake State Park, NJ.

Fig. 10: Sample BBDC0006, Barnegat Bay, NJ.

Fig. 11: ***Eunotia bidentula*** W. Smith

Lit.: W. Smith 1856, p.83; Van Heurck 1881, pl. 33, fig. 20-21; Krammer & Lange-Bertalot 1991, p.226, figs 161:21-25; Lange-Bertalot, Bak & Witkowski 2011:63, pl.56: figs 1-14.

Synonyms:

Eunotia tridentula var. *bidentula* (W. Smith) Heribaud 1893

Eunotia diodon f. *bidentula* (W. Smith) Å. Berg 1945

Fig. 11: Sample BBDC0033, Barnegat Bay, NJ.

Figs 12-15: ***Eunotia sudetica*** O. Müller

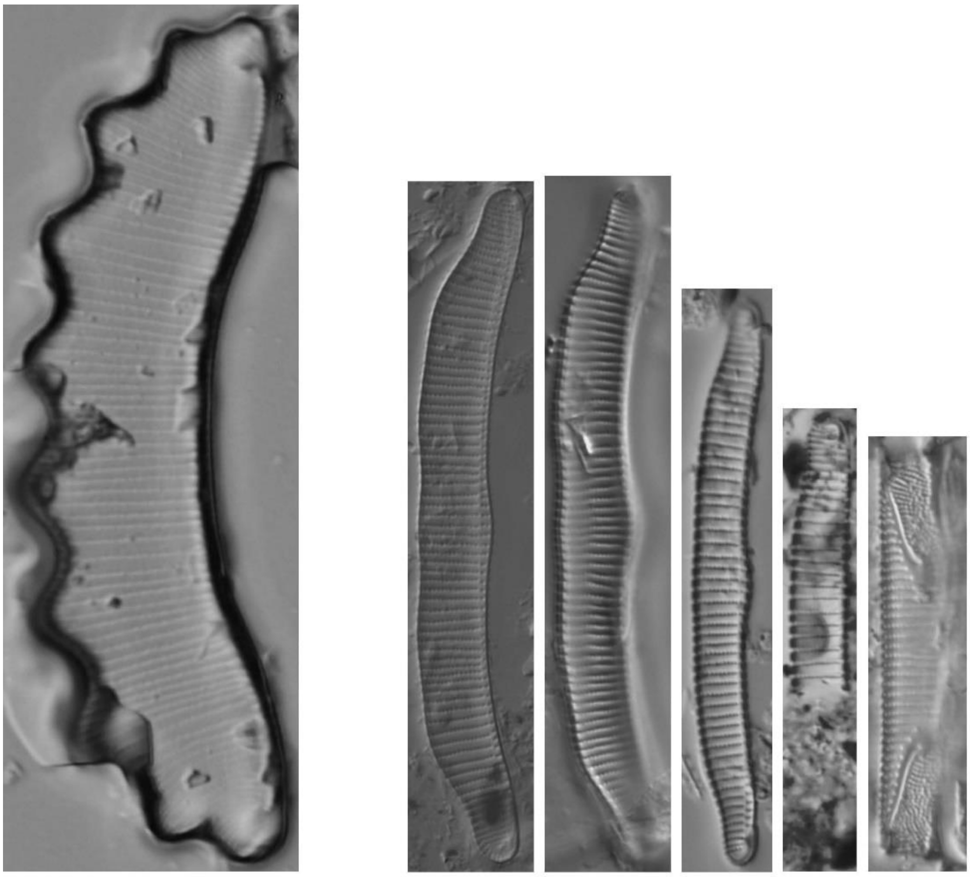
Lit.: Van Heurck 1881, pl. 33, fig. 20-21; O. Müller 1898, p.12, figs 3:25,26; Krammer & Lange-Bertalot 1991, p.224, figs 161:1-7; Lange-Bertalot, Bak & Witkowski 2011:227, pl.48: figs 1-28, 49:1-8.

Basionyms: *Himantidium sudetica* (Otto Müller) Schonfeldt 1907

Figs 12-13: Sample BBDC0004, Barnegat Bay, NJ.

Fig. 14: Sample BBDC0008, Barnegat Bay, NJ.

Fig. 15: Sample BB0071, Barnegat Bay, NJ.



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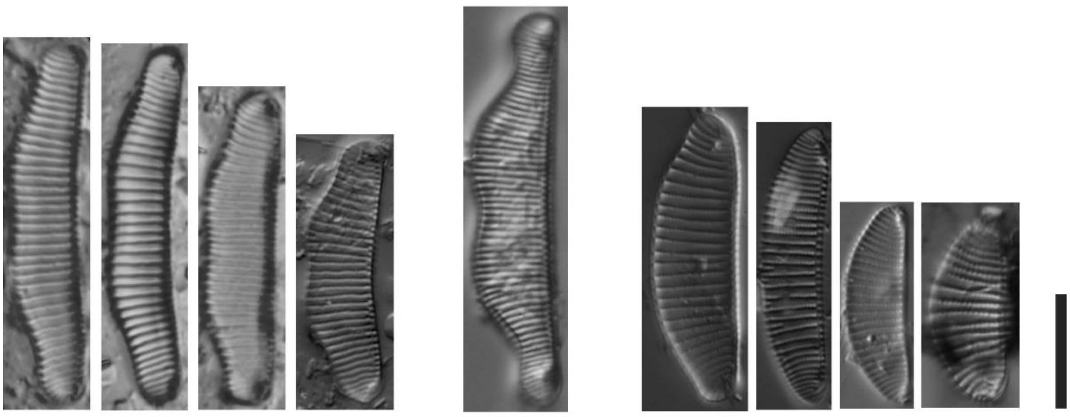


7 - 10 11 12 - 15

Plate 97 (Scale bars: Figs 1-35; 38=10 µm; Figs 36-37=1 µm)

Figs 1-11: ***Eunotia nymanniana*** Grunow

Lit.: Van Heurck 1881, pl. 34, fig. 8,10; Lange-Bertalot, Bak & Witkowski 2011: 182, pl. 120: 1-43, 121:1-26.
Synonyms: *Eunotia steineckii* J.B. Petersen 1950
Figs 1,3,5: Sample BB0035, Barnegat Bay, NJ.
Figs 2,6: Sample RUTG0240, Cape May Courthouse, NJ.
Fig. 4: Sample BB0060, Barnegat Bay, NJ.
Fig. 7: Sample BB0070, Barnegat Bay, NJ.
Fig. 8: Sample BB0069, Barnegat Bay, NJ.
Figs 9-10: Sample BB0071, Barnegat Bay, NJ.
Fig. 11: Sample BBDC0009, Barnegat Bay, NJ.

Figs 12-13: ***Eunotia tenella*** (Grunow) Hustedt

Lit.: Schmidt et al. 1913, pl. 287, fig. 20-25; Krammer & Lange-Bertalot 1991, p.202, figs 154:23-30; Lange-Bertalot, Bak & Witkowski 2011: 233, pl. 129: 1-66, 130:1-7.
Basionyms: *Himantidium arcus* var. *tenella* (Grunow in Van Heurck) Schonfeldt 1907
Synonyms: *Eunotia arcus* var. *tenella* Grunow in Van Heurck 1881
Eunotia exigua var. *tenella* (Grunow) Norpel et Alles in Alles, Norpel & Lange-Bertalot 1991
Fig. 12: Sample BBDC0005, Barnegat Bay, NJ.
Fig. 13: Sample COAST0087, Atlantic City, NJ.

Figs 14-15: ***Eunotia latinasuta*** Lange-Bertalot

Lit.: Lange-Bertalot, Bak & Witkowski 2011: 136, pl. 55: figs 18-31.
Synonyms: *Eunotia praerupta* var. *monodon* f. *polaris* (A. Berg) Symoens sensu Camburn & Charles 2000, p.20
Fig. 14: Sample RUTG0520, Cheesequake State Park, NJ.
Fig. 15: Sample BBDC0072, Barnegat Bay, NJ.

Figs 16-18: ***Eunotia paludosa*** Grunow

Lit.: Grunow 1862, p. 22 (336); pl. 3/6, fig. 10; Krammer & Lange-Bertalot 1991, p.203, figs 155:1-20,22-37; Lange-Bertalot, Bak & Witkowski 2011: 186, pl. 146: figs 1-31, 147:1-47; 149:20-22.
Basionyms: *Himantidium paludosum* (Grunow) Lagerstedt 1873
Synonyms: *Eunotia* (*exigua* Brébisson var.) *paludosa* Grunow in Van Heurck 1881, fig.34:9
Himantidium pludosum (Grunow) Lagerstedt 1873
Fig. 16: Sample BB0070, Barnegat Bay, NJ.
Fig. 17: Sample BBDC0009, Barnegat Bay, NJ.
Fig. 18: Sample BB0069, Barnegat Bay, NJ.

Figs 19-21: ***Eunotia rhomboidea*** Hustedt

Lit.: Hustedt 1950, p. 435; pl. 36, fig. 34-41; Krammer & Lange-Bertalot 1991, p.223, figs 164:12-20; Lange-Bertalot, Bak & Witkowski 2011: 207, pl. 41: figs 1-49, 42:1-8; 43:12-14.
Synonyms: *Eunotia incisa* var. *minor* Grunow in Cleve & Moller 1878 (no.56); *Eunotia tenella* sensu Hustedt 1932
Fig. 19: Sample BB0070, Barnegat Bay, NJ.
Fig. 20: Sample BB0035, Barnegat Bay, NJ.
Fig. 21: Sample BB0060, Barnegat Bay, NJ.

Figs 22-25: ***Eunotia incisadistans*** Lange-Bertalot & Sienkiewicz

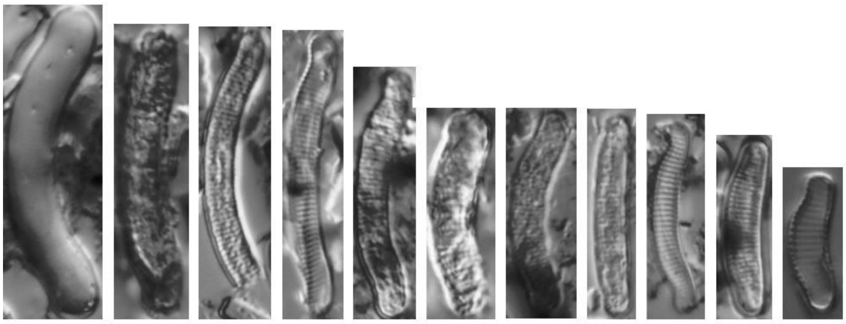
Lit.: Lange-Bertalot & Sienkiewicz 2011: 122, pl. 38: figs 1-40; pl. 40: figs 6-8.
Fig. 22: Sample BBDC0005, Barnegat Bay, NJ.
Fig. 23: Sample BBDC0028, Barnegat Bay, NJ.
Fig. 24: Sample BBDC0004, Barnegat Bay, NJ.
Fig. 25: Sample BBDC0006, Barnegat Bay, NJ.

Figs 26-35: ***Eunotia incisa*** Gregory

Lit.: Gregory 1854, p. 96; pl. 4, fig. 4; Lange-Bertalot & Sienkiewicz 2011: 120, pl. 36: figs 1-35;37:1-7, 38:41, 231:34-38.
Fig. 26: Sample BB0052, Barnegat Bay, NJ.
Fig. 27: Sample BBDC0028, Barnegat Bay, NJ.
Fig. 28: Sample BBDC0001, Barnegat Bay, NJ.
Fig. 29: Sample BB0060, Barnegat Bay, NJ.
Fig. 30,33: Sample BB0071, Barnegat Bay, NJ.
Fig. 31: Sample BBDC0067, Barnegat Bay, NJ.
Fig. 32: Sample BBDC0006, Barnegat Bay, NJ.
Fig. 34: Sample BB0054, Barnegat Bay, NJ.
Fig. 35: Sample BBDC0008, Barnegat Bay, NJ.

Figs 36-38: ***Eunotia bilunaris*** (Ehrenberg) Schaarschmidt

Lit.: Ehrenberg 1838,p.213:17:4,5; Lange-Bertalot & Sienkiewicz 2011:67,pl.30:1-27,31:1-14,32:1-16,33:1-7.
Basynonyms: *Synedra bilunaris* Ehrenberg 1832
Synonyms: *Ceratoneis lunaris* var. *bilunaris* (Ehrenberg) Grunow in Rabenhorst 1865; *Pseudo-eunotia lunaris var. bilunaris (Ehrenberg; Ehrenberg) De Toni 1892; Synedra ulna var. bilunaris (Ehrenberg; Ehrenberg) Brun 1880; Eunotia curvata var. bilunaris (Ehrenberg) Woodhead & Tweed 1954*
Fig. 36: Sample BB0052, Barnegat Bay, NJ.
Figs 37-38: Sample BBDC0028, Barnegat Bay, NJ.



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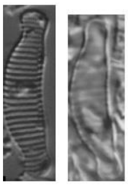
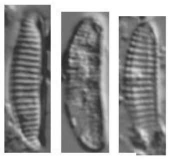


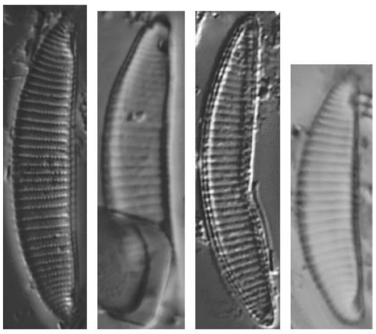
12 - 13

14 - 15

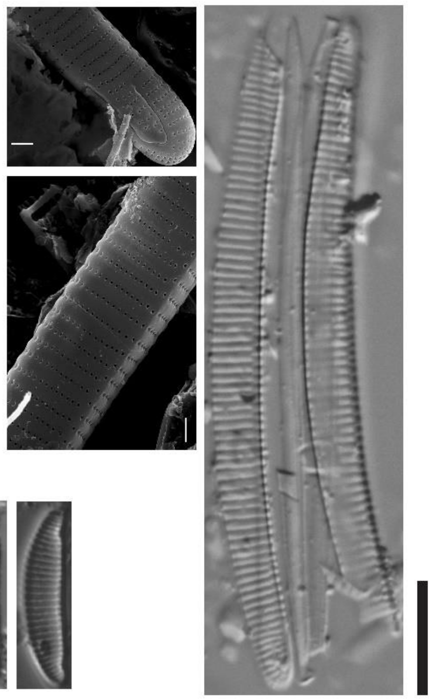
16 - 18



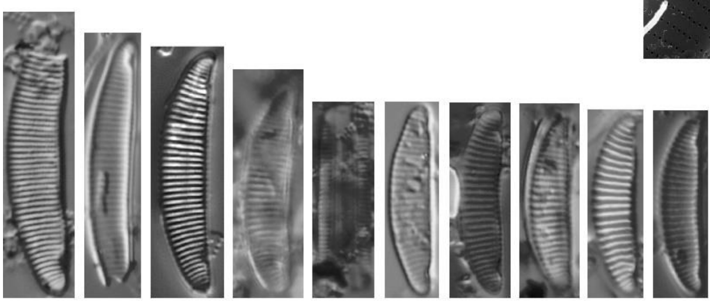
19 - 21



22 - 25



36 - 38



26 - 35

Plate 98 (Scale bar: Figs 1-5=10 µm; Figs 6-7=1 µm)

Fig. 1: ***Lyrella amphoroides*** Mann

Lit: Mann & Stickle 1997, p. 62-63; fig. 1-20

Fig. 1: Sample BBDC0095, Barnegat Bay, NJ.

Fig. 2: ***Lyrella implana*** (Hustedt) Moreno

Lit: Moreno, Licea & Santoyo 1996, p. 86-87; pl. 23, fig. 11

Synonyms:

Navicula implana Hustedt 1964

Fig. 2: Sample BB0071, Barnegat Bay, NJ.

Figs 3-7: ***Lyrella clavata*** (Gregory) Mann

Lit: Round, Crawford & Mann 1990, p. 672

Synonyms:

Navicula clavata Gregory 1856

Navicula hennedyi (hennedii) var. *clavata* (Gregory) Van Heurck 1885

Clevia clavata (Gregory) Mereschkowsky 1902

Schizonema clavatum (Gregory) Kuntze 1898

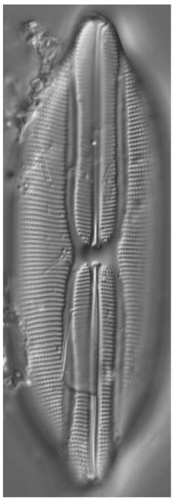
Fig. 3: Sample BBDC0071, Barnegat Bay, NJ.

Fig. 4: Sample BBDC0088, Barnegat Bay, NJ.

Fig. 5: Sample BBDC0054, Barnegat Bay, NJ.

Fig. 6: Sample BBDC0050, Barnegat Bay, NJ.

Fig. 7: Sample COAST003, Peconic Bay, NY.



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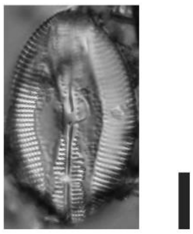

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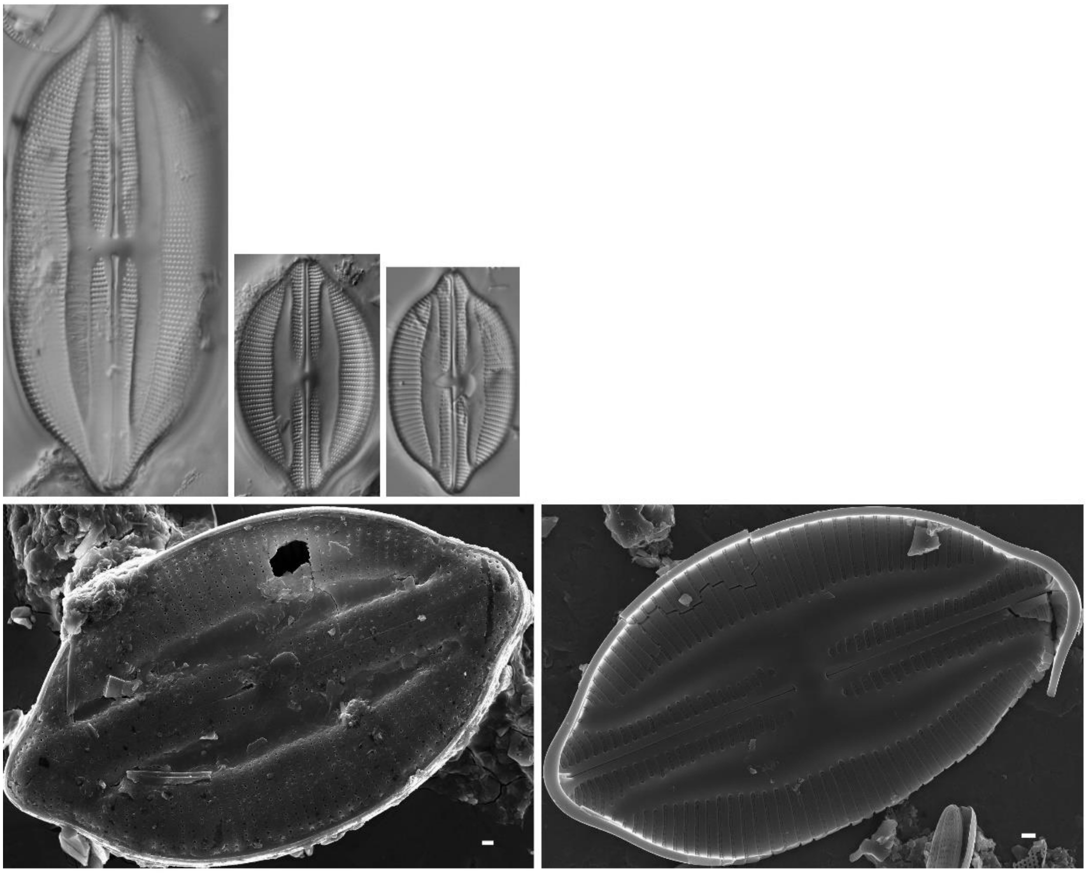


3 - 7

Plate 99 (Scale bar: Figs 1-8=10 µm)

Figs 1-5: ***Petroneis granulata*** (Bailey) Mann
Lit.: Round, Crawford & Mann 1990, p. 675
Nomenclatural synonyms:
Clevia granulata (Bailey) Mereschkowsky 1902
Navicula baileyana Grunow in Schmidt 1874
Navicula granulata J.W. Bailey 1854
Navicula baileyi Cholnoky 1968
Schizonema granulatum Kuntze 1898

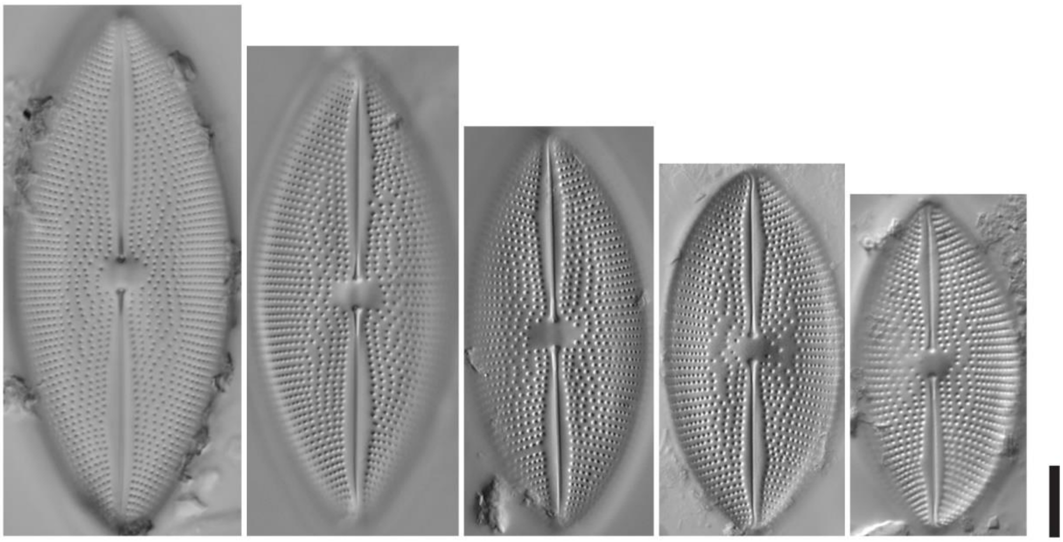
Figs 1-2: Sample BBDC0044, Barnegat Bay, NJ.
Fig. 3: Sample BBDC0001, Barnegat Bay, NJ.
Fig. 4: Sample BBDC0012, Barnegat Bay, NJ.
Fig. 5: Sample BBDC0009, Barnegat Bay, NJ.

Figs 6-7: ***Petroneis marina*** (Ralfs in Pritchard) Mann
Lit.: Round, Crawford & Mann 1990, p. 675
Nomenclatural synonyms:
Navicula marina Ralfs in Pritchard 1861

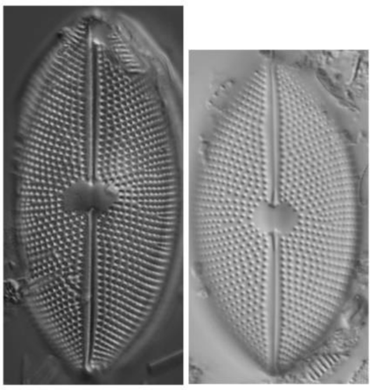
Fig. 6: Sample BBDC0003, Barnegat Bay, NJ.
Fig. 7: Sample BBDC0046, Barnegat Bay, NJ.

Figs 8: ***Petroneis humerosa*** (Brebisson ex Wm. Smith) Stickle & Mann
Lit.: Round, Crawford & Mann 1990, p. 675
Nomenclatural synonyms:
Clevia humerosa (Brebisson ex Wm. Smith) Mereschkowsky 1902
Navicula humerosa Brébisson ex W. Smith 1856
Navicula granulata var. *humerosa* (Brebisson) Carruthers 1864
Schizonema humerosum (Brébisson [ex W. Smith]) Kuntze 1898

Fig. 8: Sample BBDC0044, Barnegat Bay, NJ.



1 - 5



6 - 7

8

Plate 100 (Scale bar: Figs 1-27=10 µm)

Figs 1-11: ***Mastogloia pumila*** (Cleve & Moller; Grunow in Van Heurck) Cleve
Lit.: Cleve 1895, p. 157
Basionyms: *Mastogloia braunii (brauni)* var. *pumila* Grunow 1953

Figs 12-17: ***Mastogloia pusilla*** Grunow
Lit.: Grunow 1878, p. 111; pl. 3, fig. 10

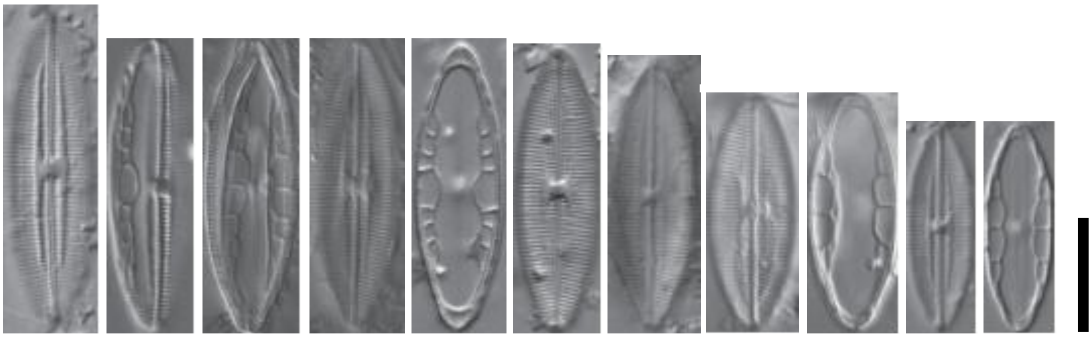
Figs 18: ***Mastogloia linearis*** Simonsen
Lit.: Simonsen 1959, p. 77; pl. 11, fig. 2

Figs 19-20: ***Mastogloia lanceolata*** Thwaites
Lit.: Thwaites & Smith 1856, p. 64; pl. 54, fig. 340

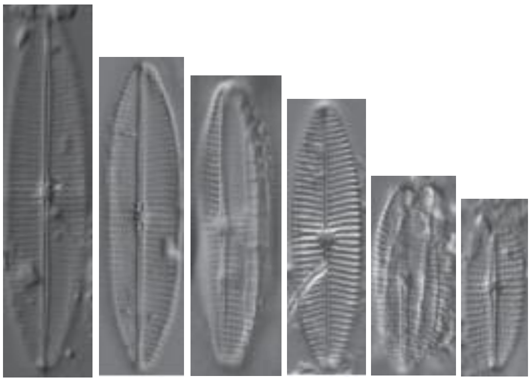
Figs 21-22: ***Mastogloia erythraea*** Grunow
Lit.: Grunow 1860, p. 577; pl. 5, fig. 4 (pl. 7, fig. 4)

Figs 23: ***Mastogloia braunii*** Grunow
Lit.: Grunow 1863, p. 156; pl. 13, fig. 2

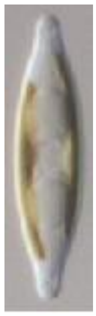
Figs 24-27: ***Mastogloia smithii*** Thwaites
Lit.: Thwaites & Smith 1856, p. 65; pl. 54, fig. 341



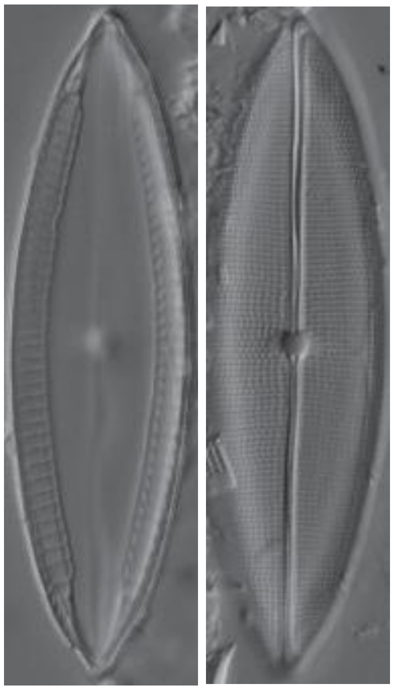
1 - 11



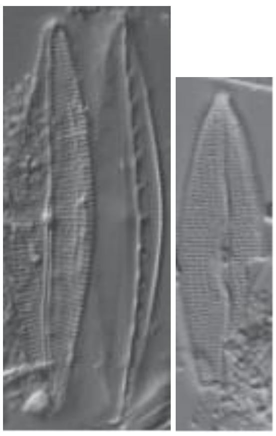
12 - 17



18

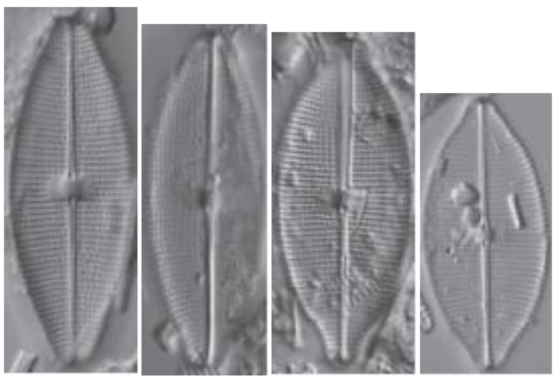


19 - 20



21 - 22

23



24 - 27

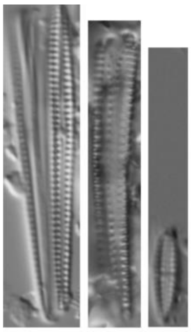
Plate 101 (Scale bars: Figs 1-13; 15-17=10 µm; Fig. 14=1µm)

Figs 1-3: ***Gomphonemopsis* sp. 2**

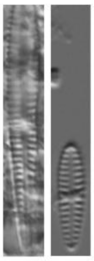
Figs 4-5: ***Gomphonemopsis* sp. 3**

Figs 6-14: ***Gomphonemopsis pseudexigua*** (Simonsen) Medlin
Lit.: Medlin & Round 1986, p. 208; fig. 8-11
Basionyms: *Gomphonema pseudoexiguum* Simonsen 1959

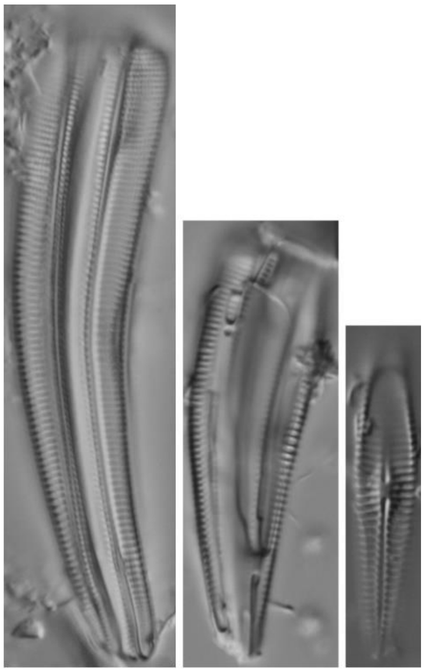
Figs 15-17: ***Rhoicosphenia abbreviata*** (Agardh) Lange-Bertalot
Lit.: Lange-Bertalot 1980, p. 586; fig. 1A, 3C-D, 5A



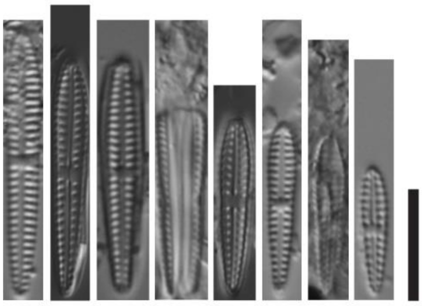
1 - 3



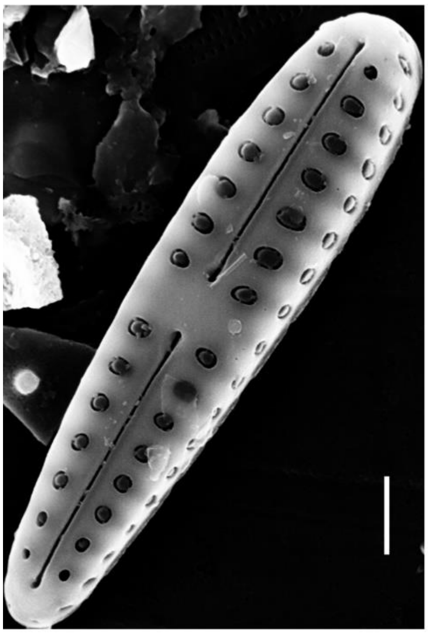
4 - 5



15 - 17



6 - 13

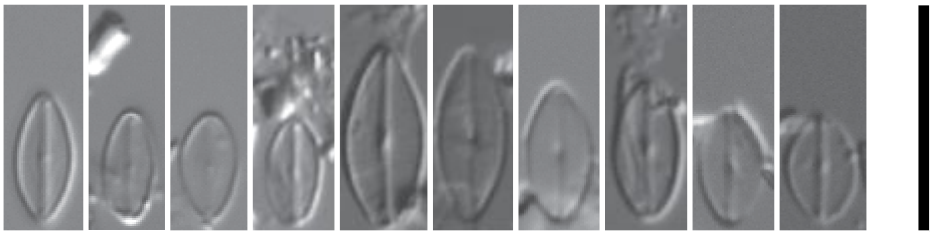


14

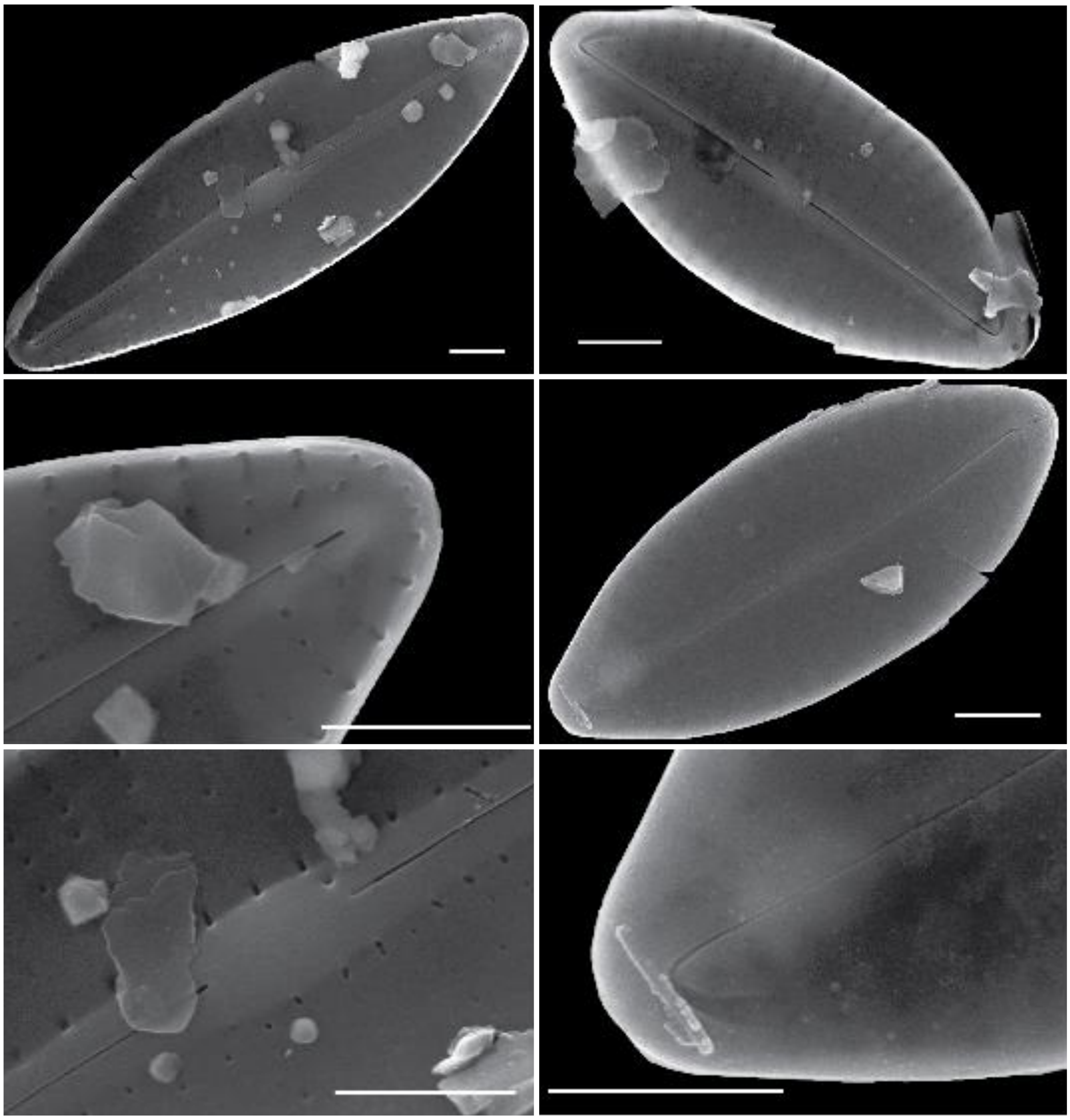
Plate 102 (Scale bars: Figs 1-10=10 µm; Figs 11-16=1 µm)

Adlafia sp. 3

Figs 1-4: Sample RUTG0131, Cheesequake State Park, NJ.
Figs 5,8-10: Sample BBDC0036, Barnegat Bay, NJ.
Fig. 6: Sample BBDC0051, Barnegat Bay, NJ.
Fig. 7: Sample BBDC0052, Barnegat Bay, NJ.
Figs 11-13: Sample BBDC0054, Barnegat Bay, NJ.
Figs 14-16: Sample BBDC0003, Barnegat Bay, NJ.



1 - 10

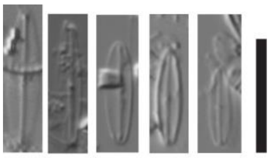


11 - 16

Plate103 (Scale bar: Figs 1-5=10 µm)

Adlafia sp. 4

Fig. 1: Sample BBDC0036, Barnegat Bay, NJ.
Fig. 2: Sample BBDC0041, Barnegat Bay, NJ.
Fig. 3: Sample BBDC0052, Barnegat Bay, NJ.
Fig. 4: Sample COAST052, Barnegat Bay, NJ.
Fig. 5: Sample BBDC0053, Barnegat Bay, NJ.



1 - 5

Plate 104 (Scale bar: Fig. 1=10 µm)

Brebissonia lanceolata (Agardh) Mahoney & Reimer

Lit: Mahoney & Reimer 1986, p. 184; fig. 1-18

Basionym: *Gomphonema lanceolatum* Agardh 1831

Synonyms: *Cocconema lanceolatum* (Agardh) Ehrenberg 1838
Cymbella lanceolata (Agardh) Van Heurck 1881
Cymbella lanceolata (Agardh) Kirchner 1878

Fig. 1: Sample BBDC0028, Barnegat Bay, NJ.

1

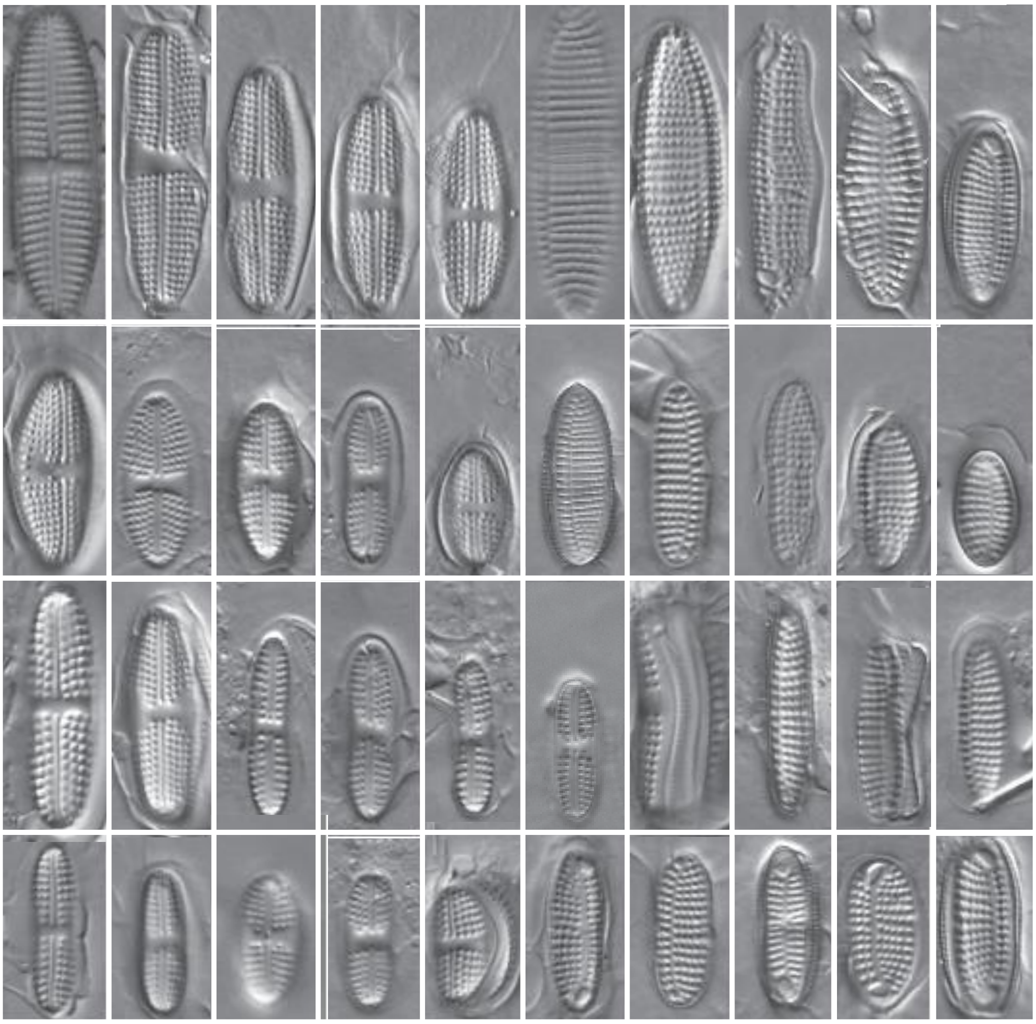
Plate 105 (Scale bars: Figs 1-40; 42=10 µm; Fig. 41=1 µm)

Achnanthes brevipes Agardh

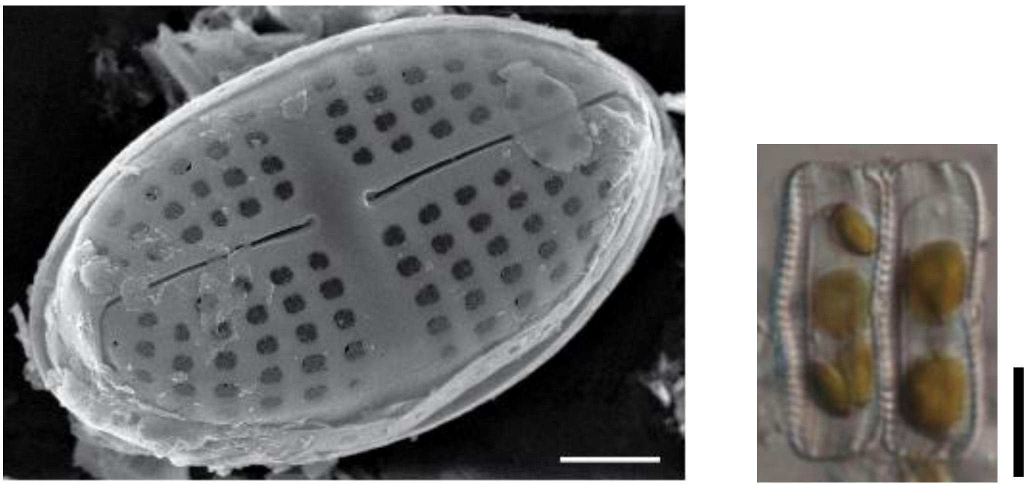
Lit.: Agardh 1824, p. 1

Synonyms: *Achnanthidium brevipes* (Agardh) Cleve 1895
Achnantella brevipes (Agardh) Gaillon 1833
Achnanthidium brevipes (Agardh) Heiberg 1863

Figs 1,6: Sample BBDC0071, Barnegat Bay, NJ.
Figs 2-5,7-40: Sample RUTG272, Barnegat Light House, NJ.
Fig. 41: Sample RUTG0001, Cape May Courthouse, NJ.
Fig. 42: Sample RUTG0807, Cape May Courthouse, NJ.



1 - 40



41 - 42

Plate 106 (Scale bar: Figs 1-17=10 µm)

Figs 1-4: ***Achnanthes curvirostrum*** Brun
Lit.: Brun 1895, pl. 16, fig. 84, 85

Figs 1-2: Sample BBDC0007, Barnegat Bay, NJ.

Figs 3-4: Sample BBDC0033, Barnegat Bay, NJ.

Figs 5-8: ***Achnanthes danica*** (Flögel) Grunow
Lit.: Cleve & Grunow 1880, p. 21
Basionym: *Cocconeis danica* Flögel 1873
Synonyms: *Actinoneis danica* (Flogel) Cleve 1895
Fig. 5: Sample BBDC0054, Barnegat Bay, NJ.

Fig. 6: Sample BBDC0044, Barnegat Bay, NJ.

Fig. 7: Sample COAST010, Great South Bay, NY.

Fig. 8: Sample COAST028, Great South Bay, NY.

Figs 9-10: ***Achnanthidium minutissimum*** (Kützing) Czarnecki
Lit.: Czarnecki 1994, p. 157
Basionym: *Achnanthes minutissima* Kützing 1833
Synonyms: *Cocconeis minutissima* (Kützing) Schonfeldt 1907
Microneis minutissima (Kützing) Cleve 1895
Achnanthidium lanceolatum f. *minutissima* (Kützing) Tömösváry 1879
Microneis minutissima (Kützing) Meister 1912
Figs 9-10: Sample BBDC0028, Barnegat Bay, NJ.

Figs 9-11: ***Achnanthes radiatus*** Hohn & Hellerman
Lit.: Hohn & Hellerman 1966, p. 115; pl. I, fig. 11-12

Figs 9-10: Sample BBDC0016, Barnegat Bay, NJ.

Figs 11-12: Sample BBEDC0099, Cattus Island, NJ.

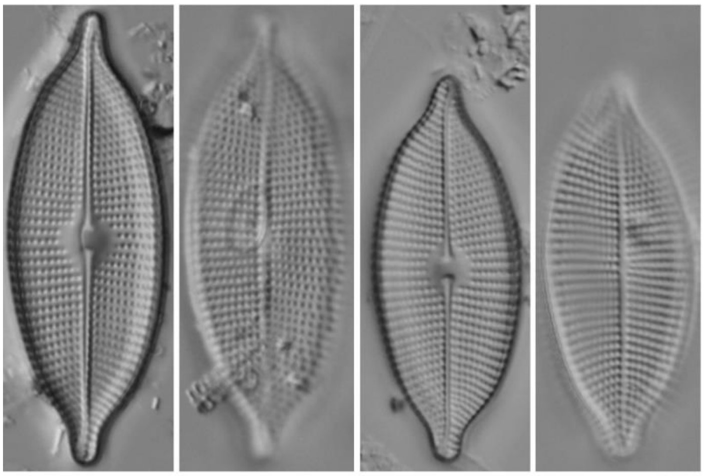
Figs 13-15: ***Achnanthes pseudobliqua*** Simonsen
Lit.: Simonsen 1960, p. 127; pl. 1, fig. 5-7

Fig. 13: Sample COAST009, Great South Bay, NY.

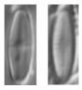
Figs 14-15: Sample COAST043, Barnegat Bay, NJ.

Figs 16-17: ***Achnanthes leonardii*** Witkowski & Lange-Bertalot
Lit.: Witkowski, Lange-Bertalot & MetzeltLit.:2000, p. 92, 420; pl. 50, fig. 1-12

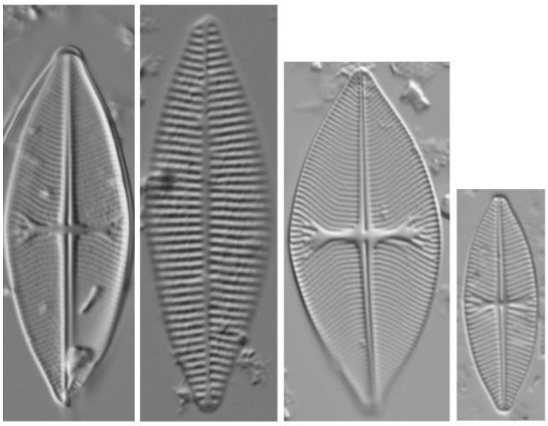
Figs 16-17: Sample BBDC0038, Barnegat Bay, NJ.



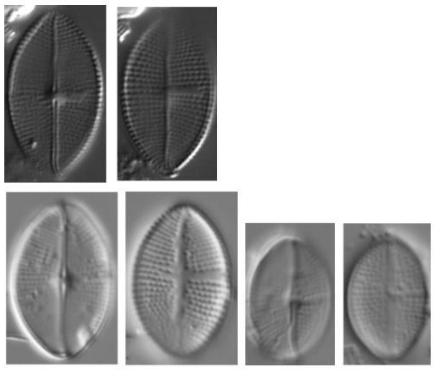
1 - 4



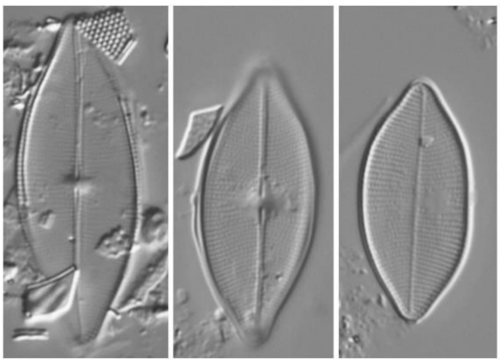
9 - 10



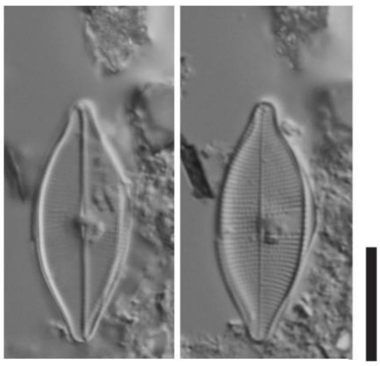
5 - 8



9 - 12



13 - 15

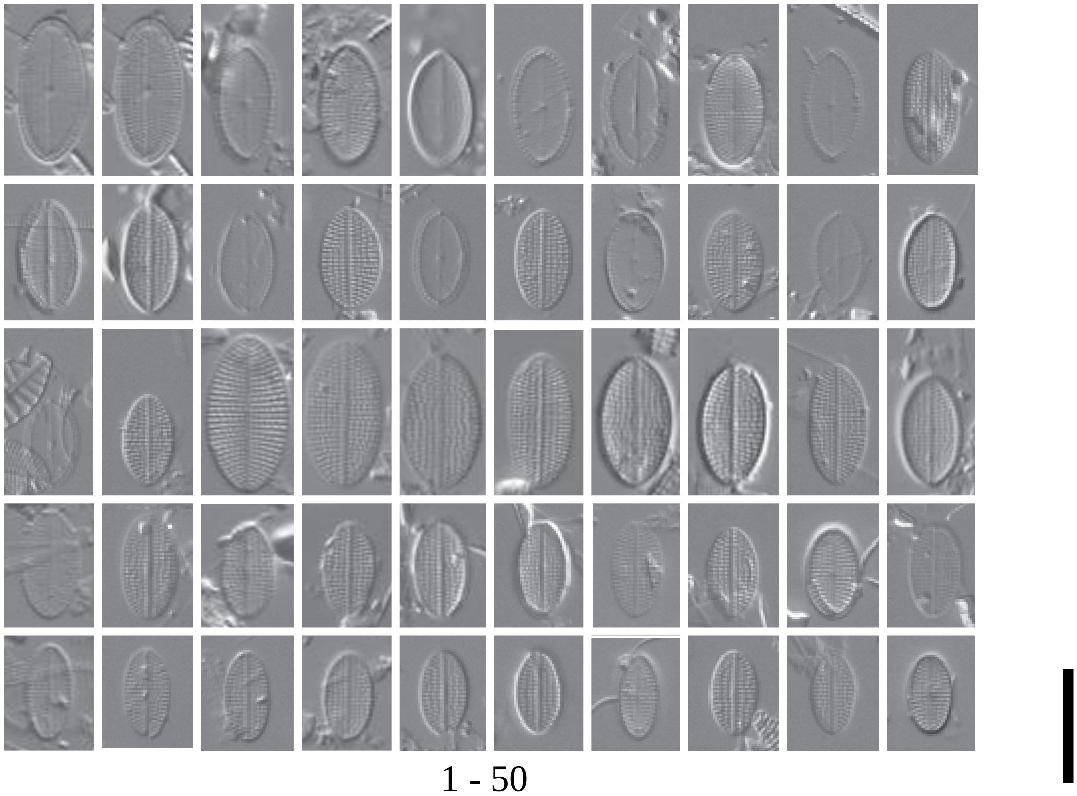


16 - 17

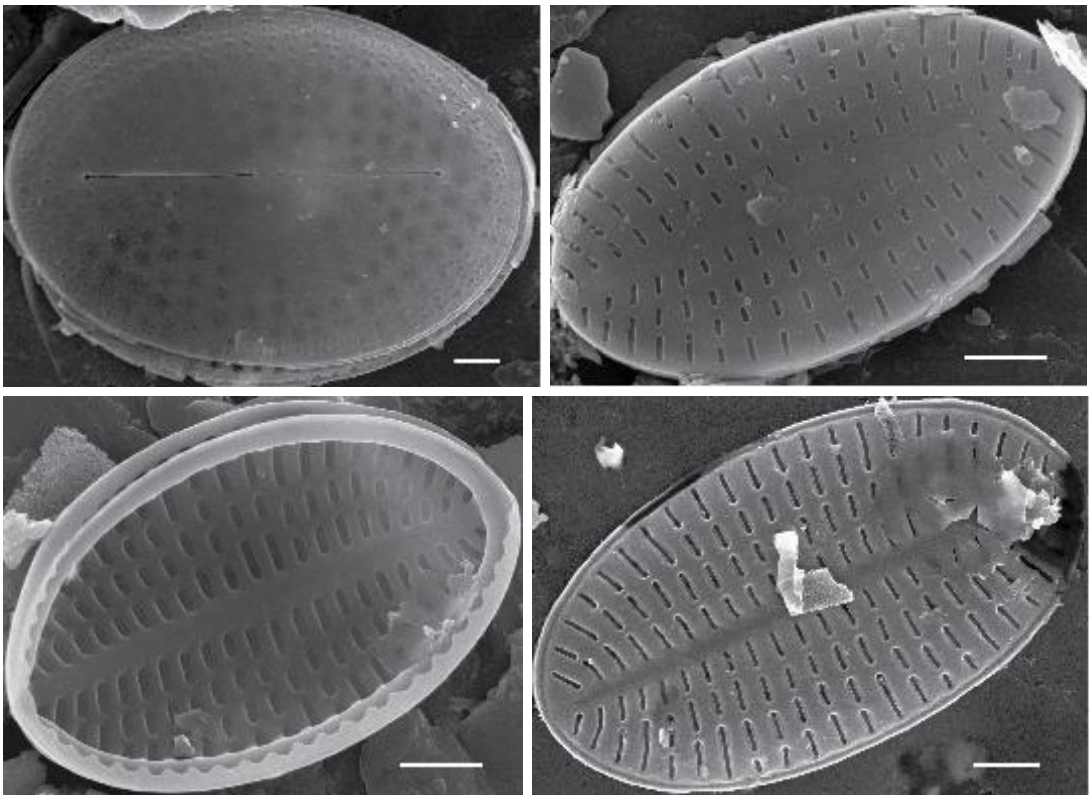
Plate 107 (Scale bars: Figs 1-50=10 µm; Figs 51-54=1 µm)

Cocconeis neothumensis* var. *marina De Stefano, Marino & Mazzella
Lit.: De Stefano, Marino & Mazzella 2000, p. 233; figs. 53-65

Figs 1-50: Sample BBDC0024, Barnegat Bay, NJ.
Fig. 51: Sample COAST062, Great Bay, NJ.
Fig. 52: Sample COAST096, Cape May Peninsula, NJ.
Fig. 53: Sample BBDC0045, Barnegat Bay, NJ.
Fig. 54: Sample BBDC0015, Barnegat Bay, NJ.



1 - 50



51 - 54

Plate 108 (Scale bars: Figs 1-10; 13-20=10 µm; Figs 11-12; 23-24=1 µm)

Figs 1-12: ***Cocconeis peltoides*** Hustedt

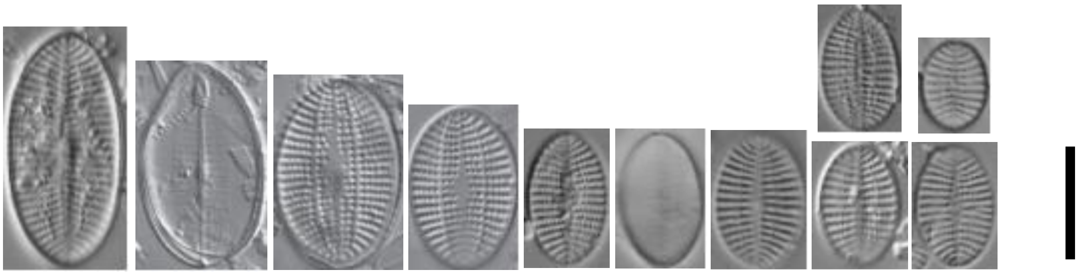
Lit.: Hustedt 1939, p. 606; fig. 23-27

Fig. 1: Sample BBDC0045, Barnegat Bay, NJ.
Fig. 2: Sample COAST009, Great South Bay, NY.
Fig. 3: Sample COAST014, Great South Bay, NY.
Fig. 4: Sample COAST010, Great South Bay, NY.
Figs 5-7,9-10: Sample BBDC0041, Barnegat Bay, NJ.
Fig. 8: Sample BBDC0047, Barnegat Bay, NJ.
Figs 11-12: Sample BBDC0054, Barnegat Bay, NJ.

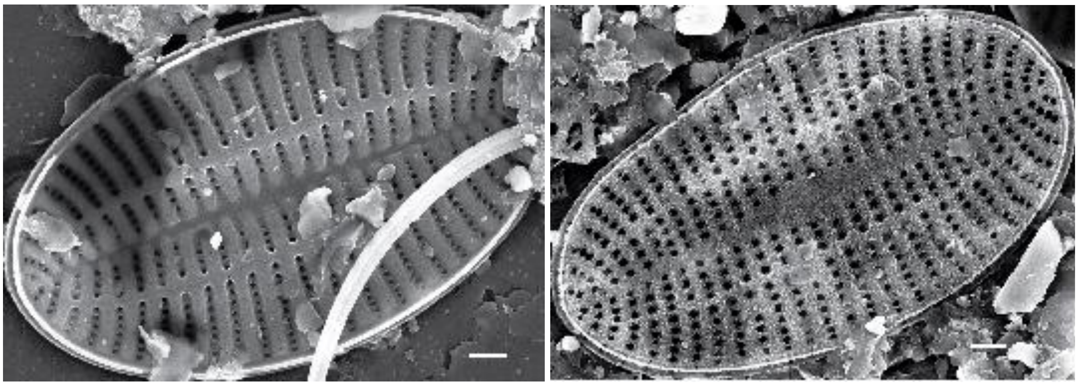
Figs 13-24: ***Cocconeis sigillata*** Riaux-Gobin & Al-Handal

Lit.: Riaux-Gobin et al. 2011: 332, figs 37-45

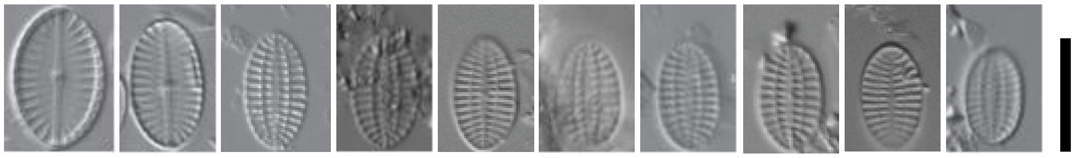
Figs 13,15: Sample COAST004, Peconic Bay, NY.
Fig. 14: Sample COAST016, Great South Bay, NY.
Fig. 16: Sample BB0069, Barnegat Bay, NJ.
Fig. 17: Sample BB0056, Barnegat Bay, NJ.
Figs 18,21: Sample BBDC0041, Barnegat Bay, NJ.
Fig. 19: Sample COAST003, Peconic Bay, NY.
Fig. 20: Sample BBDC0054, Barnegat Bay, NJ.
Figs 22-23: Sample BBDC0045, Barnegat Bay, NJ.
Fig. 24: Sample COAST022, Great South Bay, NY.



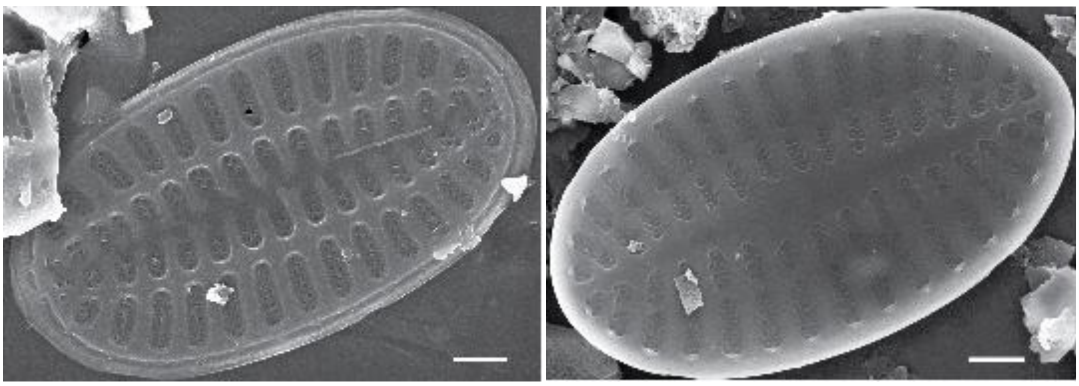
1 - 10



11 - 12



13 - 22



23 - 24

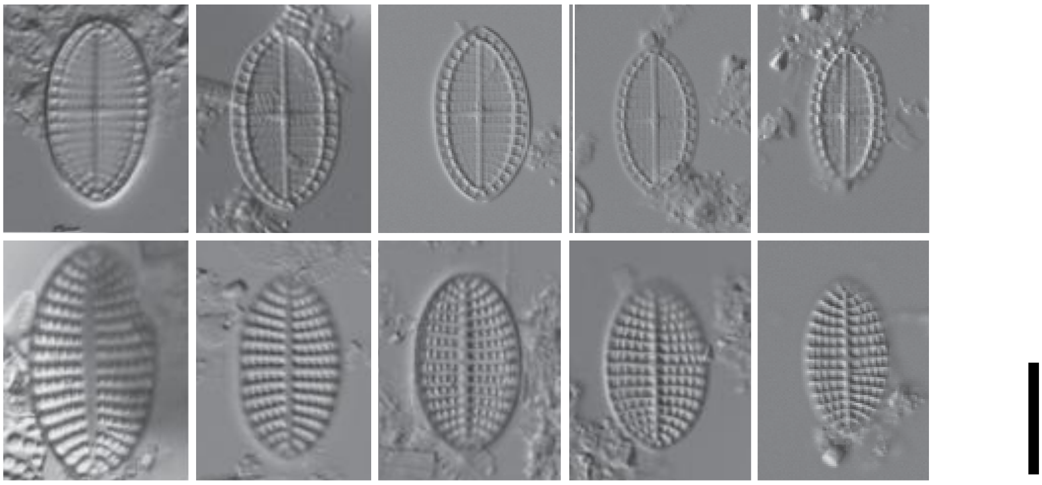
Plate 109 (Scale bars: Figs 1-10=10 µm; Figs 11-13=1 µm)

Cocconeis stauroneiformis (Smith; Rabenhorst) Okuno

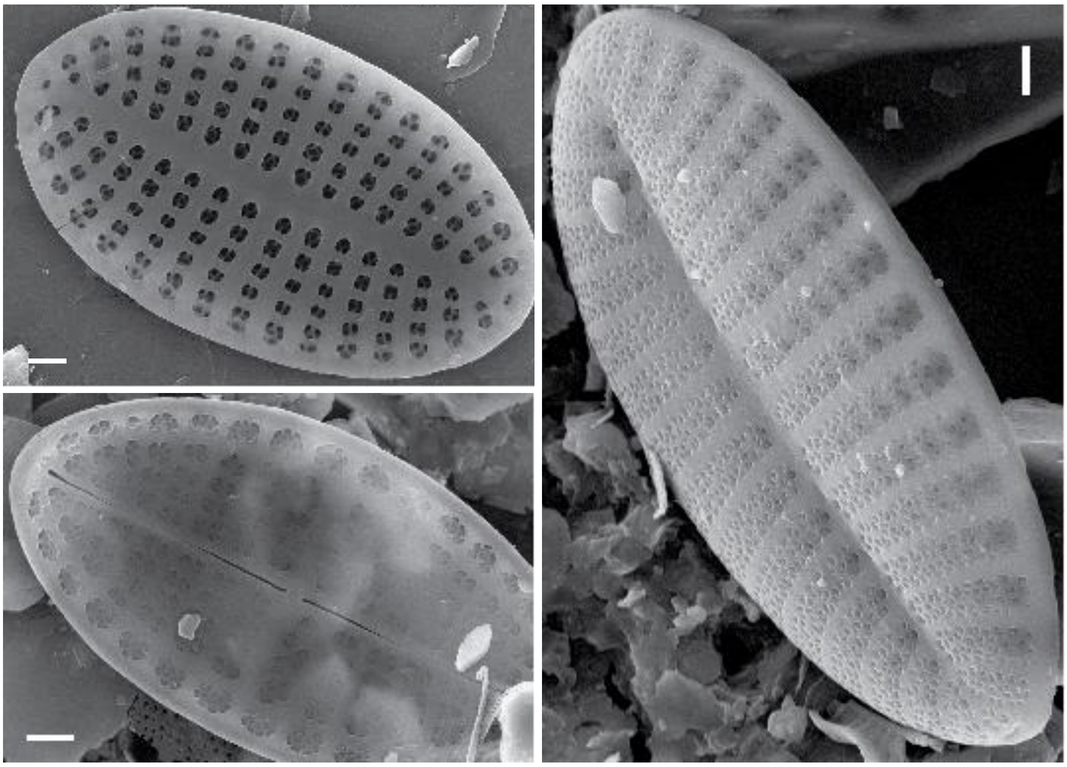
Lit.: Okuno 1957, p. 217; fig. 2, pl. 6/2

Basionym: *Cocconeis scutellum* var. *stauroneiformis* Rabenhorst 1864

Figs 1,8-9: Sample BBDC0044, Barnegat Bay, NJ.
Figs 2-7,10-13: Sample BBDC0051, Barnegat Bay, NJ.



1 - 10



11 - 13

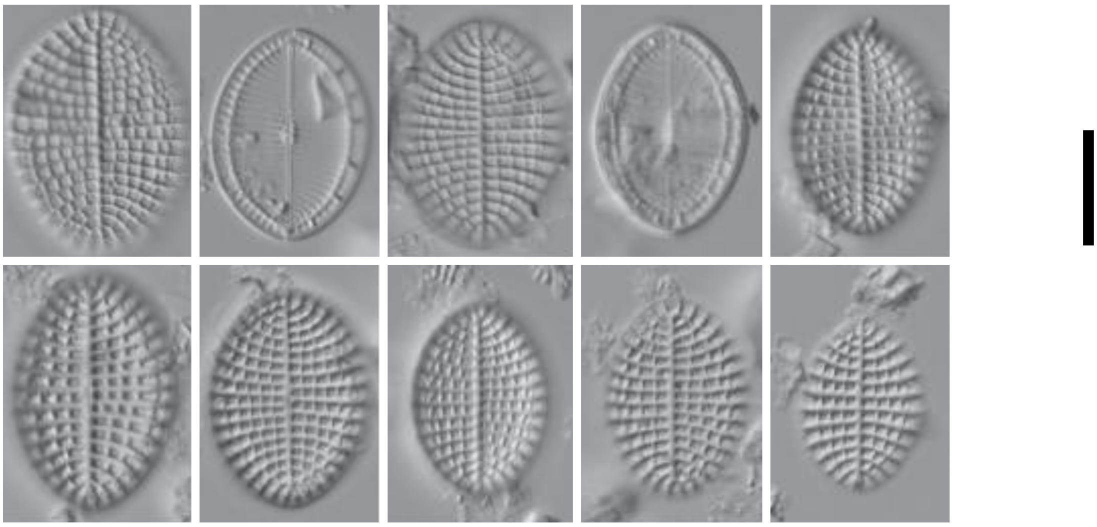
Plate 110 (Scale bars: Figs 1-10; 12-21=10 µm; Fig. 11=1 µm)

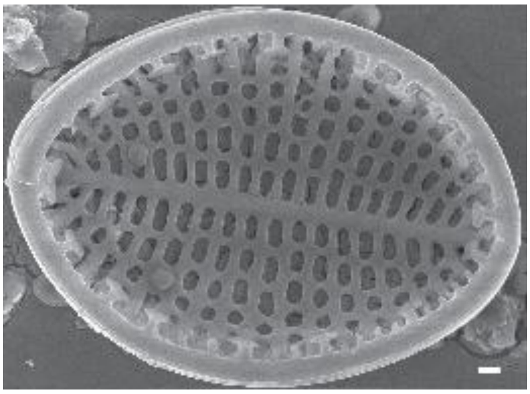
Figs 1-11: ***Cocconeis* cf. *scutellum***

Figs 1,4-6,9: Sample BBDC0051, Barnegat Bay, NJ.
Figs 2-3,7-8,10: Sample BBDC0044, Barnegat Bay, NJ.
Fig. 11: Sample BBDC0050, Barnegat Bay, NJ.

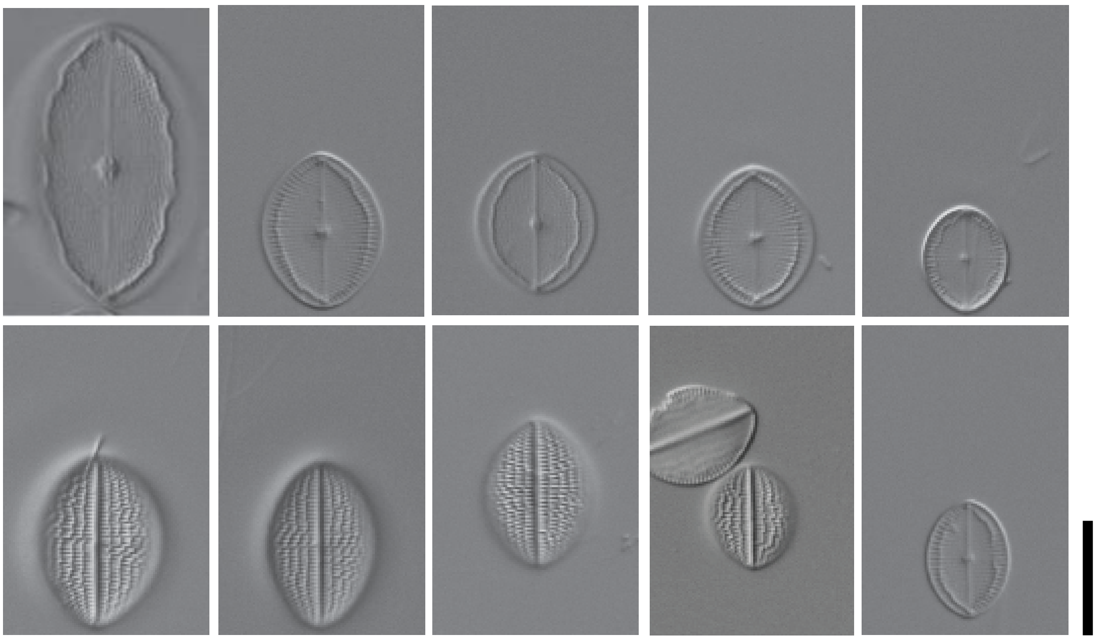
Figs 12-21: ***Cocconeis* sp. 5**

Figs 12-21: Sample RUTG0791, Tuckerton Bay, NJ.





1 - 11



12 - 21

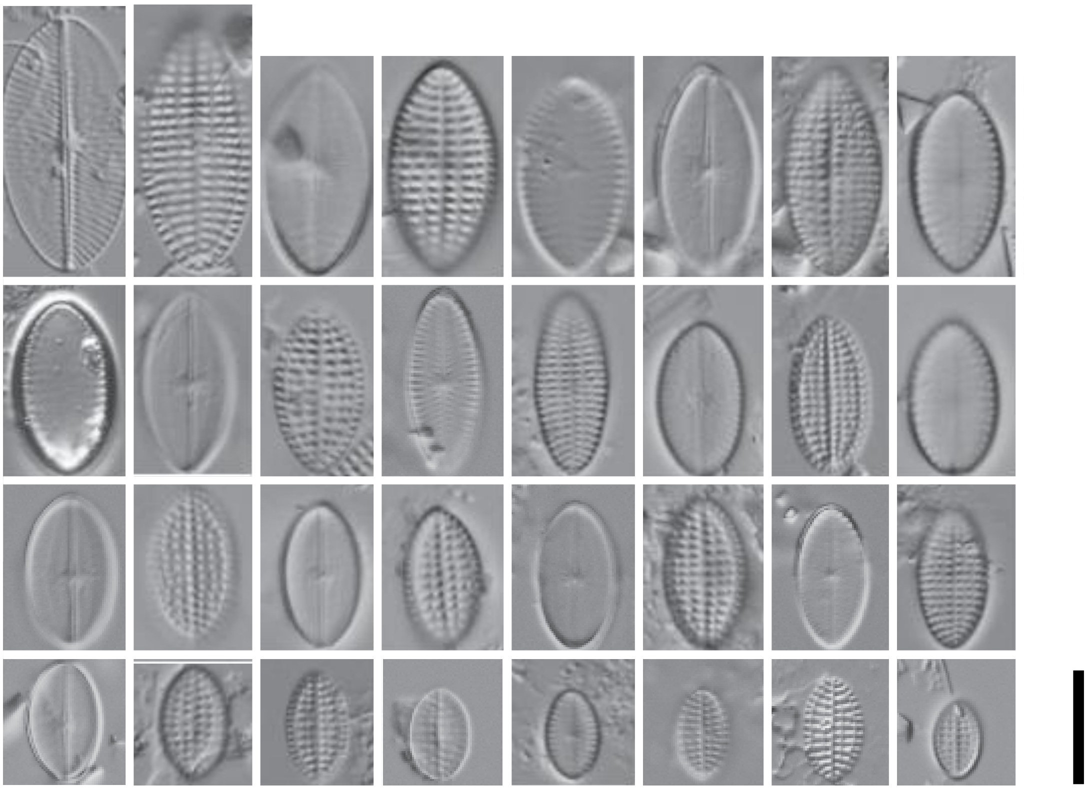
Plate 111 (Scale bars: Figs 1-32=10 µm; Figs 33-36=1 µm)

Amphicocconeis disculoides (Hustedt) De Stefano & Marino

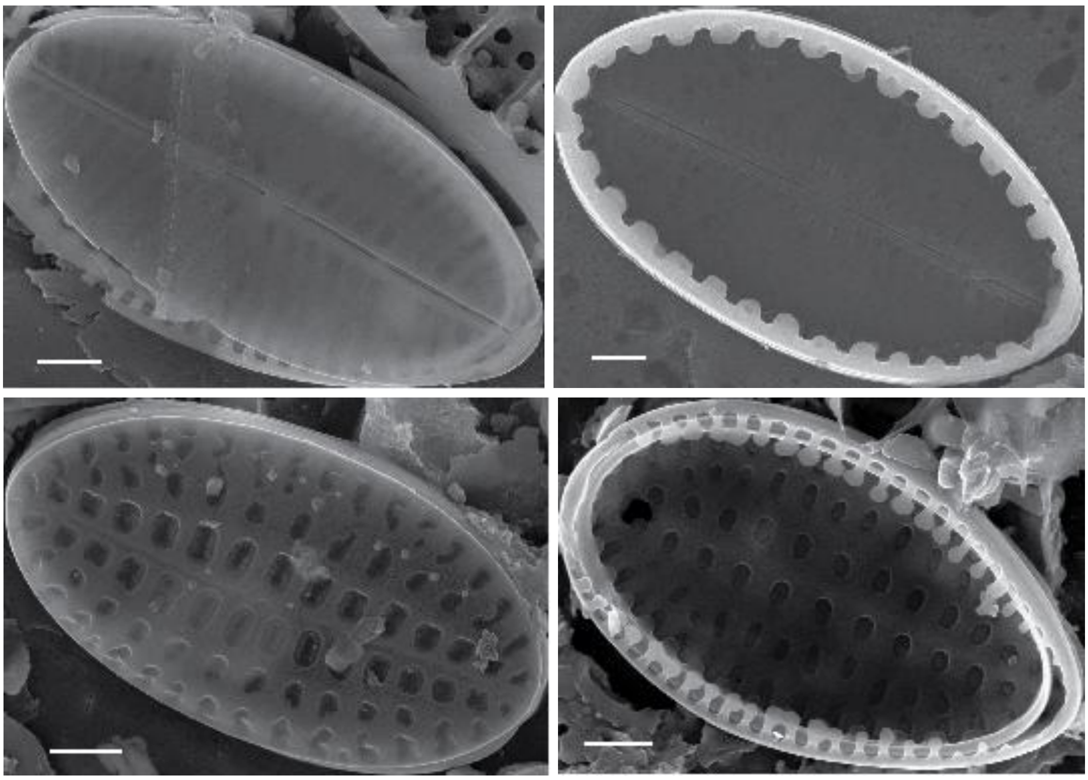
Lit.: De Stefano & Marino 2002, p. 262

Basionym: *Cocconeis disculoides* Hustedt 1955

Figs 1-2,5,8,10-13,15-17,19-21,23-25,28: Sample BBDC0041, Barnegat Bay, NJ.
Figs 3-4,14,18,26-27,29: Sample BBDC0044, Barnegat Bay, NJ.
Figs 6-7: Sample BBDC0084, Barnegat Bay, NJ.
Fig. 9: Sample BBDC0062, Barnegat Bay, NJ.
Fig. 22: Sample BBDC0066, Barnegat Bay, NJ.
Fig. 31: Sample BBDC0068, Barnegat Bay, NJ.
Fig. 32: Sample BBDC0052, Barnegat Bay, NJ.
Figs 33,35-36: Sample BBDC0054, Barnegat Bay, NJ.
Fig. 34: Sample BBDC0038, Barnegat Bay, NJ.



1 - 32



33 - 36

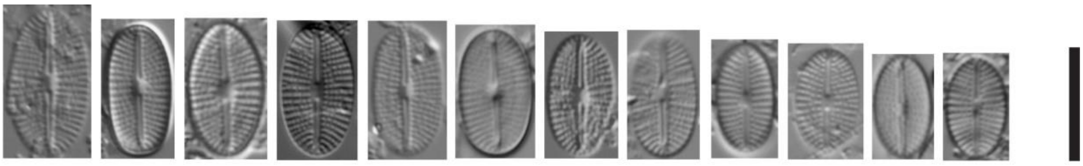
Plate 112 (Scale bars: Figs 1-12; 15-24=10 µm; Figs 13-14=1 µm)

Figs 1-14:***Cocconeiopsis breviata*** (Hustedt) Witkowski, Lange-Bertalot & Metzeltin
Lit.:Witkowski, Lange-Bertalot & MetzeltLit.:2000, p. 172
Basionym: *Navicula breviata* Hustedt 1964
Fig. 1: Sample BB0055, Barnegat Bay, NJ.
Fig. 2: COAST009, Great South Bay, NY.
Fig. 3: Sample BBDC0016, Barnegat Bay, NJ.
Fig. 4: Sample BBDC0003, Barnegat Bay, NJ.
Fig. 5: Sample BBDC0054, Barnegat Bay, NJ.
Figs 6,11: Sample BBDC0044, Barnegat Bay, NJ.
Fig. 7: Sample BBDC0041, Barnegat Bay, NJ.
Fig. 8: Sample BBDC0048, Barnegat Bay, NJ.
Figs 9-10: Sample COAST054, Barnegat Bay, NJ.
Fig. 12: Sample BB0052, Barnegat Bay, NJ.
Fig. 13: Sample BBDC0038, Barnegat Bay, NJ.
Fig. 14: Sample COAST030, Western Bay, NY.

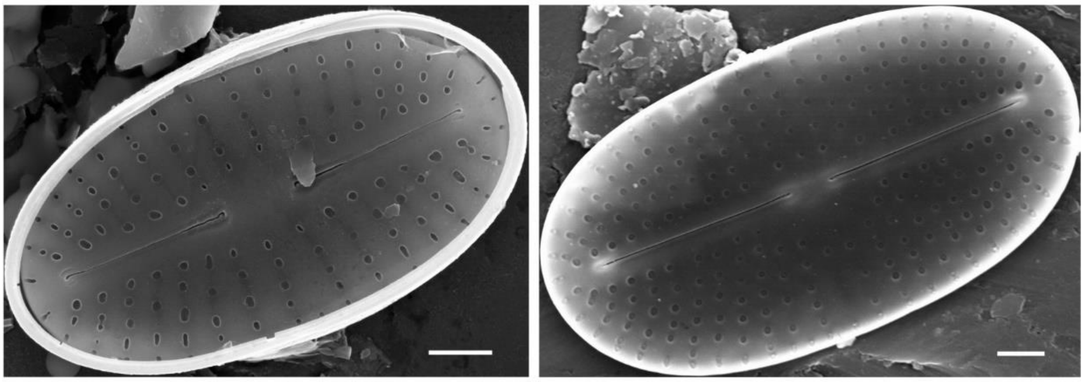
Figs 15-21: ***Cocconeiopsis fraudulenta*** (Schmidt) Witkowski, Lange-Bertalot & Metzeltin
Lit.:Witkowski, Lange-Bertalot & MetzeltLit.:2000, p. 173
Basionym: *Navicula fraudulenta* Schmidt in Schmidt et al. 1881
Synonym: *Schizonema fraudulentum* (Schmidt) Kuntze 1898
Fig. 15: Sample BB0054, Barnegat Bay, NJ.
Fig. 16: Sample BBDC0032, Barnegat Bay, NJ.
Fig. 17: COAST002, Peconic Bay, NY.
Figs 18-20: COAST004, Peconic Bay, NY.
Fig. 21: Sample BBDC0018, Barnegat Bay, NJ.

Fig. 22: ***Cocconeiopsis* sp. 1**
Fig. 22: COAST025, Great South Bay, NY.

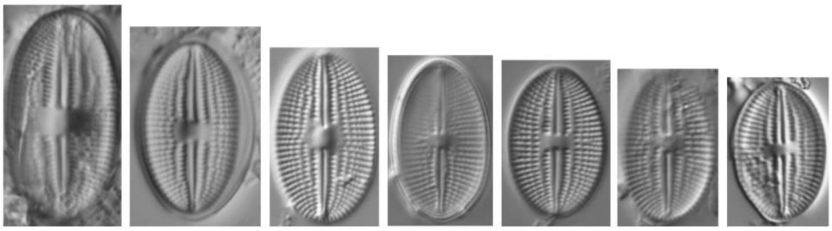
Figs 23-24: ***Cocconeiopsis* sp. 2**
Fig. 23: COAST002, Peconic Bay, NY.
Fig. 24: Sample BBDC0044, Barnegat Bay, NJ.



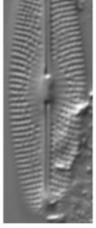
1 - 12



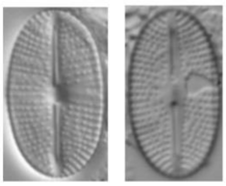
13 - 14



15 - 21



22



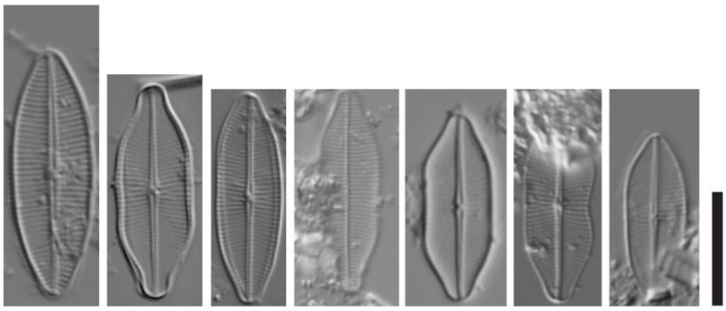
23 - 24

Plate 113 (Scale bars: Figs 1-7=10 µm; Figs 8-13=1 µm)

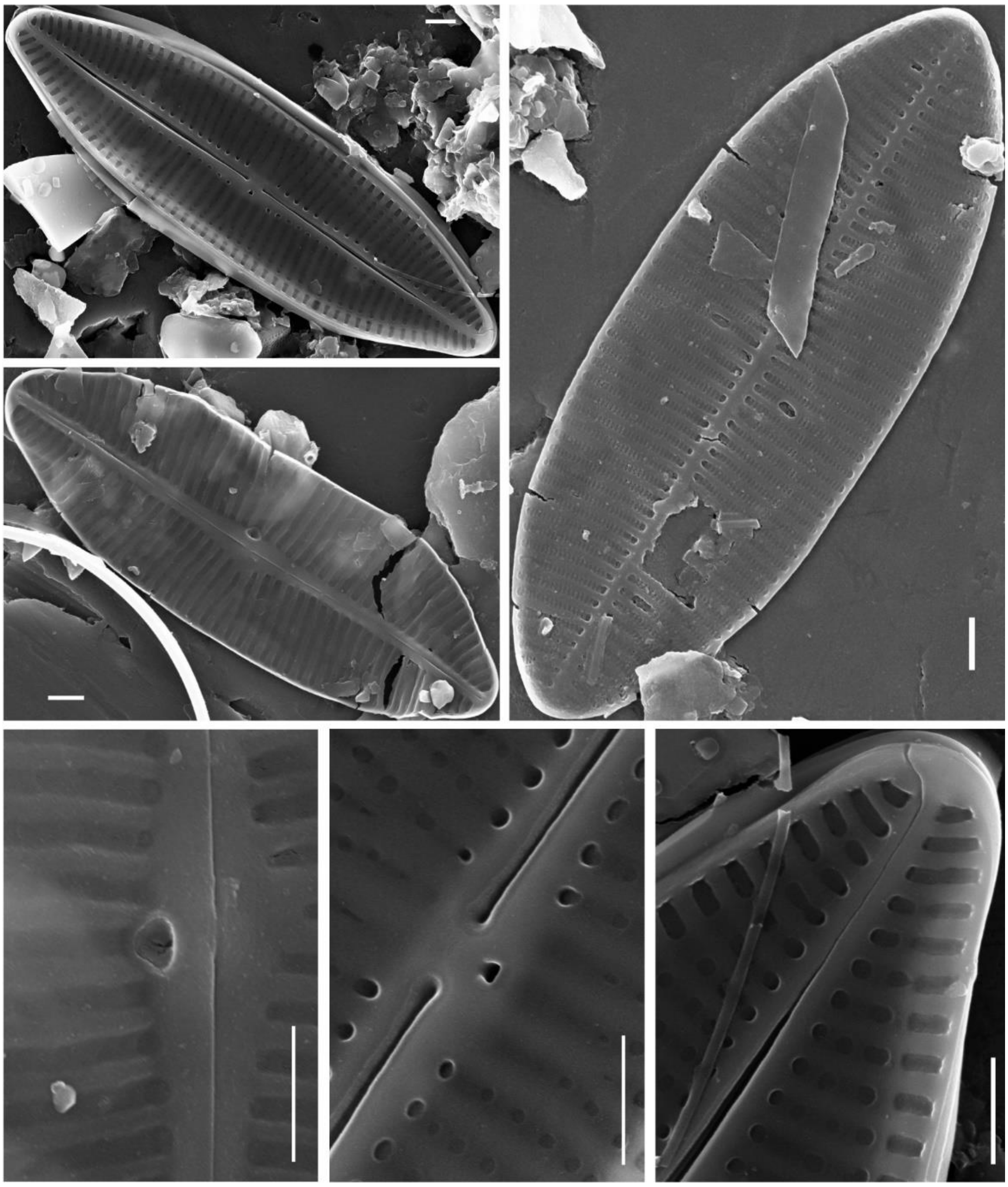
Astartiella bahusiensis (Grunow Lit.:Van Heurck) Witkowski, Lange-Bertalot & Metzeltin
Lit.:Moser, Lange-Bertalot & MetzeltLit.:1998, p. 359

Basionym: *Navicula minuscula* var. *bahusiensis* Grunow in Van Heurck 1880
Synonym: *Achnanthes bahusiensis* (Grunow) Lange-Bertalot in Lange-Bertalot & Krammer 1989
Navicula bahusiensis (Grunow) Cleve 1895
Schizonema bahusiense (Grunow) Kuntze 1898

Fig. 1: Sample BBDC0044, Barnegat Bay, NJ.
Fig. 2: Sample BBDC0001, Barnegat Bay, NJ.
Fig. 3: Sample BBDC0008, Barnegat Bay, NJ.
Fig. 4: Sample BBDC0046, Barnegat Bay, NJ.
Fig. 5: Sample BBDC0041, Barnegat Bay, NJ.
Fig. 6: Sample BBDC0049, Barnegat Bay, NJ.
Figs 7,9,11: Sample BBDC0051, Barnegat Bay, NJ.
Figs 8,12-13: Sample BBDC0080, Barnegat Bay, NJ.
Fig. 10: Sample BBDC0050, Barnegat Bay, NJ.



1 - 7



8 - 13

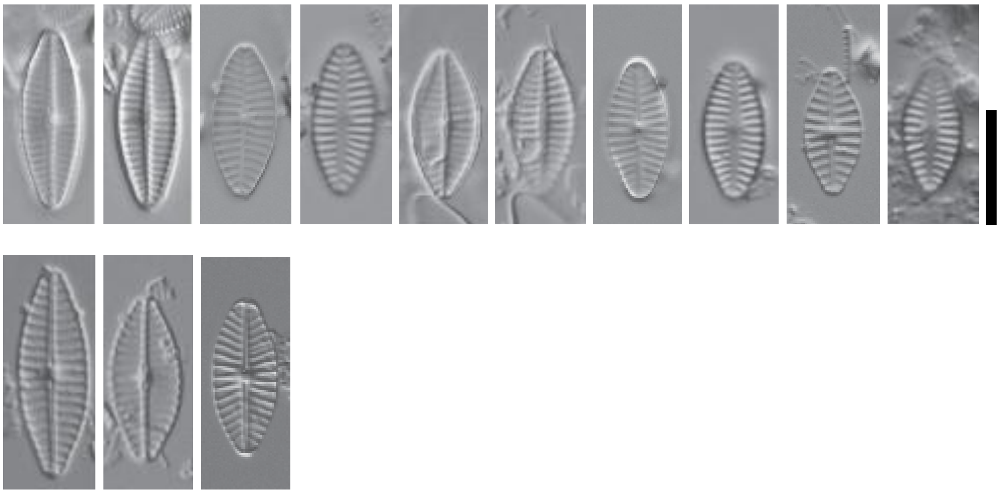
Plate 114 (Scale bars: Figs 1-11=10 µm; Figs 14-15=1 µm)

Planothidium delicatulum (Kützing) Round & Bukhtiyarova

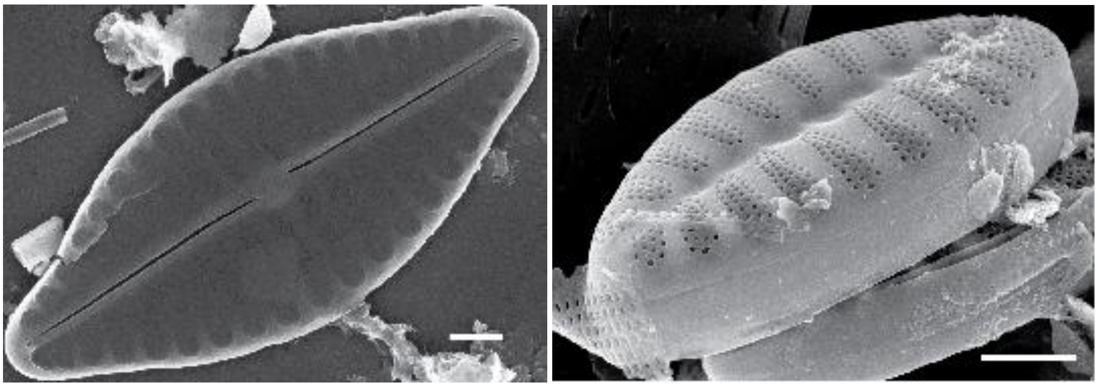
Lit.:Round et Bukhtiyarova 1996, p. 353

Basionym: *Achnanthidium delicatulum* Kützing 1844
Synonym: *Achnanthes delicatula* (Kützing) Brun 1880
Achnanthes delicatula (Kützing) Grunow in Cleve & Grunow 1880
Microneis delicatula (Kützing) Cleve 1895
Falcatella delicatula (Kützing) Rabenhorst 1853
Achnantheiopsis delicatula (Kützing) Lange-Bertalot 1997

Figs 1-2: Sample RUTG0001, Cape May Courthouse, NJ.
Figs 3-4: Sample BBDC0044, Barnegat Bay, NJ.
Figs 5-6,9,11-12: Sample BBDC0036, Barnegat Bay, NJ.
Figs 7-8: Sample BBDC0052, Barnegat Bay, NJ.
Fig. 10: Sample BB0066, Barnegat Bay, NJ.
Fig. 13: Sample BB0054, Barnegat Bay, NJ.
Fig. 14: Sample BBDC0037, Barnegat Bay, NJ.
Fig. 15: Sample BBDC0106, Great Bay, NJ.



1 - 13

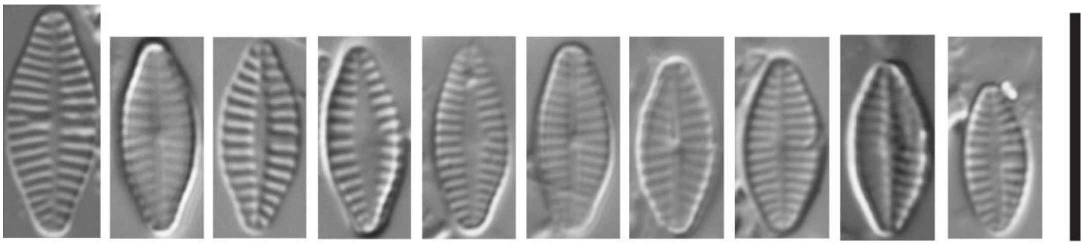


14 - 15

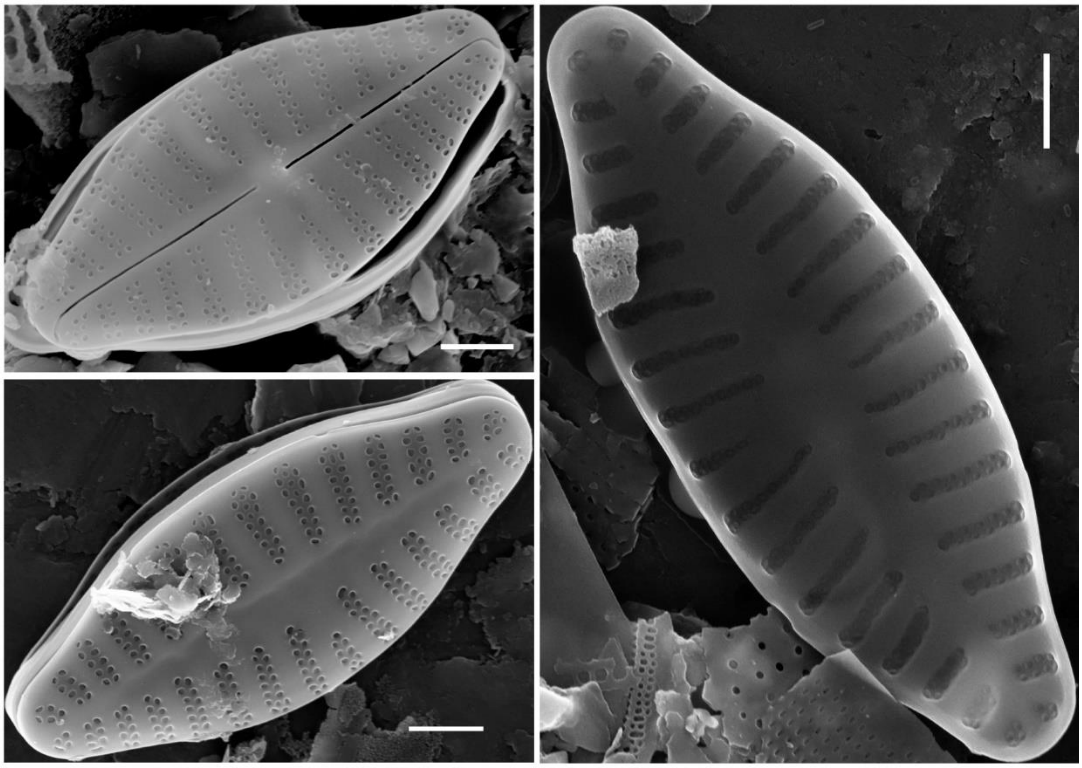
Plate 115 (Scale bars: Figs 1-10=10 μm; Figs 11-13=1 μm)

***Planothidium* sp. 11**

Figs 1,9: COAST001, Peconic Bay, NY.
Figs 2-4: COAST002, Peconic Bay, NY.
Figs 5-6,10: COAST004, Peconic Bay, NY.
Figs 7-8: COAST010, Great South Bay, NY.
Fig. 11: Sample BBDC0095, Great Bay, NJ.
Fig. 12: COAST003, Peconic Bay, NY.
Fig. 13: Sample BBDC0030, Barnegat Bay, NJ.



1 - 10



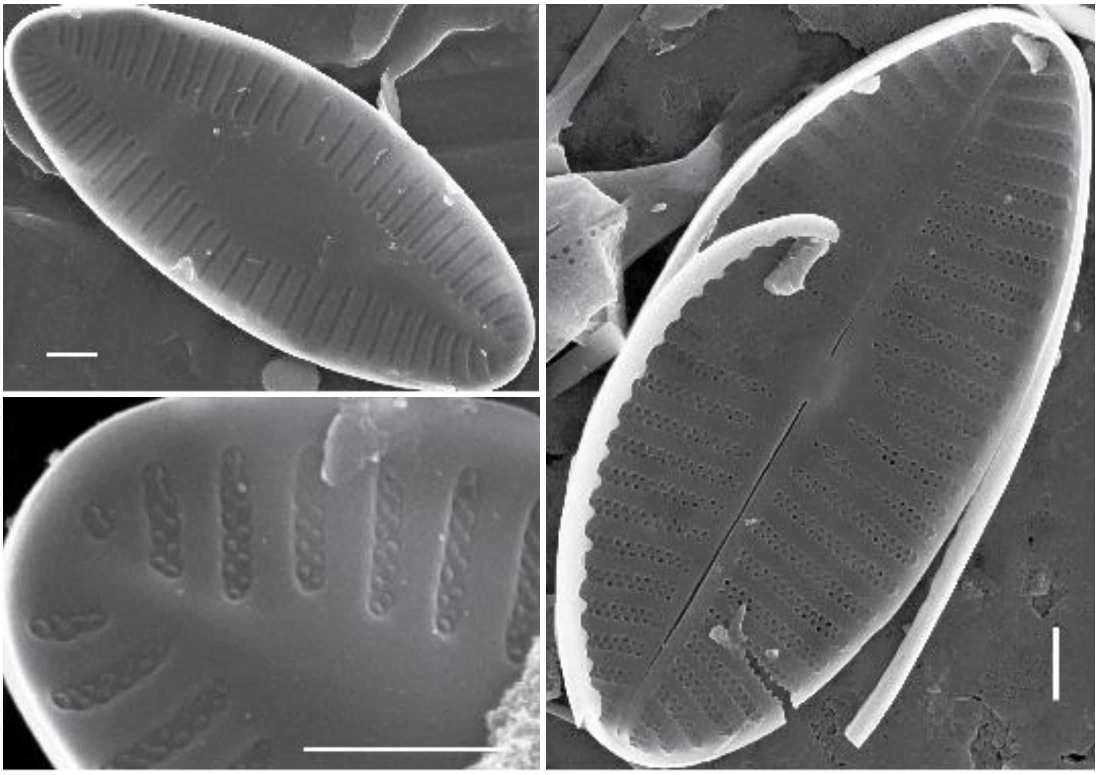
11 - 13

Plate 116 (Scale bars: Figs 1-13=10 µm; Figs 14-16=1 µm)

Planothidium rodriguense Riaux-Gobin & Compère
Lit.:Riaux-Gobin et al. 2012: 297, figs 1, 13-25

Figs 1-5: COAST0014, Great South Bay, NY.
Fig. 6: COAST009, Great South Bay, NY.
Figs 7-8: COAST010, Great South Bay, NY.
Figs 9-10: COAST003, Peconic Bay, NY.
Fig. 11: Sample BB0055, Barnegat Bay, NJ.
Figs 12-13: Sample BBDC0095, Great Bay, NJ.
Fig. 14: COAST013, Great South Bay, NY.
Figs 15-16: COAST022, Great South Bay, NY.

1 - 13

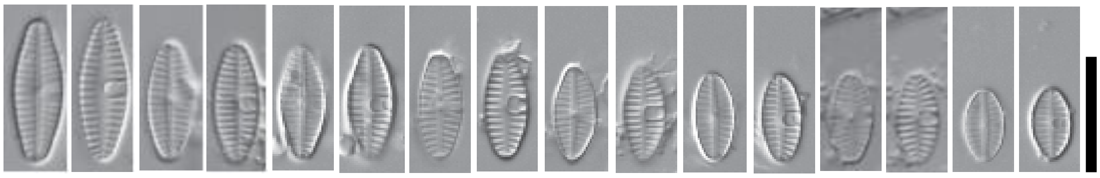


14 - 16

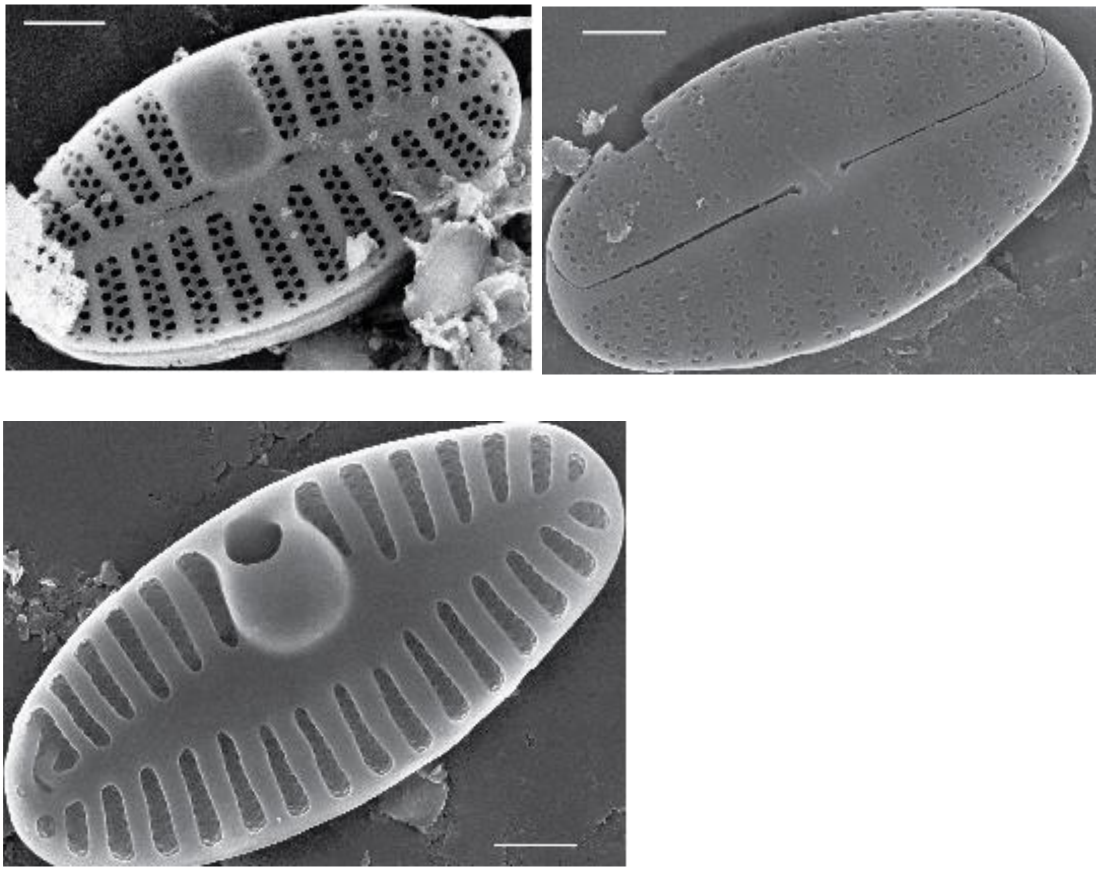
Plate 117 (Scale bars: Figs 1-16=10 µm; Figs 17-19=1 µm)

Planothidium* cf. *frequentissimum

Figs 1-2,5-12,15-16: Sample RUTG0001, Cape May Courthouse, NJ.
Figs 3-4: Sample BBDC0049, Barnegat Bay, NJ.
Figs 13-14: Sample BBDC0071, Barnegat Bay, NJ.
Fig. 17: Sample BBDC0040, Barnegat Bay, NJ.
Figs 18-19: Sample BBDC0037, Barnegat Bay, NJ.



1 - 16

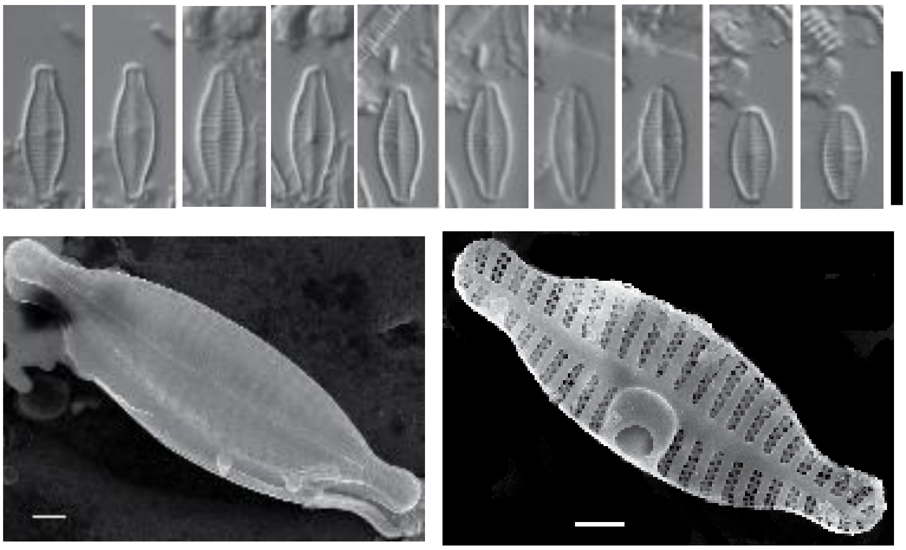


17 - 19

Plate 118 (Scale bars: Figs 1-10=10 µm; Figs 11-12=1 µm)

***Planothidium* cf. *frequentissimum* morphotype 2**

Figs 1-11: Sample RUTG0852, Bass River, NJ.
Fig. 12: Sample BBDC0038, Barnegat Bay, NJ.
Fig. 13: Sample BB0003, Barnegat Bay, NJ.



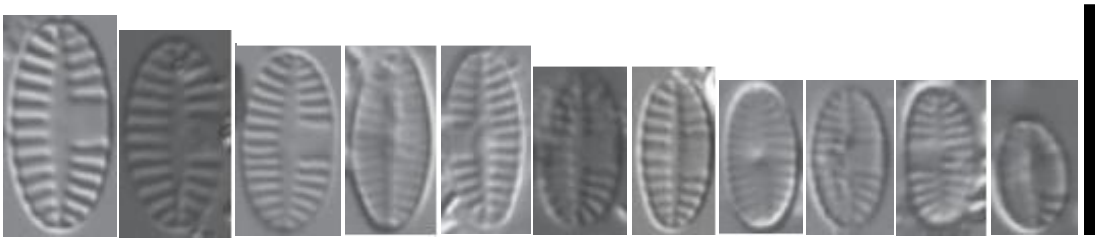
1 - 12

Plate 119 (Scale bars: Figs 1-11=10 µm; Figs 12-17=1 µm)

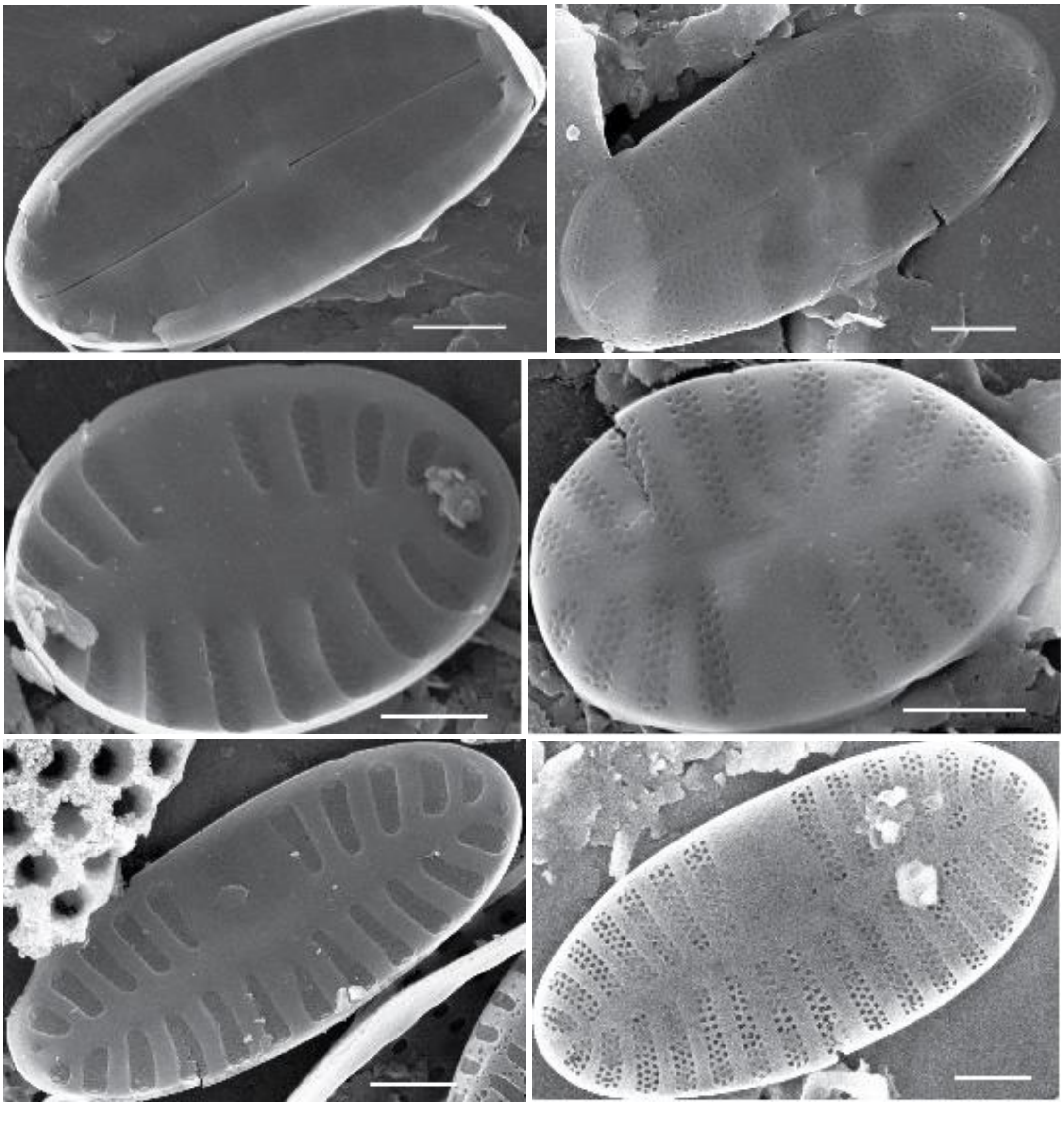
Planothidium deperditum (Giffen) Witkowski, Lange-Bertalot & Metzeltin
Lit.:Witkowski, Lange-Bertalot & MetzeltLit.:2000, p. 119

Basionym: *Cocconeis deperdita* Giffen 1975

Figs 1,4-5: COAST0021, Great South Bay, NY.
Fig. 2: Sample BBDC0001, Barnegat Bay, NJ.
Fig. 3: COAST010, Great South Bay, NY.
Fig. 6: Sample BBEDC058, Cattus Island, NJ.
Fig. 7: COAST002, Peconic Bay, NY.
Figs 8,10: COAST0051, Barnegat Bay, NJ.
Fig. 9: COAST0052, Barnegat Bay, NJ.
Fig. 11: Sample BB079, Barnegat Bay, NJ.
Fig. 12: COAST0054, Barnegat Bay, NJ.
Figs 13,15: Sample BBDC0047, Barnegat Bay, NJ.
Fig. 14: COAST0068, North East Jersey shore, NJ.
Fig. 16: COAST0022, Great South Bay, NY.
Fig. 17: Sample BBDC0054, Barnegat Bay, NJ.



1 - 11



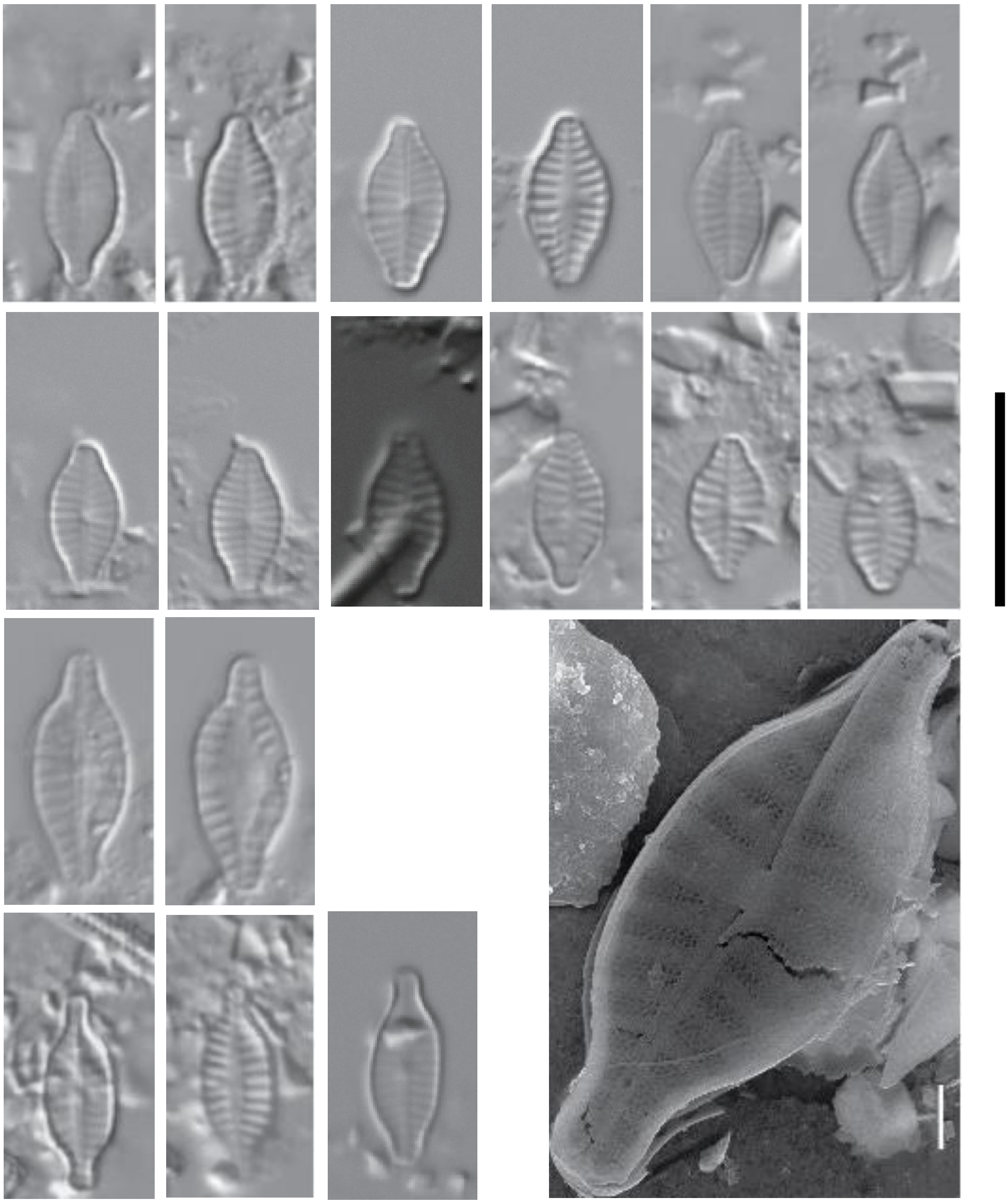
12 - 17

Plate 120 (Scale bars: Figs 1-17=10 µm; Fig.18=1µm)

Planothidium lemmermannii (Hustedt) Morales
Lit.:Morales 2006, p. 336

Basionym: *Achnanthes lemmermannii* Hustedt 1933

Figs 1-8,10-12: COAST0052, Barnegat Bay, NJ.
Fig. 9: Sample BBDC0002, Barnegat Bay, NJ.
Figs 13-14: COAST002, Peconic Bay, NY.
Fig. 14: COAST0068, North East Jersey shore, NJ.
Figs 15-16: COAST0051, Barnegat Bay, NJ.
Fig. 17: Sample BBDC0044, Barnegat Bay, NJ.
Fig. 18: Sample BBDC0003, Barnegat Bay, NJ.



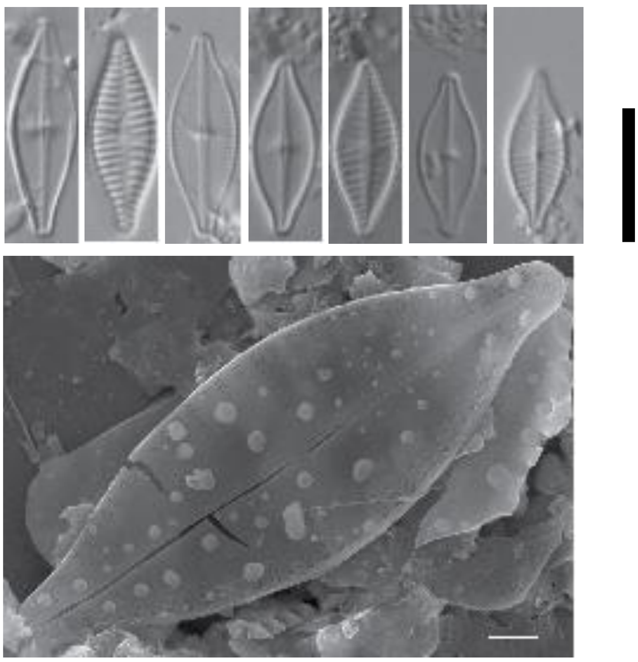
1 - 18

Plate 121 (Scale bars: Figs 1-7=10 µm; Fig. 8=1 µm)

Planothidium oculatum (Hustedt) Witkowski, Lange-Bertalot & Metzeltin
Lit.:Witkowski, Lange-Bertalot & Metzeltin, 2000, p. 122

Basionym: *Achnanthes oculata* Hustedt 1952

Fig. 1: Sample BBDC0063, Barnegat Bay, NJ.
Figs 2-3: COAST0027, Great South Bay, NY.
Figs 4-5: Sample BBDC0068, Barnegat Bay, NJ.
Fig. 6: Sample BBDC0055, Barnegat Bay, NJ.
Fig. 7: Sample BBDC0059, Barnegat Bay, NJ.



1 - 8

Plate 122 (Scale bars: Figs 1-10; 16-21=10 μm; Figs 11-15=1 μm)

Figs 1-15: ***Karayevia submarina*** (Hustedt) Bukhtiyarova
Lit.:Bukhtiyarova 2006, p. 91

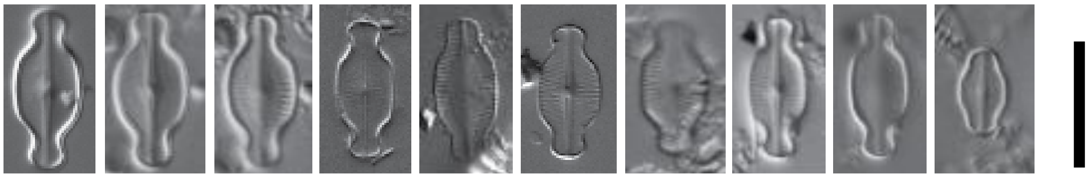
Basionym: *Achnanthes submarina* Hustedt 1956

Figs 1-2,7: Sample BBDC0065, Barnegat Bay, NJ.
Fig. 3: Sample BBDC0069, Barnegat Bay, NJ.
Fig. 4: Sample BBDC0007, Barnegat Bay, NJ.
Figs 5-6: Sample BBDC0001, Barnegat Bay, NJ.
Figs 8-9: Sample BBDC0046, Barnegat Bay, NJ.
Fig. 10: Sample BBDC0071, Barnegat Bay, NJ.
Figs 11-14: Sample BBDC0038, Barnegat Bay, NJ.
Fig. 15: Sample BBDC0016, Barnegat Bay, NJ.

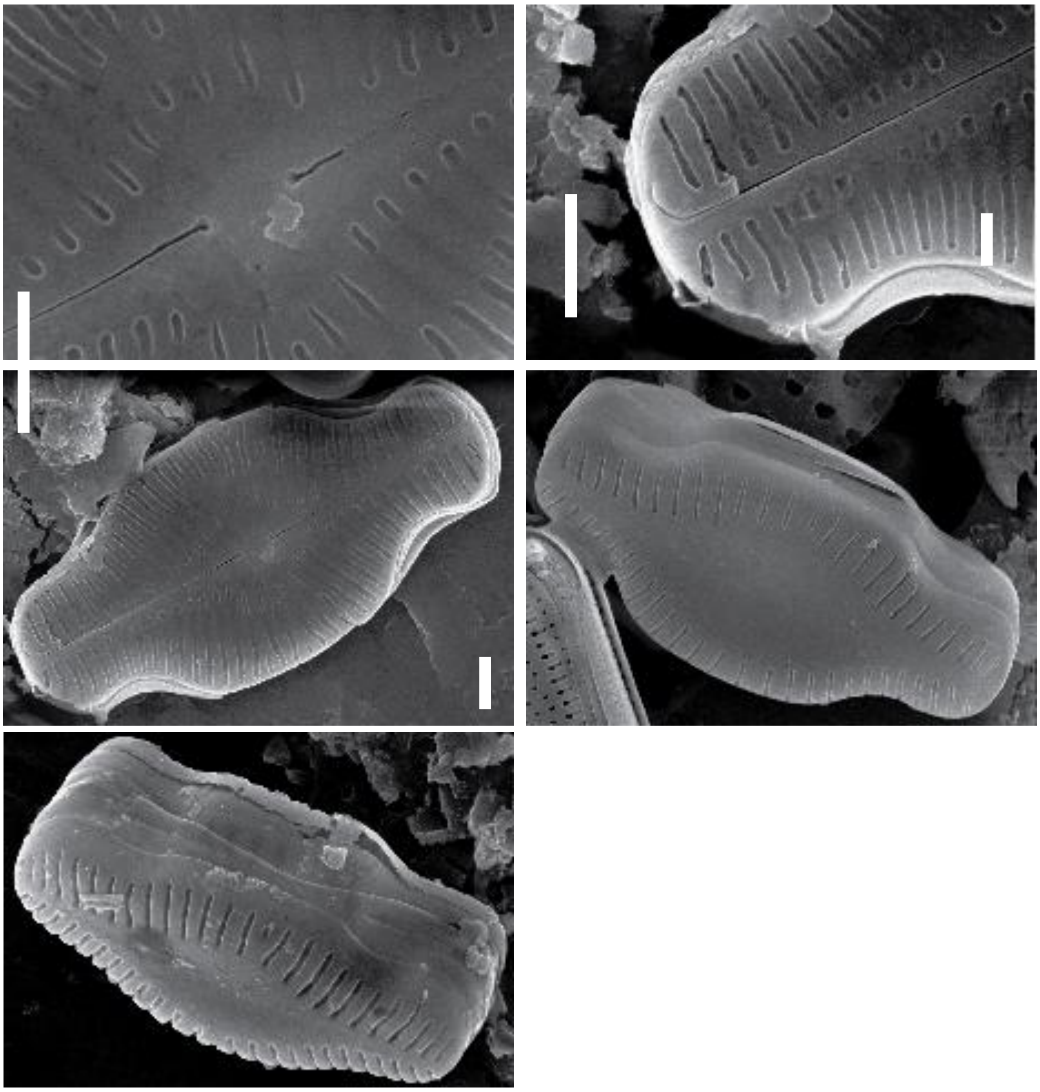
Figs 16-21: ***Karayevia amoena*** (Hustedt) Bukhtiyarova
Lit.:Bukhtiyarova 2006, p. 94

Basionym: *Achnanthes amoena* Hustedt 1952

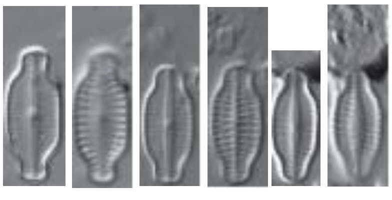
Figs 16-17: COAST0053, Barnegat Bay, NJ.
Figs 18-19: Sample BBDC0037, Barnegat Bay, NJ.
Figs 20-21: Sample BB0001, Barnegat Bay, NJ.



1 - 10



11 - 15



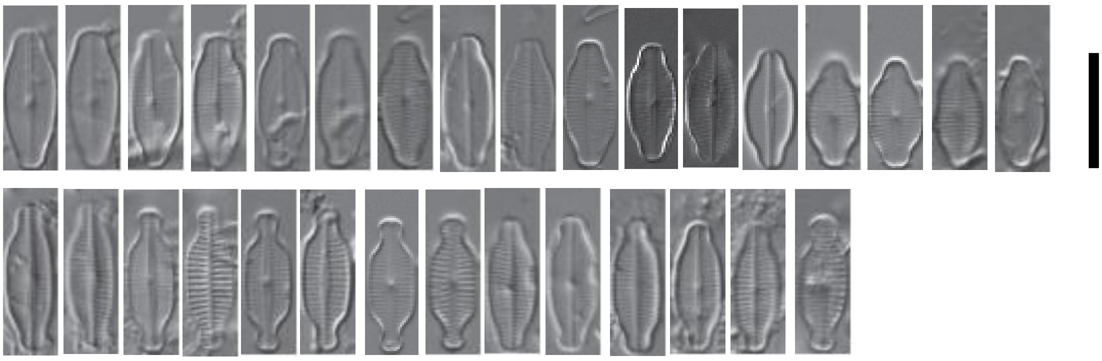
16 - 21

Plate 123 (Scale bars: Figs 1-31=10 µm; Figs 32-33=1 µm)

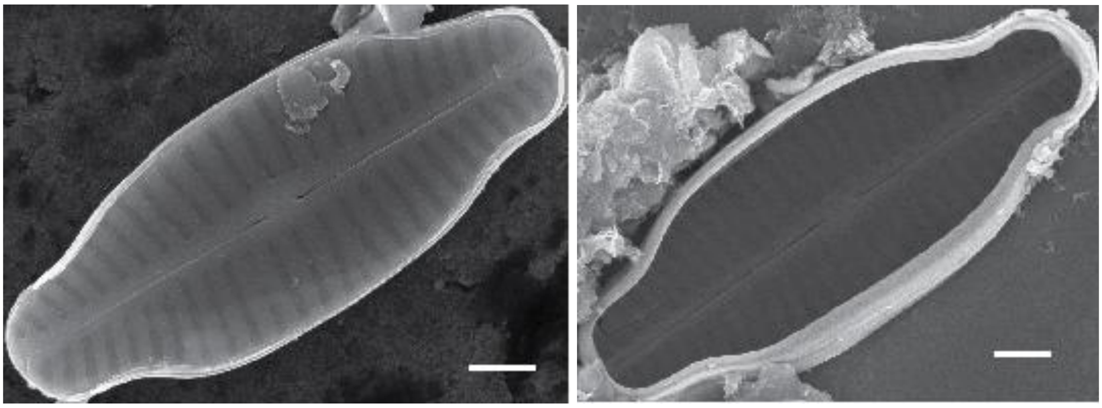
Madinithidium capitatum Desrosiers, Witkowski & Riaux-Gobin

Lit.:Desrosiers, Witkowski, Riaux-Gobin, Zglobicka, Kurzydlowski, Eulin, Leflaive, & Ten-Hage. 2014. p.583-592, figs 1-22.

Figs 1-10,13-17,20-31: Sample BBDC0037, Barnegat Bay, NJ.
Fig. 11: Sample BBDC0001, Barnegat Bay, NJ.
Fig. 12: Sample BBDC0005, Barnegat Bay, NJ.
Figs 18-19: Sample BBDC0075, Barnegat Bay, NJ.
Figs 32-33: Sample BBDC0003, Barnegat Bay, NJ.



1 - 31



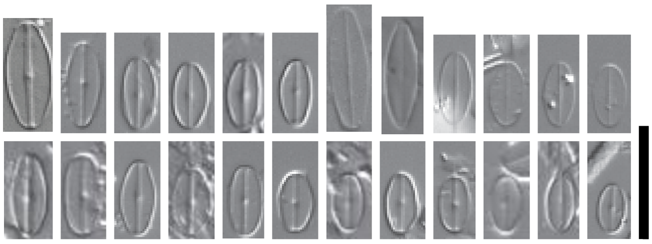
32 - 33

Plate 124 (Scale bars: Figs 1-24=10 µm; Figs 25-30=1 µm)

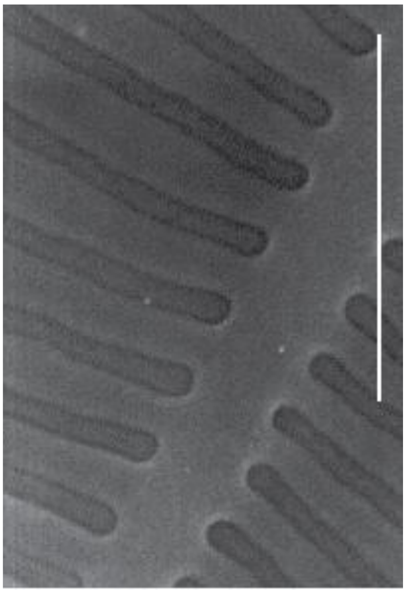
Madinithidium flexuistriatum Desrosiers, Witkowski & Riaux-Gobin
Lit.:Desrosiers, Witkowski, Riaux-Gobin, Zglobicka, Kurzydlowski, Eulin, Leflaive, & Ten-Hage. 2014. p.583-592, figs 1-22.

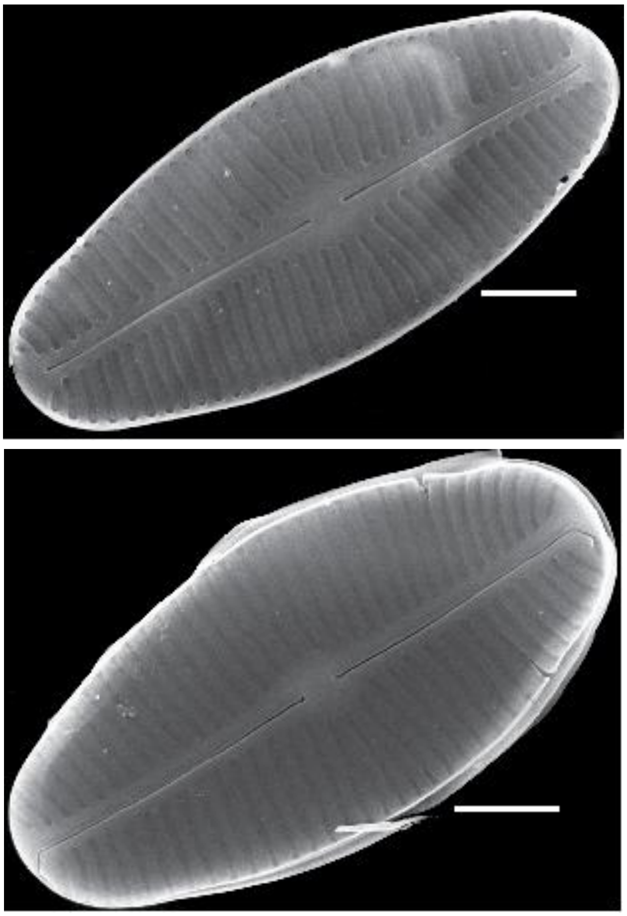
Basionym: *Achnanthidium flexuistriatum* Riaux-Gobin, Compère & Witkowski 2010

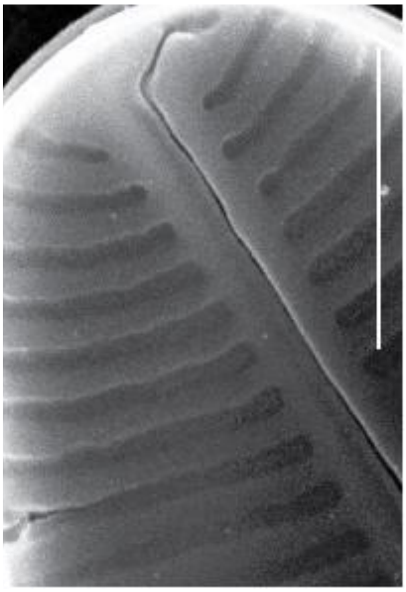
Fig. 1: COAST0002, Peconic Bay, NY.
Figs 2-6,9-14,16-24: COAST0015, Great South Bay, NY.
Fig. 7: COAST0013, Great South Bay, NY.
Fig. 8: Sample BBDC0044, Barnegat Bay, NJ.
Fig. 15: COAST0004, Peconic Bay, NY.
Figs 25-30: COAST0003, Peconic Bay, NY.

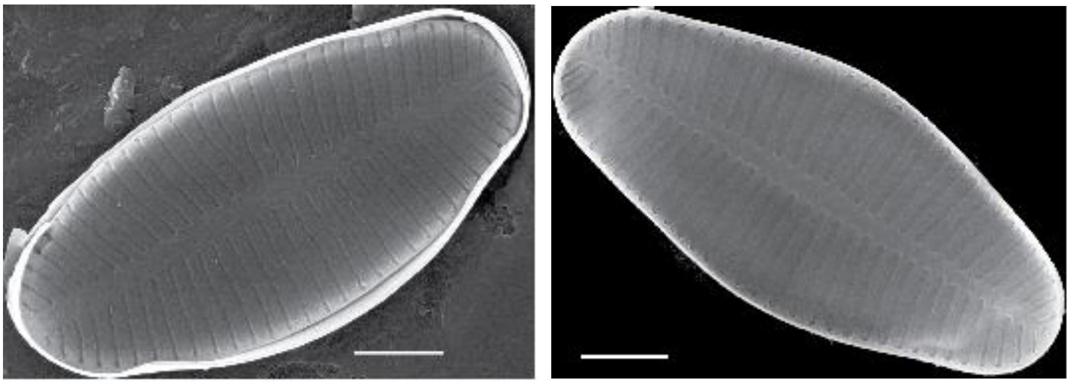


1 - 24









25 - 30

Plate 125 (Scale bar: Figs 1-13=10 µm)

Figs 1-2: ***Parlibellus crucicula*** (Smith) Witkowski, Lange-Bertalot & Metzeltin
Lit.: Witkowski, Lange-Bertalot & Metzeltin 2000, p. 321
Basionym: *Stauroneis crucicula* Smith 1853
Synonyms: *Navicula crucicula* (Smith) Donkin 1871
Schizonema crucicula (Smith) Kuntze 1898
Fig. 1: Sample BBDC0049, Barnegat Bay, NJ.
Fig. 2: Sample BB0064, Barnegat Bay, NJ.

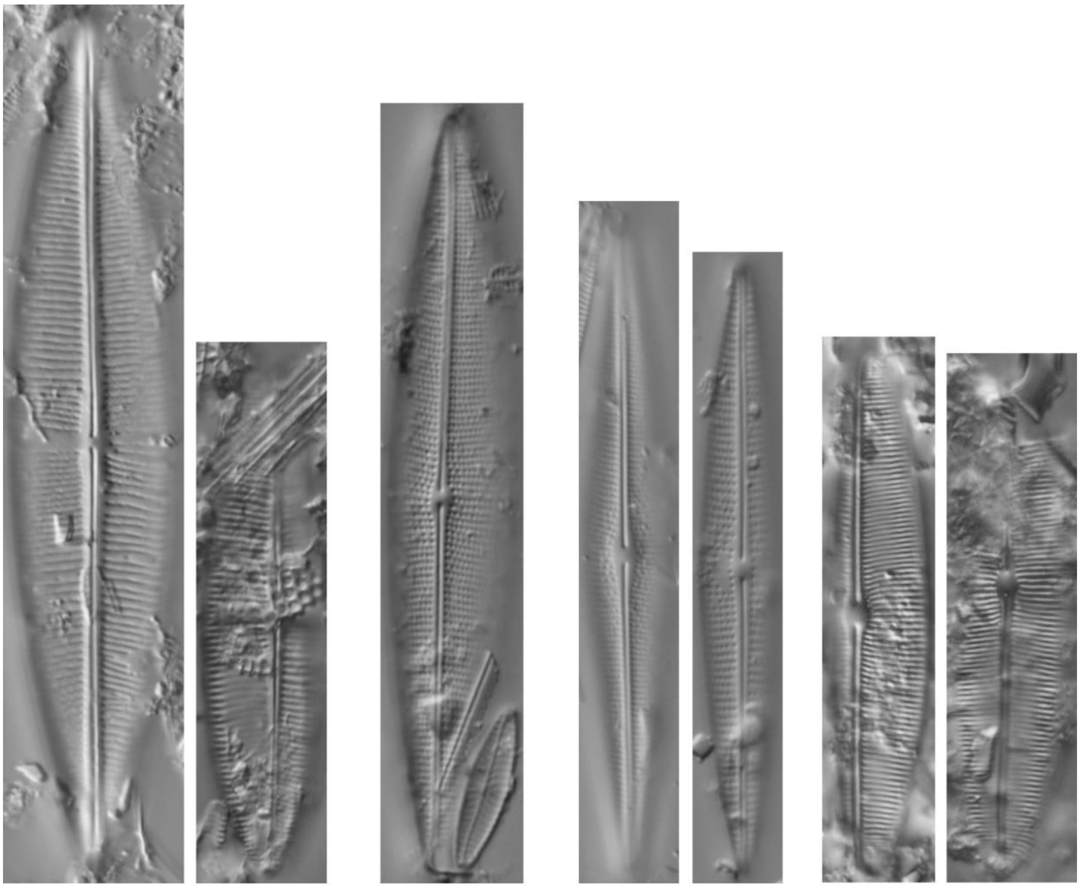
Fig. 3: ***Parlibellus grevilleoides*** (Hustedt) Cox
Lit.: Cox 1988, p. 23
Basionym: *Navicula grevilleoides* Hustedt 1962
Fig. 3: Sample RUTG0863, Pilot Drive, NJ.

Figs 4-5: ***Parlibellus* sp. 1**
Fig. 4: Sample RUTG0870, Eugene Furey, NJ.
Fig. 5: Sample BBDC0108, Great Bay, NJ.

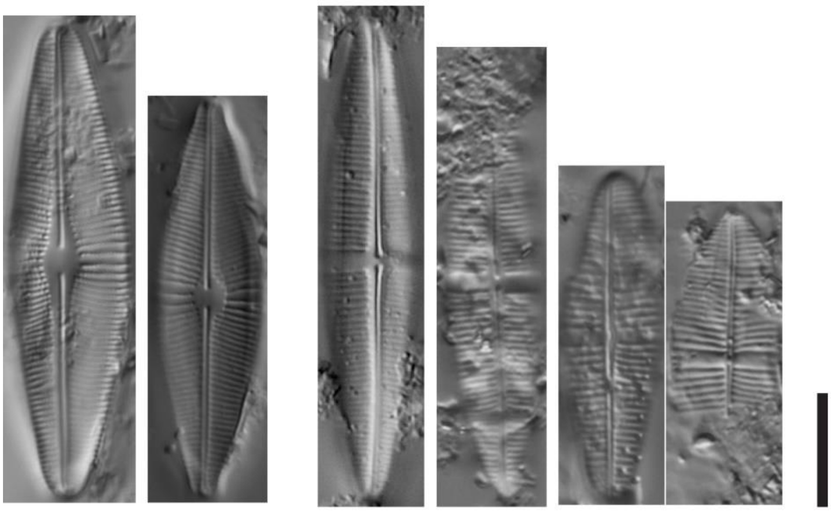
Figs 6-7: ***Parlibellus plicatus*** (Donkin) Cox
Lit.: Cox 1988, p. 25; fig. 28, 31, 32, 39
Basionym: *Navicula plicata* Donkin
Fig. 6: Sample BB0076, Barnegat Bay, NJ.
Fig. 7: Sample BB0064, Barnegat Bay, NJ.

Figs 8-9: ***Parlibellus* sp. 8**
Figs 8-9: Sample BBDC0009, Barnegat Bay, NJ.

Figs 10-13: ***Parlibellus* sp. 9**
Fig. 10: Sample BBDC0002, Barnegat Bay, NJ.
Fig. 11: Sample BBDC0058, Barnegat Bay, NJ.
Fig. 12: Sample GB023, Great Bay, NJ.
Fig. 13: Sample BB0067, Barnegat Bay, NJ.



1 - 2 3 4 - 5 6 - 7



8 - 9 10 - 13

Plate 126 (Scale bar: Figs 1-40=10 µm)

Figs 1-9: ***Parlibellus* cf. *crucicula***

Figs 1-8: Sample RUTG0863, Pilot Drive, NJ.
Fig. 9: Sample BBDC0001, Barnegat Bay, NJ.

Fig. 10: ***Parlibellus* sp. 3**

Fig. 10: Sample BBDC0022, Barnegat Bay, NJ.

Fig. 11: ***Parlibellus* sp. 6**

Fig. 11: Sample BB0065, Barnegat Bay, NJ.

Fig. 12: ***Parlibellus* sp. 7**

Fig. 12: Sample BBDC0065, Barnegat Bay, NJ.

Fig. 13: ***Parlibellus* sp. 10**

Fig. 13: Sample BBDC0016, Barnegat Bay, NJ.

Fig. 14: ***Parlibellus* sp. 11**

Fig. 13: Sample GB001, Great Bay, NJ.

Fig. 15: ***Parlibellus* sp. 12**

Fig. 15: Sample RUTG0277, Rutgers Field Station, NJ.

Fig. 16: ***Parlibellus* sp. 13**

Fig. 16: Sample COAST043, Barnegat Bay, NJ.

Fig. 17-18: ***Parlibellus protracta*** (Grunow) Witkowski, Lange-Bertalot & Metzeltin

Lit.: Witkowski, Lange-Bertalot & Metzeltin 2000, p. 324
Basionym: *Navicula protracta* Grunow 1880
Synonym: *Schizonema protractum* (Grunow) Kuntze 1898

Fig. 17: Sample BBDC0008, Barnegat Bay, NJ.
Fig. 18: Sample BBDC0004, Barnegat Bay, NJ.

Fig. 19-21: ***Parlibellus* sp. 5**

Fig. 19: Sample BBDC0026, Barnegat Bay, NJ.
Fig. 20: Sample BBDC0108, Great Bay, NJ.
Fig. 21: Sample BBDC0003, Barnegat Bay, NJ.

Fig. 22: ***Parlibellus* sp. 14**

Fig. 22: Sample COAST043, Barnegat Bay, NJ.

Fig. 23: ***Parlibellus* sp. 15**

Fig. 22: Sample COAST056, Barnegat Bay, NJ.

Fig. 24: ***Parlibellus* sp. 2**

Fig. 24: Sample BBDC0107, Great Bay, NJ.

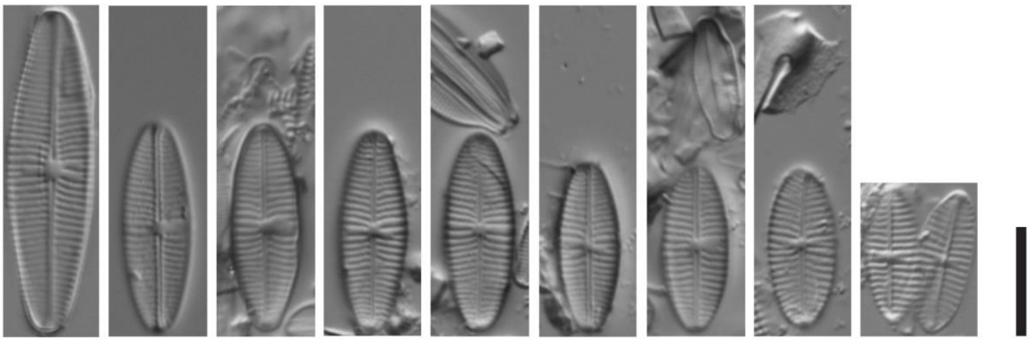
Figs 25-36: ***Parlibellus* sp. 4**

Fig. 25: Sample COAST011, Great South Bay, NY.
Fig. 26: Sample BBDC0029, Barnegat Bay, NJ.
Figs 27-30,33-36: Sample RUTG0277, Rutgers Field Station, NJ.
Fig. 31: Sample BBEDC0059, Cattus Island, NJ.
Fig. 32: Sample COAST043, Barnegat Bay, NJ.

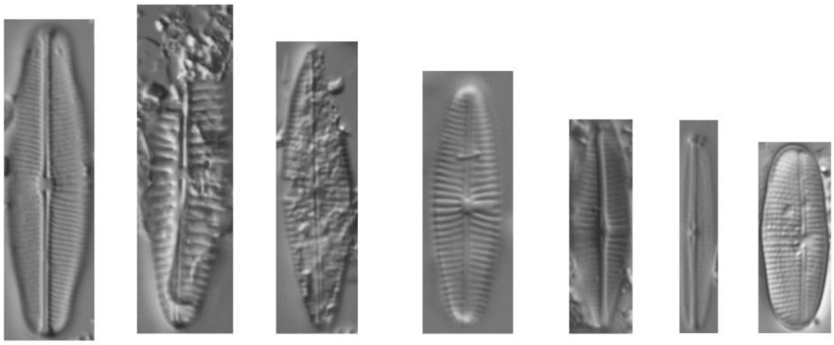
Figs 37 - 40: ***Parlibellus hendeyi*** Witkowski, Lange-Bertalot & Metzeltin

Lit.: Witkowski, Lange-Bertalot & Metzeltin 2000, p. 323, 438; pl. 104, fig. 21-23

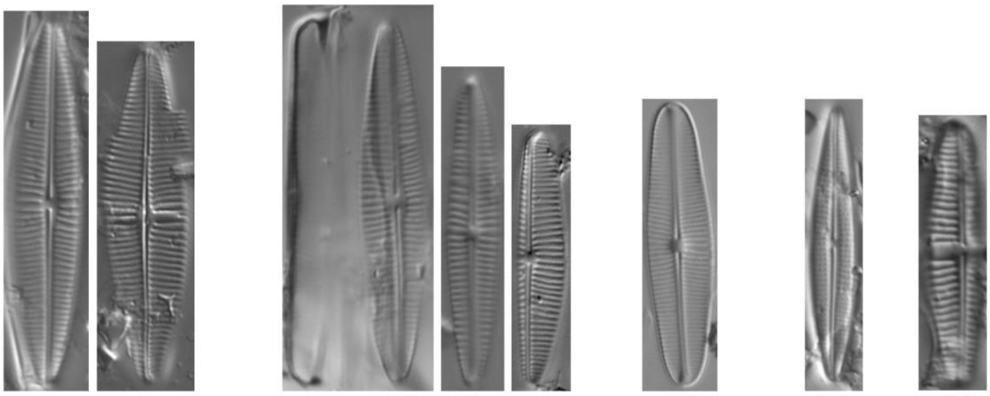
Fig. 37: Sample BB0006, Barnegat Bay, NJ.
Fig. 38: Sample BBDC0001, Barnegat Bay, NJ.
Fig. 39: Sample BB0066, Barnegat Bay, NJ.
Fig. 40: Sample BBDC0062, Barnegat Bay, NJ.



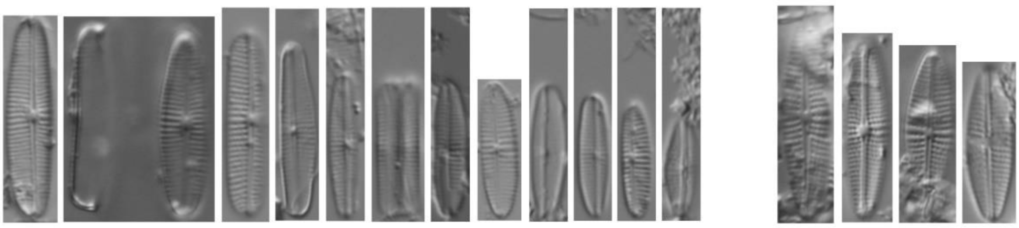
1 - 9



10 11 12 13 14 15 16



17 - 18 19 - 21 22 23 24



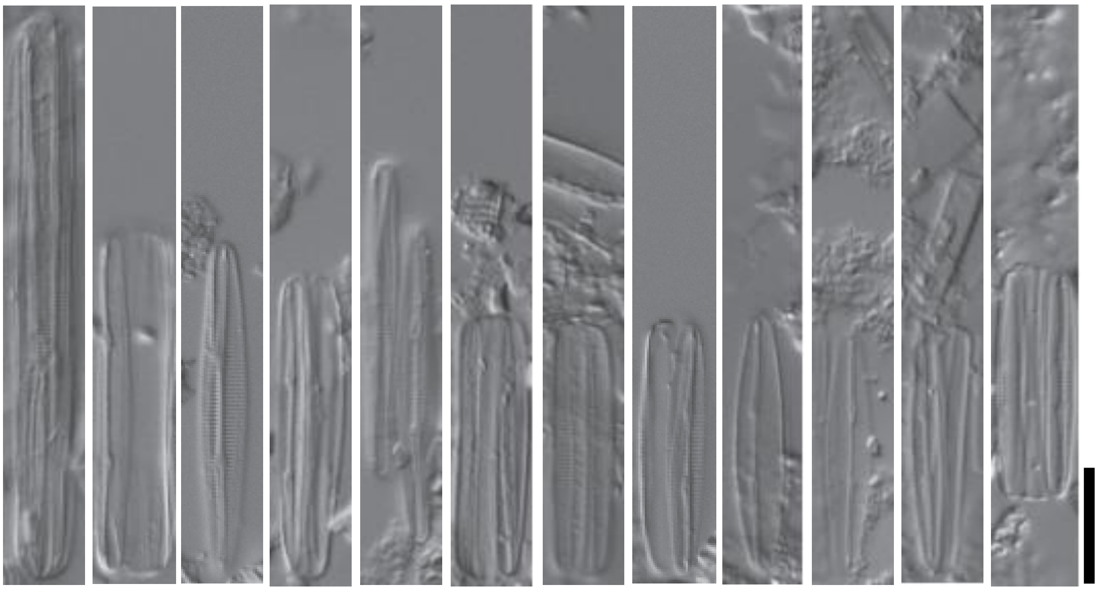
25 - 36 37 - 40

Plate 127 (Scale bars: Figs 1-12=10 µm; Figs 13-17=1 µm)

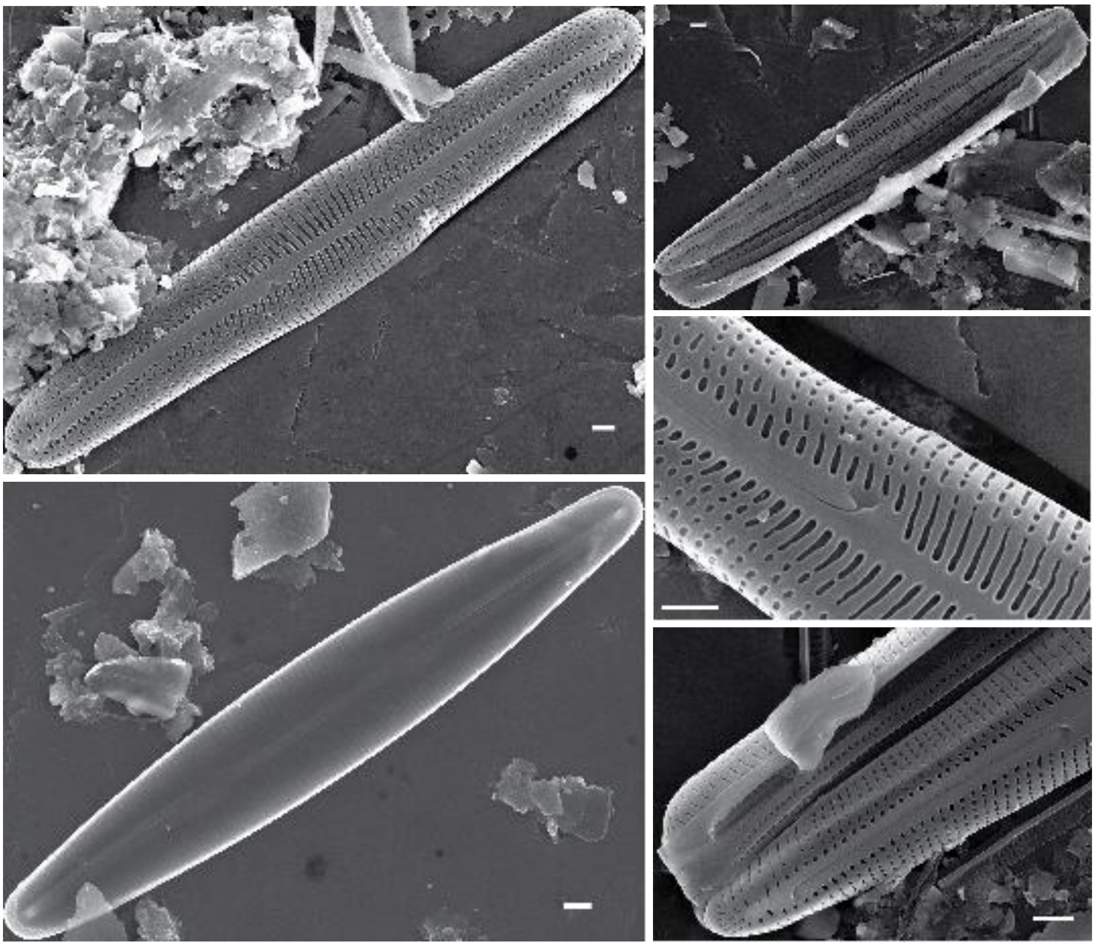
Berkeleya rutilans (Trentepohl ex Roth) Grunow
Lit.:Grunow 1880, p. 1587

Basionym: *Conferva rutilans* Trentepohl ex Roth 1806
Synonyms: *Bangia rutilans* (Roth) Lyngbye 1819
Amphipleura rutilans (Trentepohl ex Roth) Cleve 1894
Hydrolinum rutilans (Trentepohl ex Roth) Link 1820
Monema rutilans (Trentepohl ex Roth) Meneghini 1845
Schizonema rutilans (Trentepohl ex Roth) Agardh 1824
Berkeleya dillwynii var. *rutilans* (Trentepohl ex Roth) Eiben 1871
Carrodoria rutilans (Roth) Kuntze 1898
Girodella rutilans (Roth) Gaillon 1833

Figs 1-12: Sample BB0080, Tuckerton Bay, NJ.
Figs 13,15-16: Sample BBDC0045, Barnegat Bay, NJ.
Figs 14,17: Sample BBDC0080, Barnegat Bay, NJ.



1 - 12



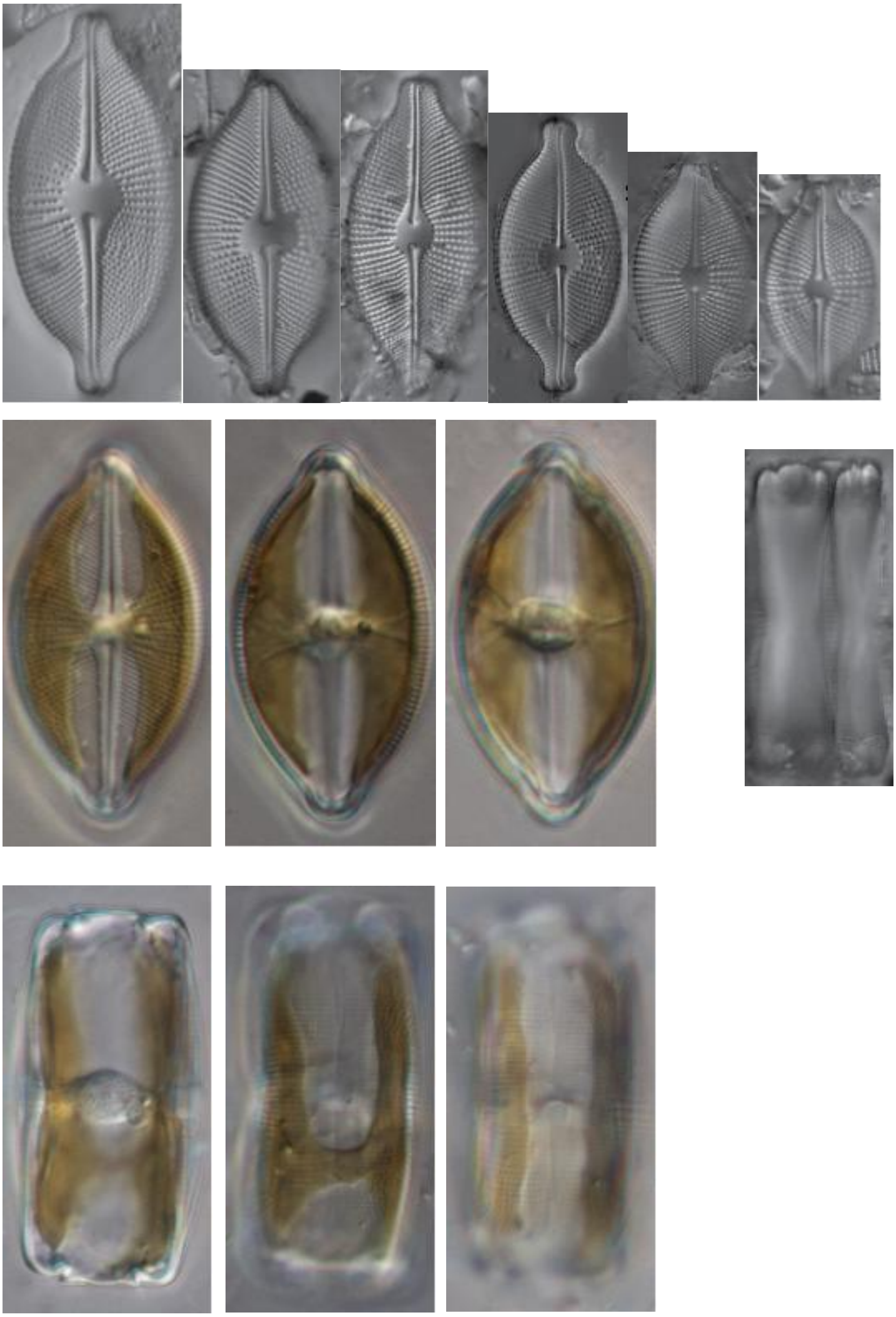
13 - 17

Plate 128 (Scale bar: Figs 1-13=10 µm)

Cosmioneis pusilla (Smith) Mann & Stickle Lit.:Round, Crawford & Mann
Lit.:Round, Crawford & Mann 1990, p. 666

Basionym: *Navicula pusilla* Smith 1853
Synonym: *Schizonema pusillum* (Smith) Kuntze 1898

Fig. 1: Sample BBDC0046, Barnegat Bay, NJ.
Fig. 2: Sample BB0059, Barnegat Bay, NJ.
Fig. 3: Sample BB0069, Barnegat Bay, NJ.
Fig. 4: Sample BBDC0007, Barnegat Bay, NJ.
Fig. 5: Sample BBDC0006, Barnegat Bay, NJ.
Fig. 6: Sample BB0058, Barnegat Bay, NJ.
Figs 7-9,11-13: Sample RUTG0818, Cape May Courthouse, NJ.
Fig. 10: Sample BB0070, Barnegat Bay, NJ.



1 - 13

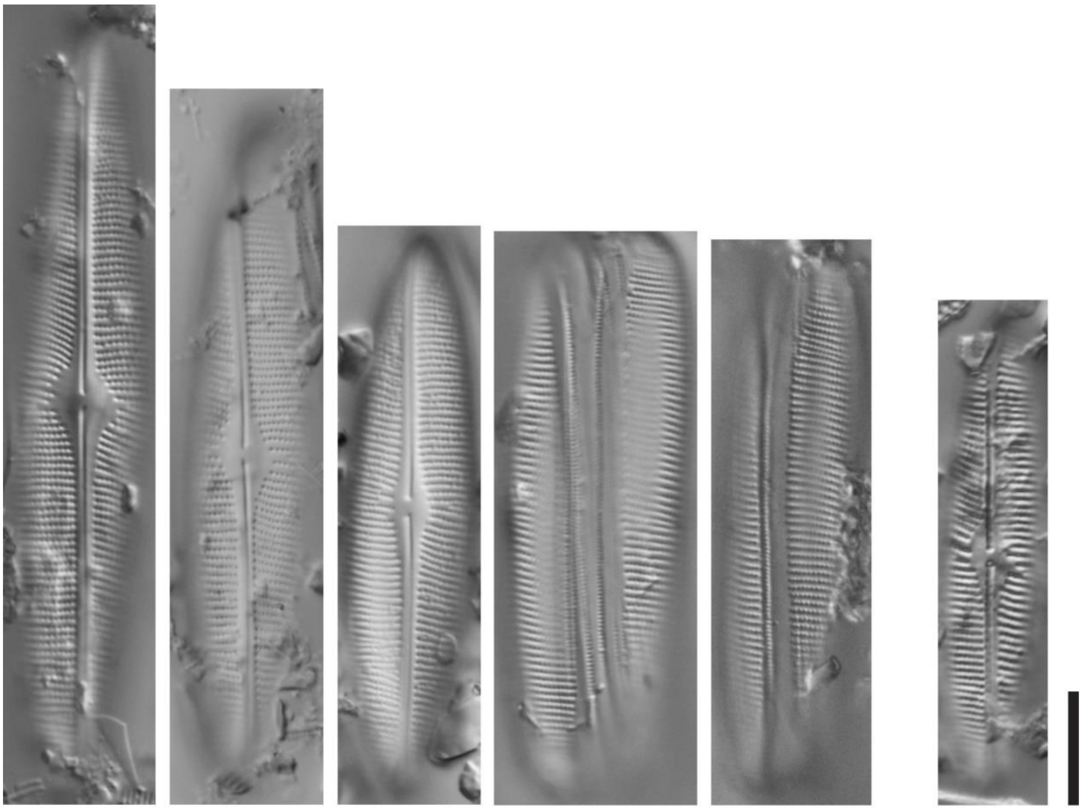
Plate 129 (Scale bar: Figs 1-6=10 µm)

Figs 1-5: ***Scolioneis tumida*** (Brébisson ex Küzing) Mann
Lit.: Round, Crawford & Mann 1990, p. 676

Basionym: *Navicula tumida* Brébisson in Kützing 1849
Synonyms: *Scoliopleura tumida* (Brébisson in Kützing) Rabenhorst 1864
Microstigma tumida (Brébisson) Meister 1919
Scoliotropis tumida (Brébisson ex Kützing) Patrick & Freese 1961

Figs 1,5: Sample BBDC0058, Barnegat Bay, NJ.
Fig. 2: Sample BBDC0071, Barnegat Bay, NJ.
Figs 3-4: Sample GB0001, Great Bay, NJ.

Fig. 6: ***Scolioneis* sp. 1**
Fig. 6: Sample BB0074, Barnegat Bay, NJ.



1 - 5 6

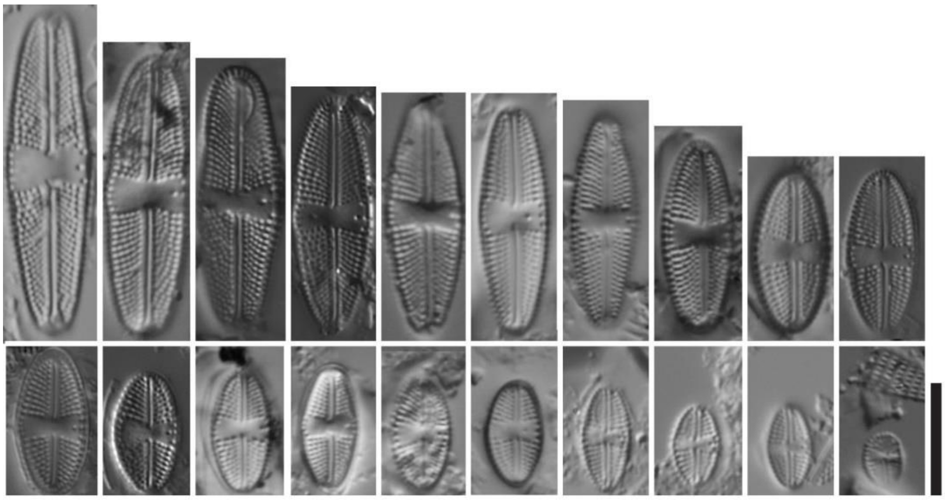
Plate 130 (Scale bars: Figs 1-20=10 µm; Figs 21-24=1 µm)

Luticola mutica (Kützing) Mann

Lit.:Round, Crawford & Mann 1990, p. 670

Basionym: *Navicula mutica* Kützing 1844
Synonyms: *Navicula mutica* (Kützing) Frenguelli 1924
Placoneis mutica (Kützing) Mereschkowsky 1903
Schizonema muticum (Kützing) Kuntze 1898

Figs 1,16: Sample BBDC0071, Barnegat Bay, NJ.
Figs 2,5,8,13,20: Sample BB0052, Barnegat Bay, NJ.
Fig. 3: Sample BBDC0009, Barnegat Bay, NJ.
Fig. 4: Sample BBDC0005, Barnegat Bay, NJ.
Figs 6-7,14,17-19: Sample BBDC0046, Barnegat Bay, NJ.
Fig. 9: Sample BBDC0065, Barnegat Bay, NJ.
Figs 10-11: Sample BBDC0007, Barnegat Bay, NJ.
Fig. 12: Sample BBDC0004, Barnegat Bay, NJ.
Fig. 15: Sample BB0076, Barnegat Bay, NJ.
Fig. 21: Sample BBDC0028, Barnegat Bay, NJ.
Fig. 22: Sample RUTG0800, Sluice Creek, NJ.
Figs 23-24: Sample BBDC0038, Barnegat Bay, NJ.



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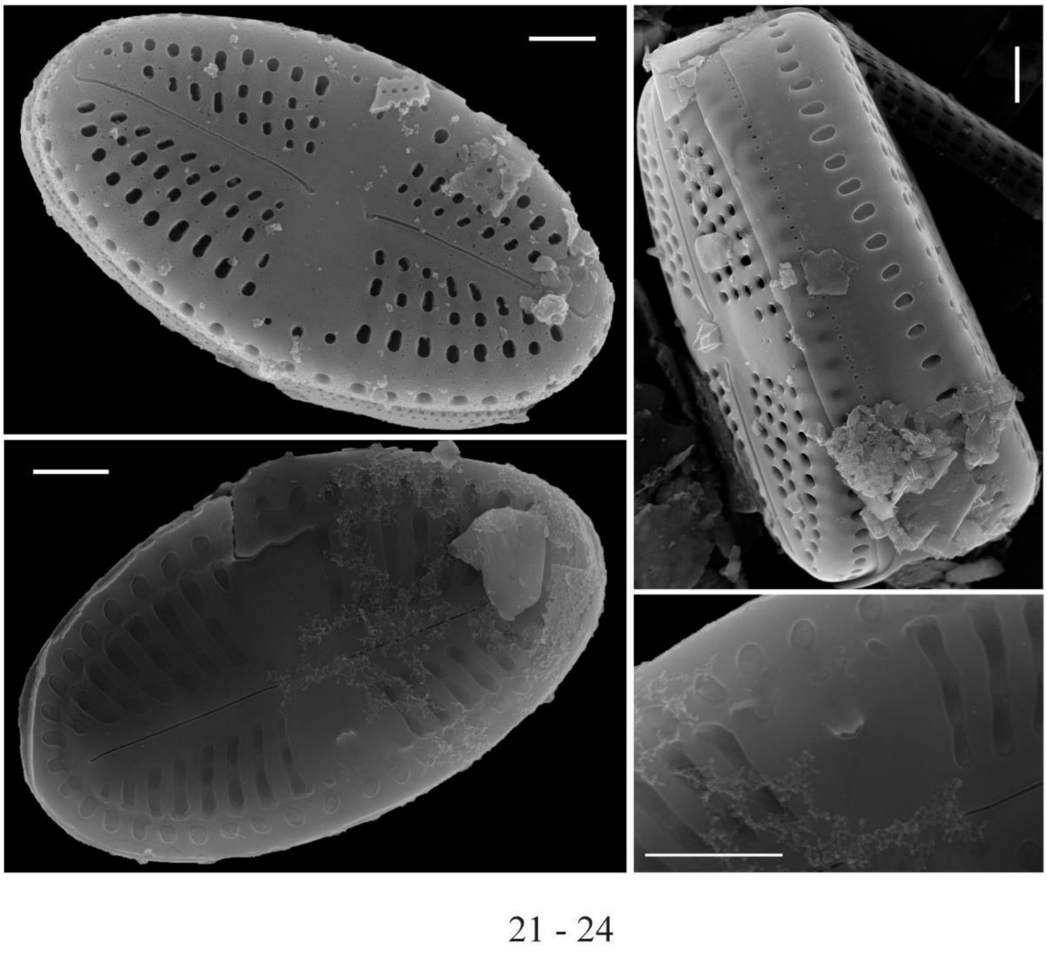
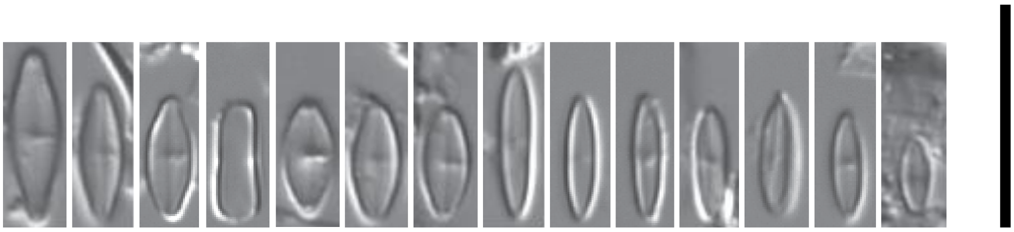


21 - 24

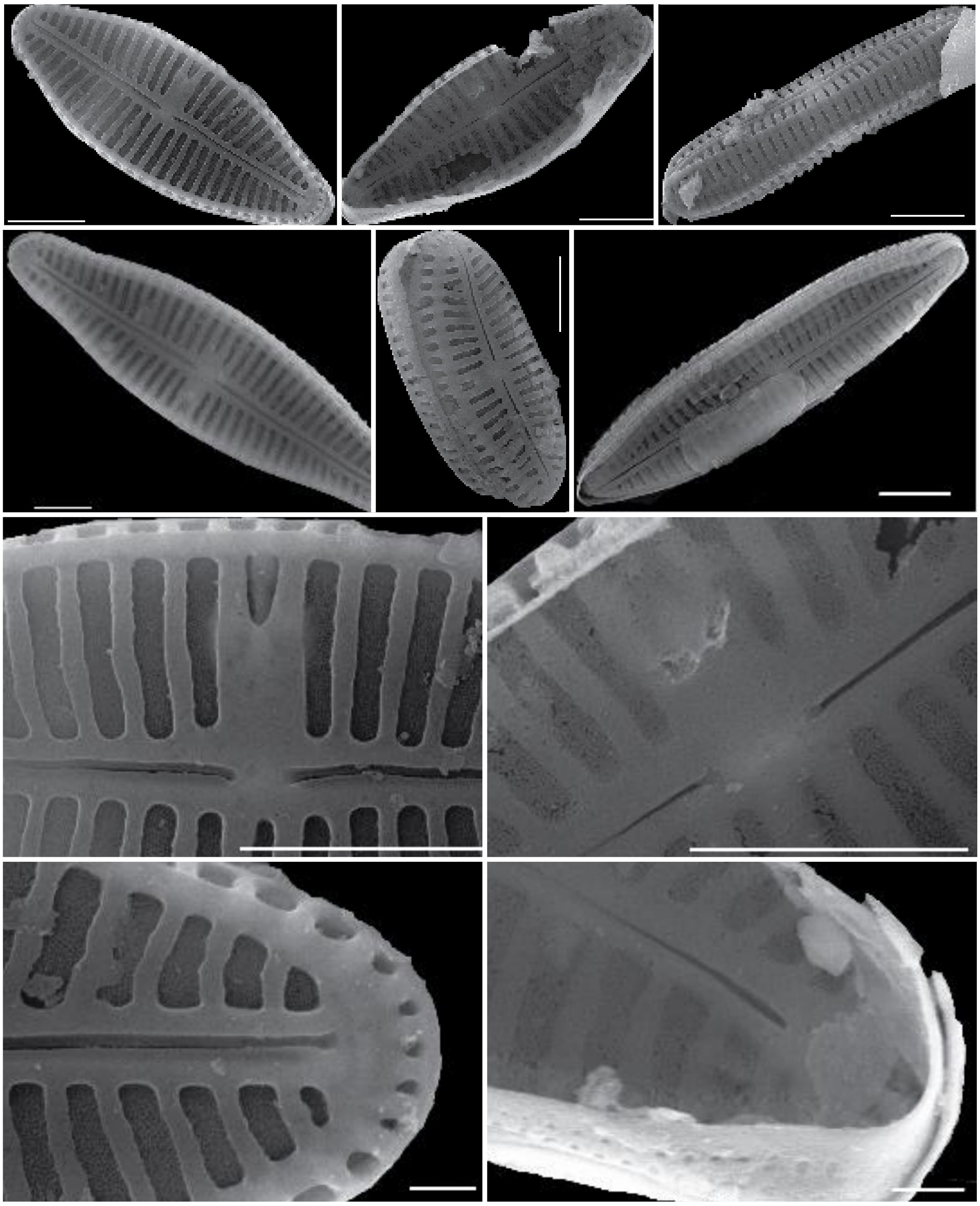
Plate 131 (Scale bars: Figs 1-14=10 µm; Figs 15-24=1 µm)

Olifantiella sp. 1

Figs 1-14: Sample RUTG0381, Cheesequake State Park, NJ.
Figs 15-24: Sample RUTG0598, Fortescue, NJ.



1 - 14



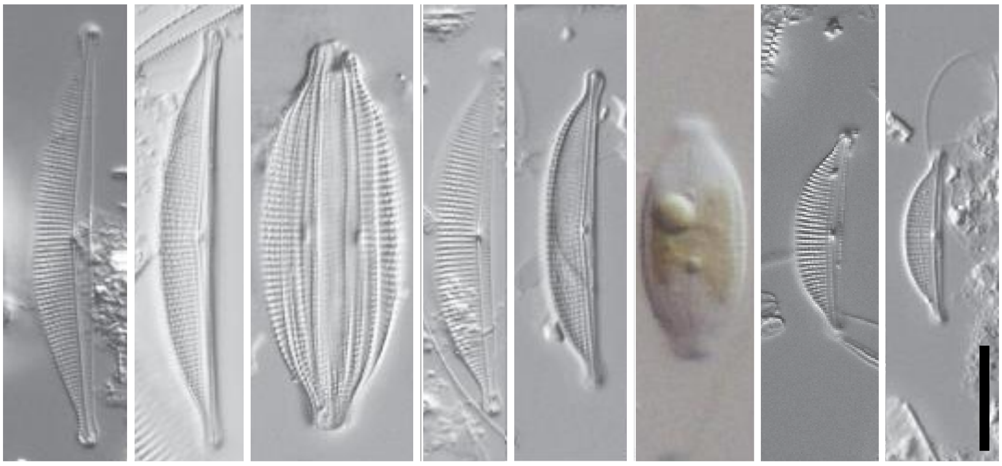
15 - 24

Plate 132 (Scale bars: Figs 1-8=10 µm; Figs 9-14=1 µm)

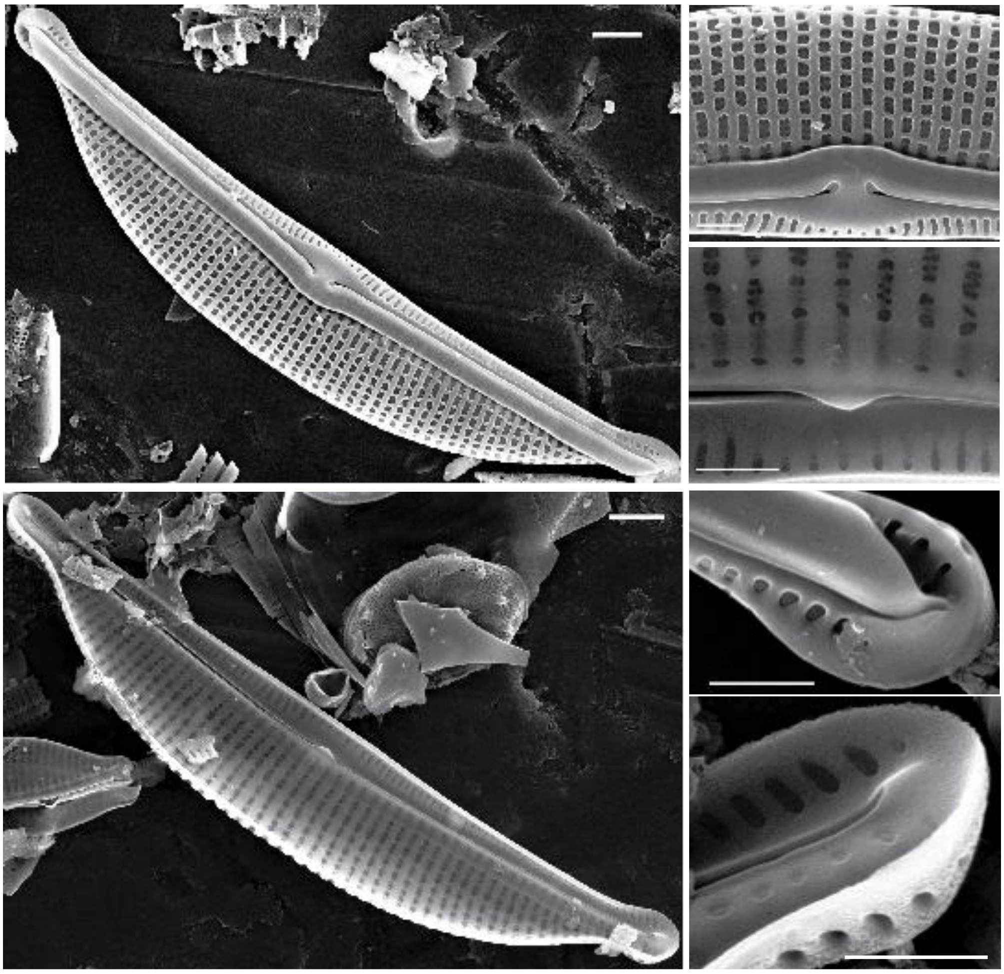
Halamphora acutiuscula (Kützing) Levkov
Lit.:Levkov 2009, p. 167

Basionym: *Amphora acutiuscula* Kützing 1844
Synonyms: *Amphora coffeaeformis* var. *acutiuscula* (Kützing) Hustedt 1930
Amphora coffeaeformis var. *acutiuscula* (Kützing) Rabenhorst 1864

Figs 1-5,7-8,9-14: Sample BBDC0031, Barnegat Bay, NJ.
Fig. 6: Great Bay, NJ.



1 - 8



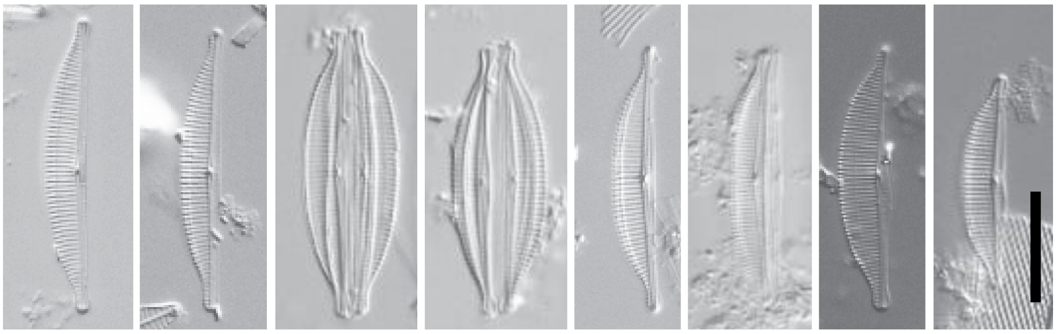
9 - 14

Plate 133 (Scale bars: Figs 1-8=10 µm; Figs 9-20=1 µm)

Halamphora aponina (Kützing) Levkov
Lit.:Levkov 2009, p. 170

Basionym: *Amphora aponina* Kützing 1844
Synonym: *Amphora coffeaeformis var. aponina* (Kützing) Archibald & Schoeman 1984

Figs 1-20: Sample BBDC0031, Barnegat Bay, NJ.



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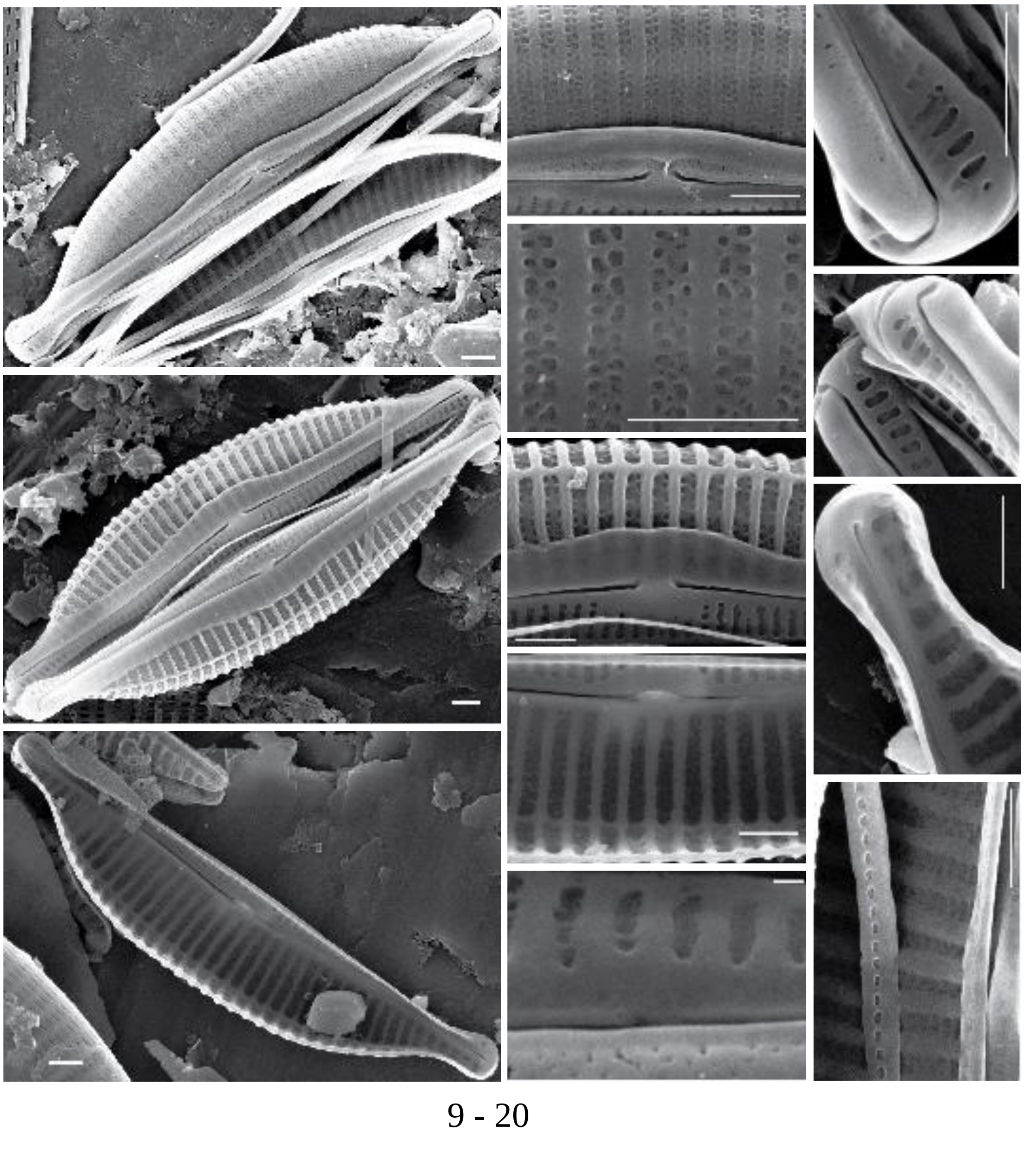


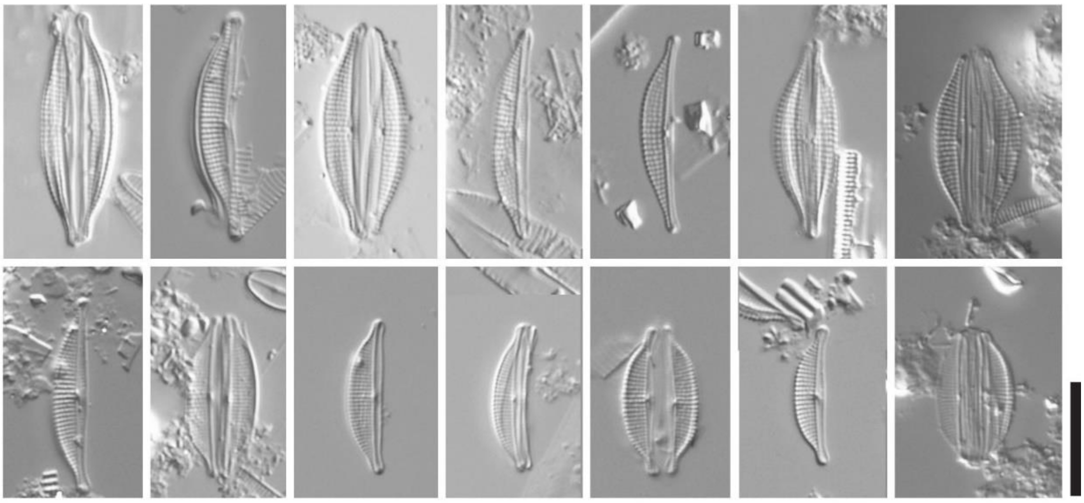
9 - 20

Plate 134 (Scale bar: Figs 1-14=10 µm)

Halamphora crenulatoides Stepanek & Kociolek

Lit.: Stepanek & Kociolek 2018, p. 67, Plate 62, figs 11-18; Plate 65, figs 4-6.

Figs 1-14: Sample BBDC0031, Barnegat Bay, NJ.



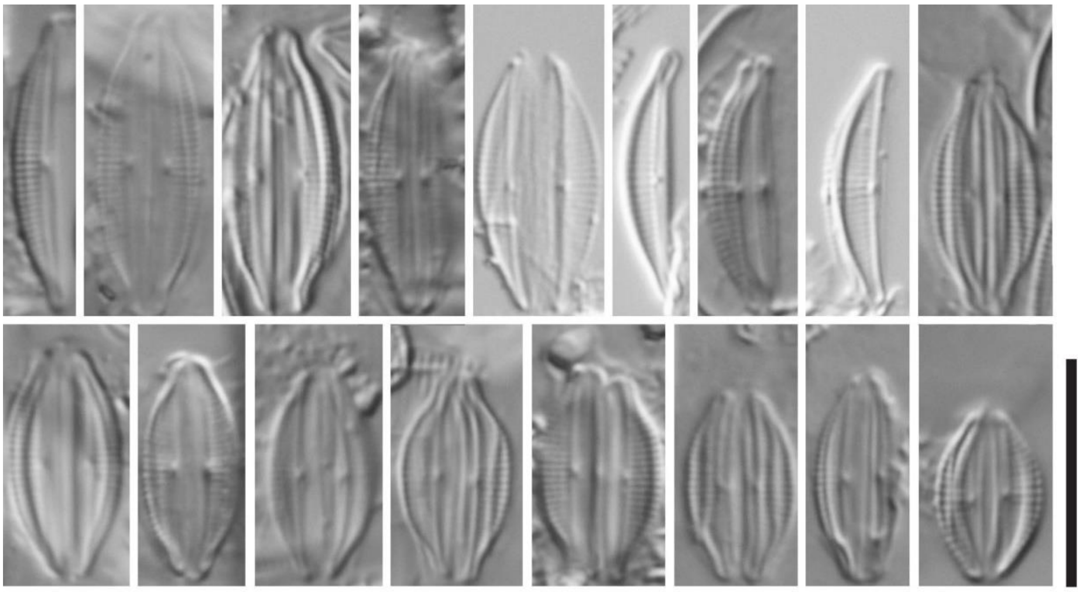
1 - 14

Plate 135 (Scale bar: Figs 1-17=10 µm)

Halamphora tenerrima (Aleem & Hustedt) Levkov
Lit.:Levkov 2009, p. 235

Basionym: *Amphora tenerrima* Aleem & Hustedt 1951

Figs 1-4,7,9-17: Sample RUTG284, Drexel Field Station, NJ.
Figs 5-6,8: Sample BBDC0031, Barnegat Bay, NJ.



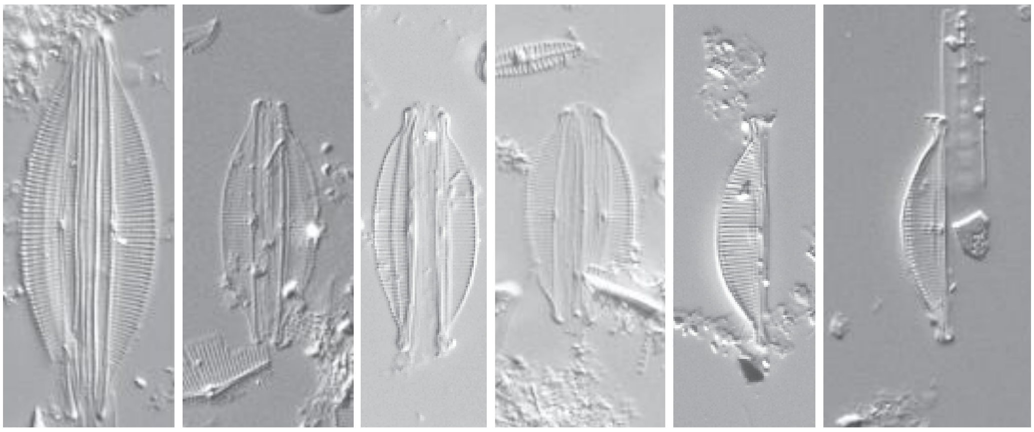
1 - 17

Plate 136 (Scale bars: Figs 1-6=10 µm; Figs 7-12=1 µm)

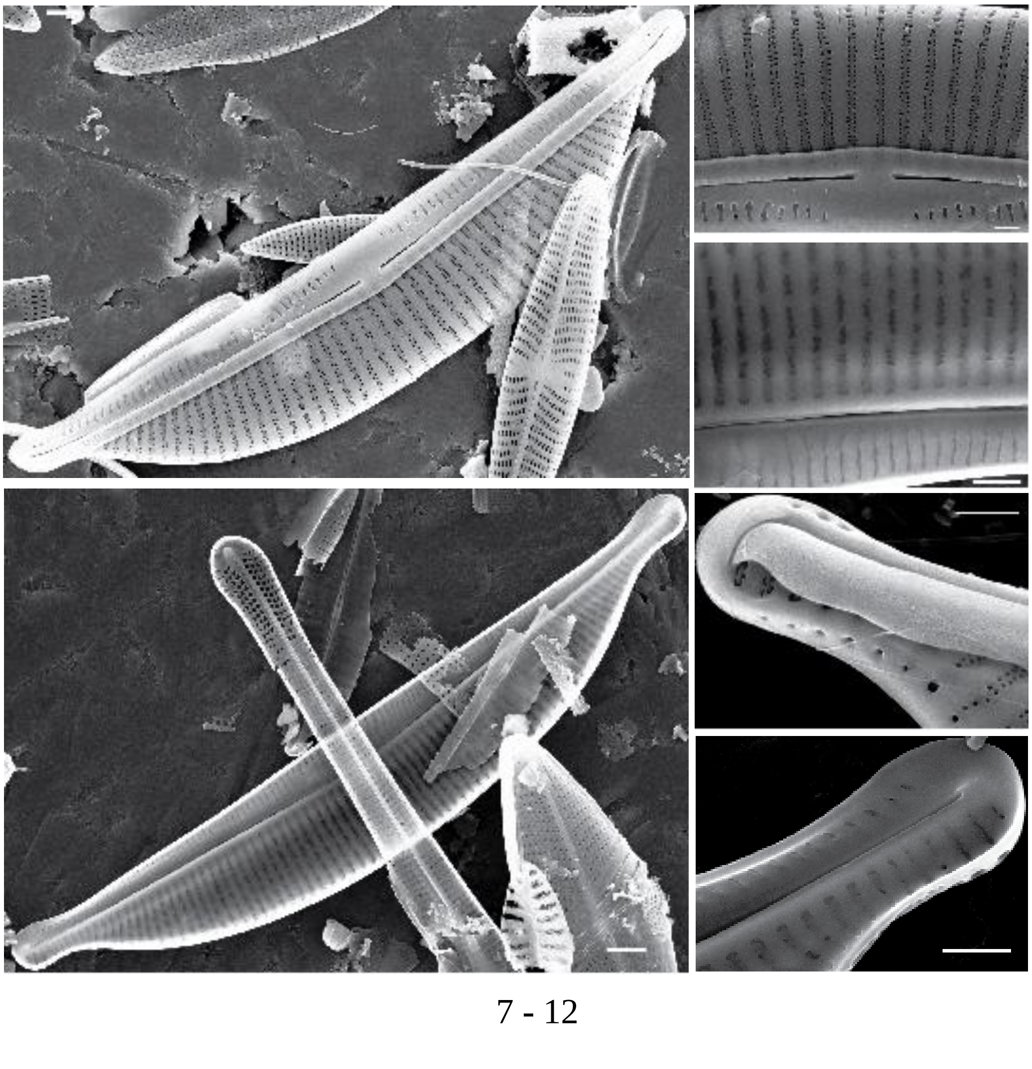
Halamphora coffeaeformis (Agardh) Levkov
Lit.:Levkov 2009, p. 179

Basionym: *Frustulia coffeaeformis* Agardh 1827
Synonym: *Amphora coffeaeformis* (Agardh) Kützing 1844

Figs 1-12: Sample BBDC0031, Barnegat Bay, NJ.



1 - 6



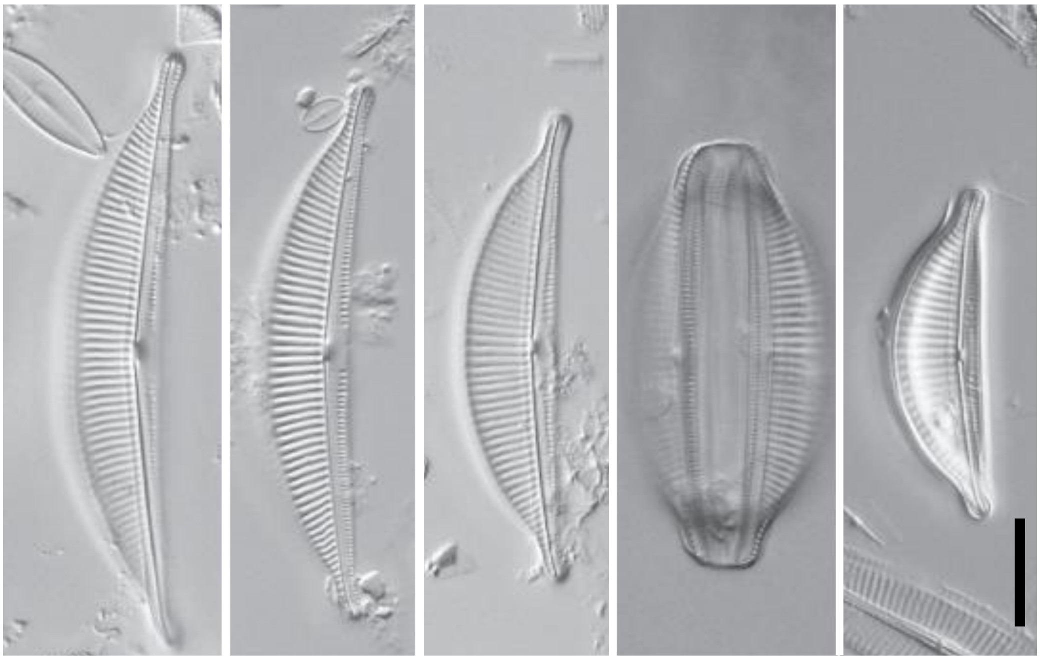
7 - 12

Plate 137 (Scale bars: Figs 1-5=10 µm; Figs 6-8=1 µm)

Halamphora cymbifera (Gregory) Levkov
Lit.:Levkov 2009, p. 183

Basionym: *Amphora cymbifera* Gregory 1857
Synonym: *Amphora erebi* f. *cymbifera* (Gregory) Zimmermann 1918

Figs 1-8: Sample BBDC0031, Barnegat Bay, NJ.



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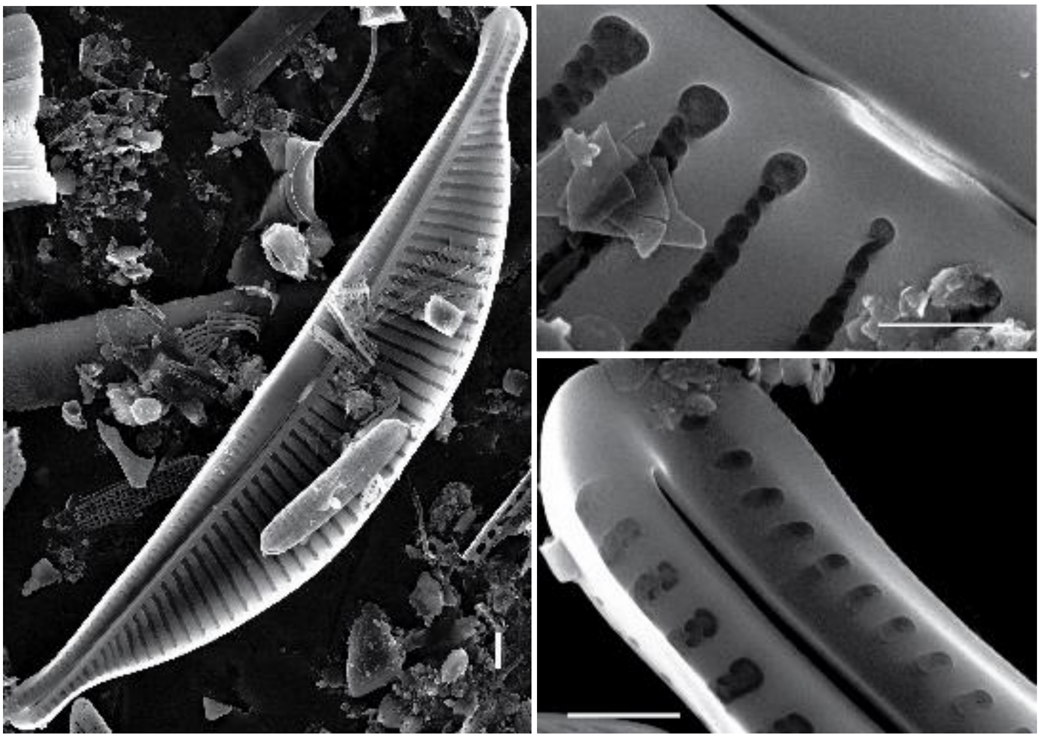


6 - 8

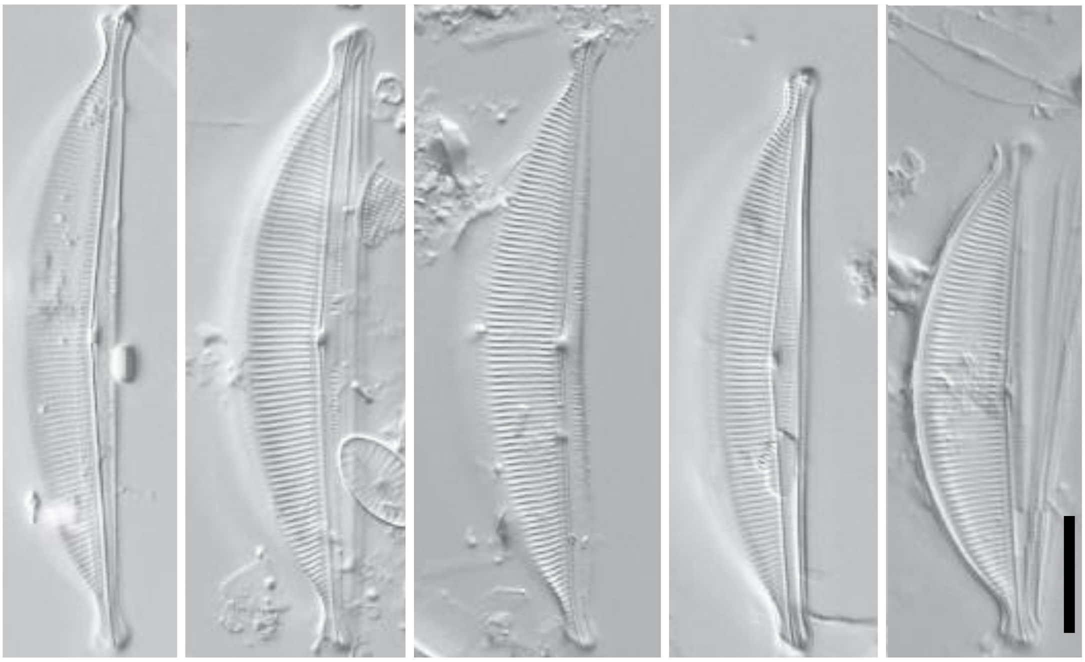
Plate 138 (Scale bars: Figs 1-5=10 µm; Fig 6-10=1 µm)

Halamphora lineata (Gregory) Levkov

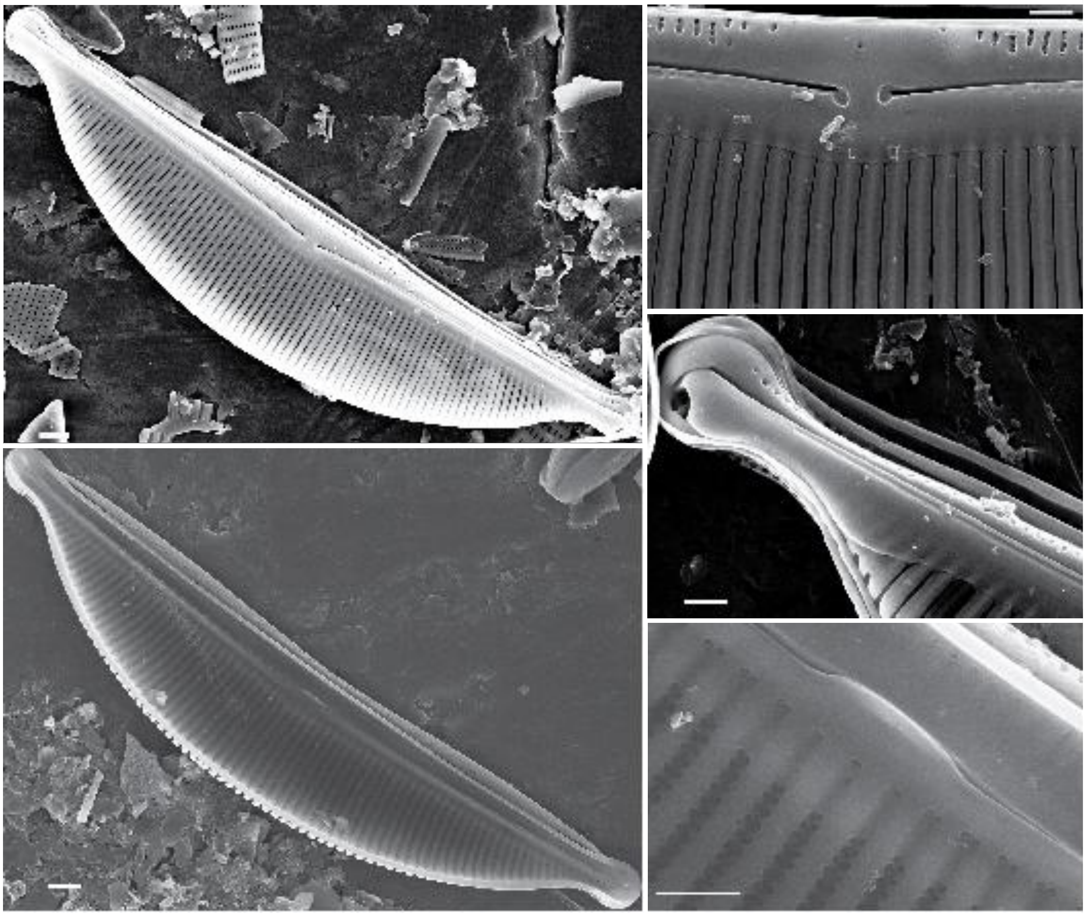
Lit.:Levkov 2009, p. 202

Basionym: *Amphora lineata* Gregory 1857
Synonym: *Amphora coffeaeformis* var. *lineata* (Gregory) Rabenhorst 1864

Figs 1-8: Sample BBDC0031, Barnegat Bay, NJ.
Figs 9-10: Sample COAST003, Peconic Bay, NY.



1 - 5



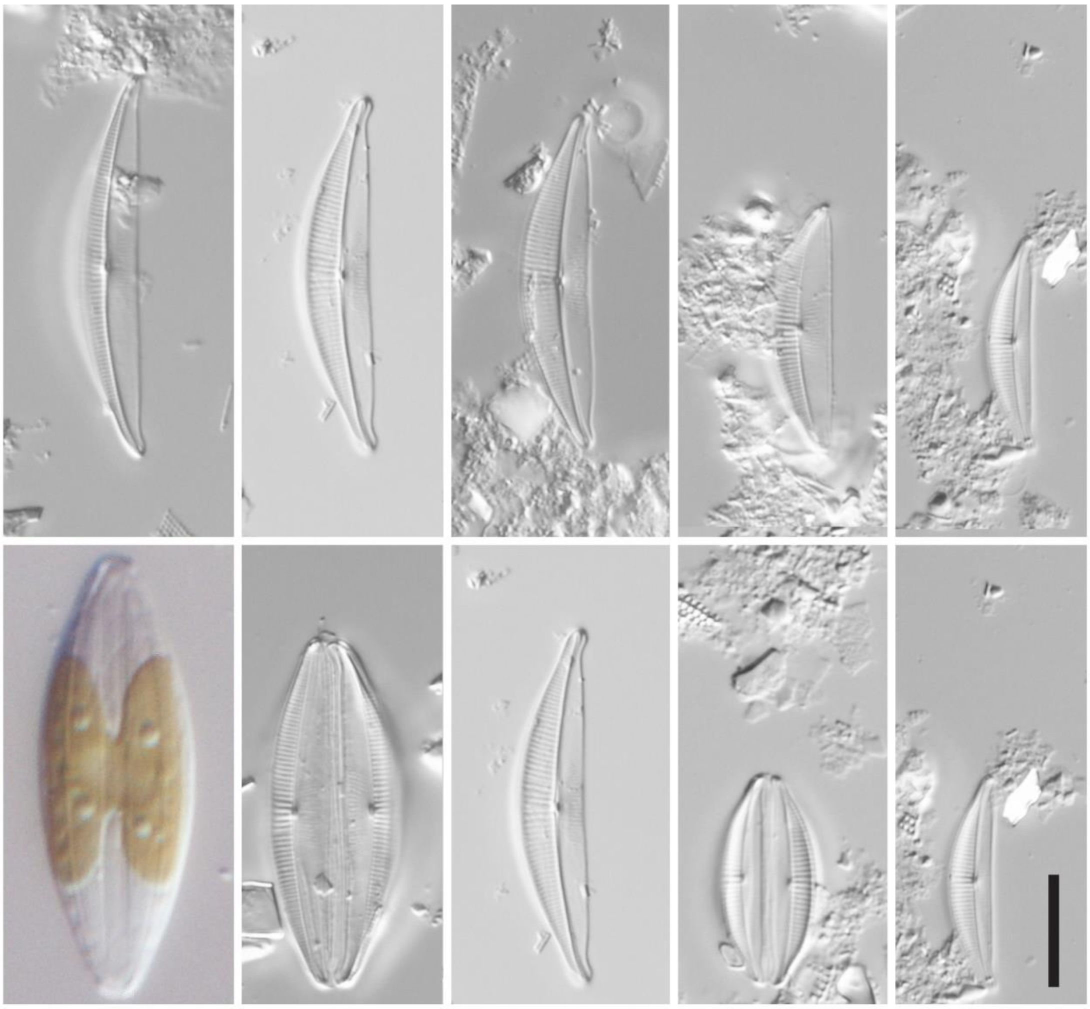
6 - 10

Plate 139 (Scale bars: Figs 1-10=10 µm; Figs 11-14=1 µm)

Halamphora mosensis Stepanek & Kociolek

Lit.:Stepanek & Kociolek, 2018 p. 63-64; Plate 61, figs 9-12; Plate 64, figs 1-3.

Figs 1-5,7-10,13: Sample BBDC0064, Barnegat Bay, NJ.
Fig. 6: Great Bay, NJ.
Figs 11-10: Sample COAST031, Western Bay, NY.
Figs 12,14: Sample BBEDC0064, Tuckerton Bay, NJ.



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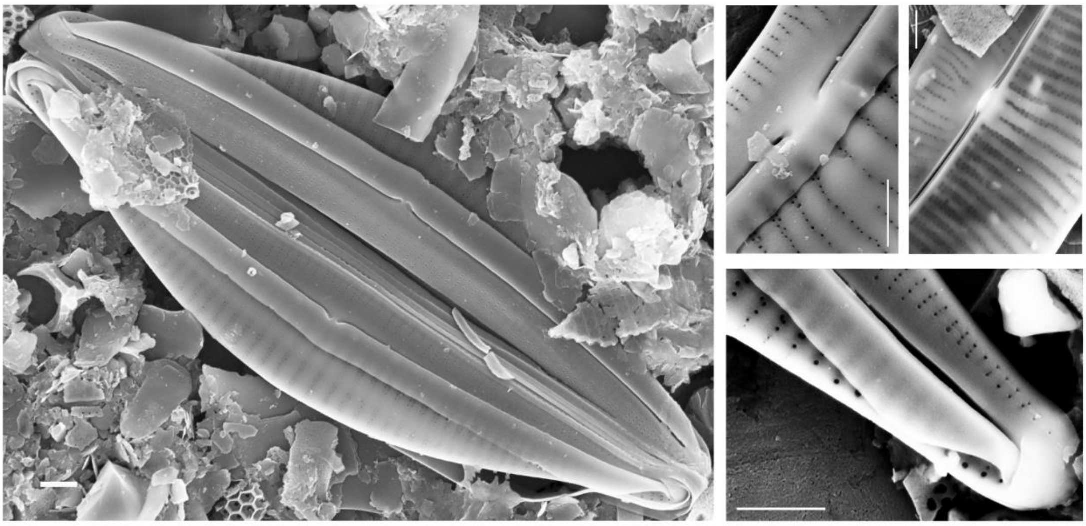


11 - 14

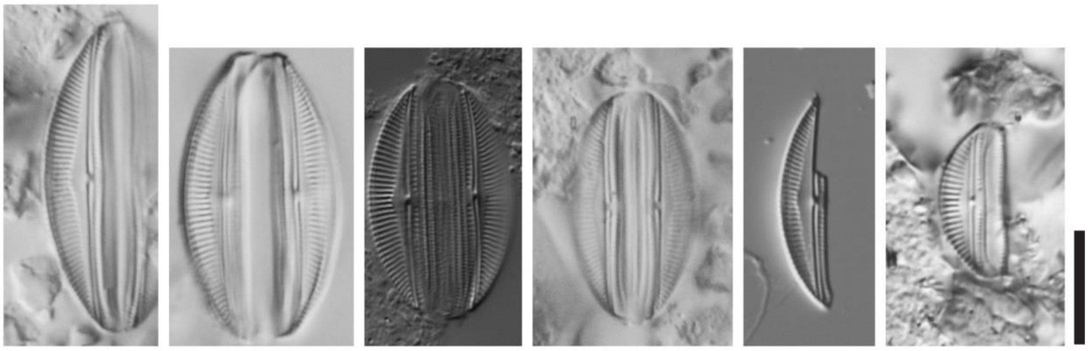
Plate 140 (Scale bars: Figs 1-6=10 μm; Figs 7-10=1 μm)

Amphora polita Krasske

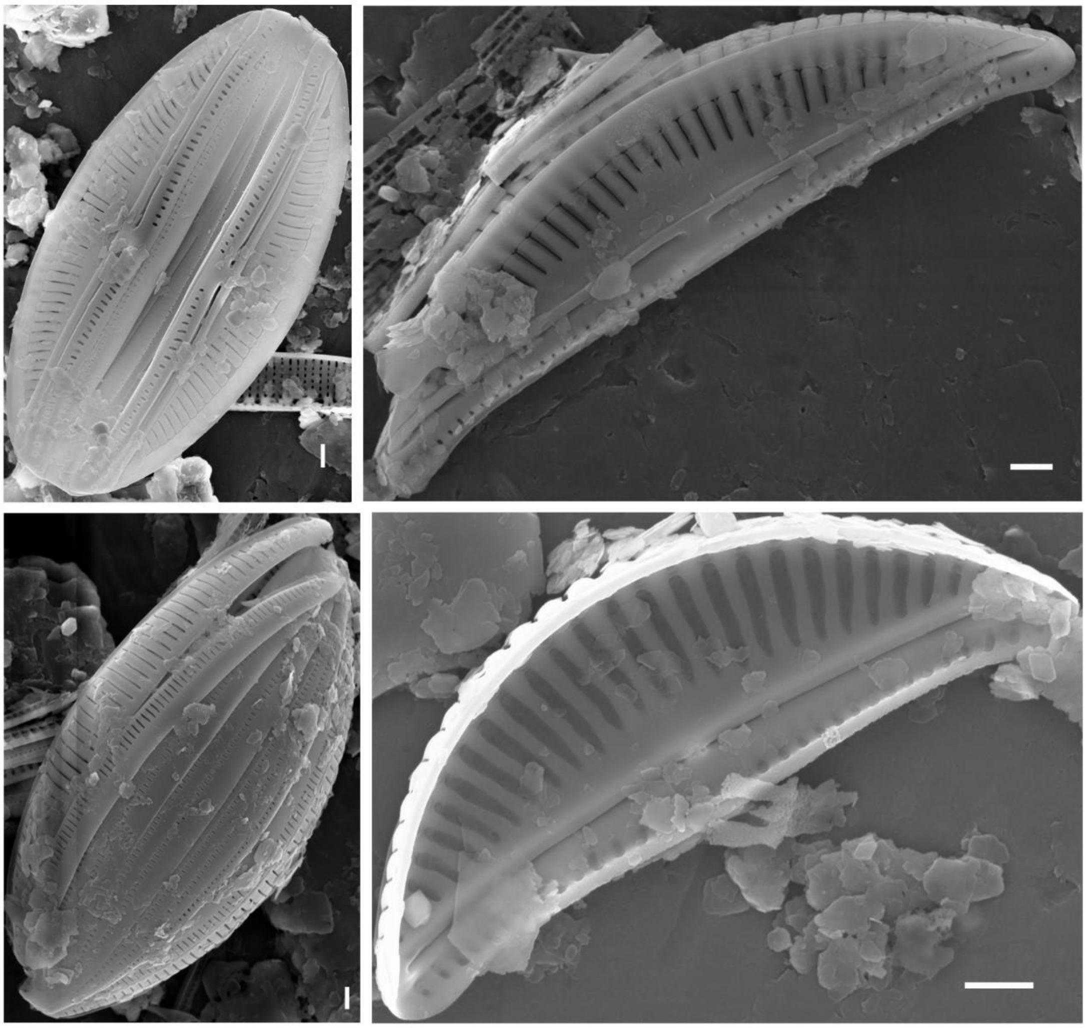
Lit.: Krasske 1939, p. 401; pl. 12, fig. 24, 25; Desianti, Potapova & Beals 2015, Figs 105-112

Synonyms: *Amphora australiensis* John 1981
Amphora pleniluna Hohn & Hellerman 1966

Figs 1-2,4,6-10: Sample GC44902, Nabbs Creek, MD.
Fig. 3: Sample BBDC0088, Great Bay, NJ.
Fig. 5: Sample BBDC0029, Barnegat Bay, NJ.



1 - 6



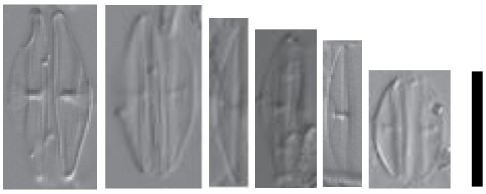
7 - 10

Plate 141 (Scale bars: Figs 1-6=10 µm; Figs 7-12=1 µm)

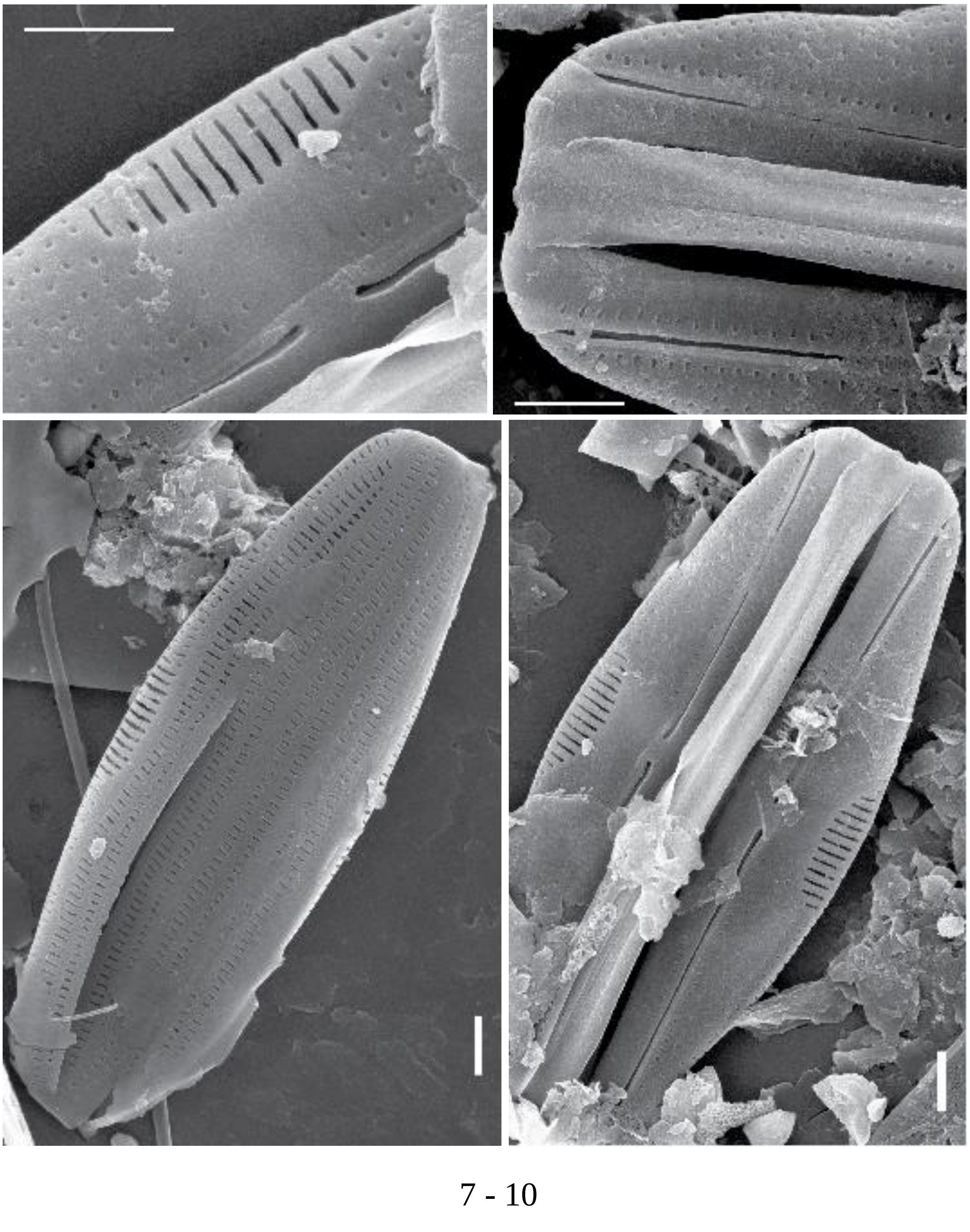
Halamphora staurophora (Juhlin-Dannfelt) Álvarez-Blanco & Blanco
Lit.:Álvarez-Blanco & Blanco, 2014 fig., 3 tables, 91 pls.

Basionym: *Amphora staurophora* Juhlin-Dannfelt 1882
Synonym: *Amphora dannfeltii* Berg 1952

Fig. 1: Sample BBDC0046, Barnegat Bay, NJ.
Fig. 2: Sample BB0029, Barnegat Bay, NJ.
Figs 3,6: Sample COAST031, Great South Bay, NY.
Fig. 4: Sample BBDC0001, Barnegat Bay, NJ.
Fig. 5: Sample COAST015, Great South Bay, NY.
Figs 7-8,11: Sample BBDC0029, Barnegat Bay, NJ.
Figs 9,12: Sample COAST003, Peconic Bay, NY.
Fig. 10: Sample BBDC0015, Barnegat Bay, NJ.



1 - 6



7 - 10

Plate 142 (Scale bar: Figs 1-19=10 µm)

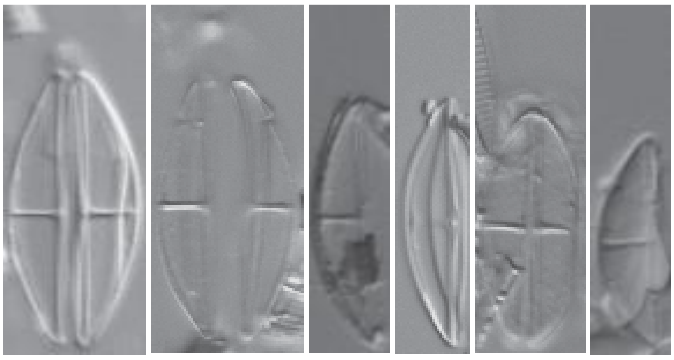
Fig.1: ***Amphora laevis*** Gregory
Lit.:Gregory 1857, p. 514; pl. 12, fig. 74 a-c

Figs 2-7: ***Amphora abludens*** Simonsen
Lit.:Simonsen 1960, p. 129; pl. 2, fig. 10-12

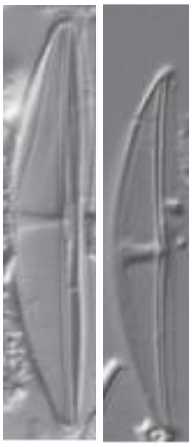
Figs 8-9: ***Amphora sublaevis*** Hustedt
Lit.:Hustedt 1955, p. 41; pl. 13, fig. 3, 12-15

Figs 10-19: *Amphora cf. laevissima* Gregory
Lit.:Hustedt 1955, p. 41; pl. 13, fig. 3, 12-15

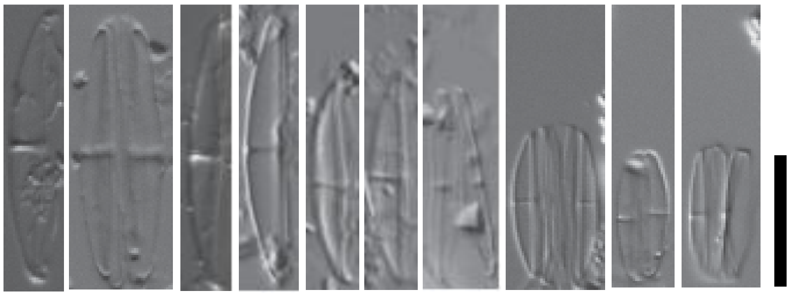
1



2 - 7



8 - 9

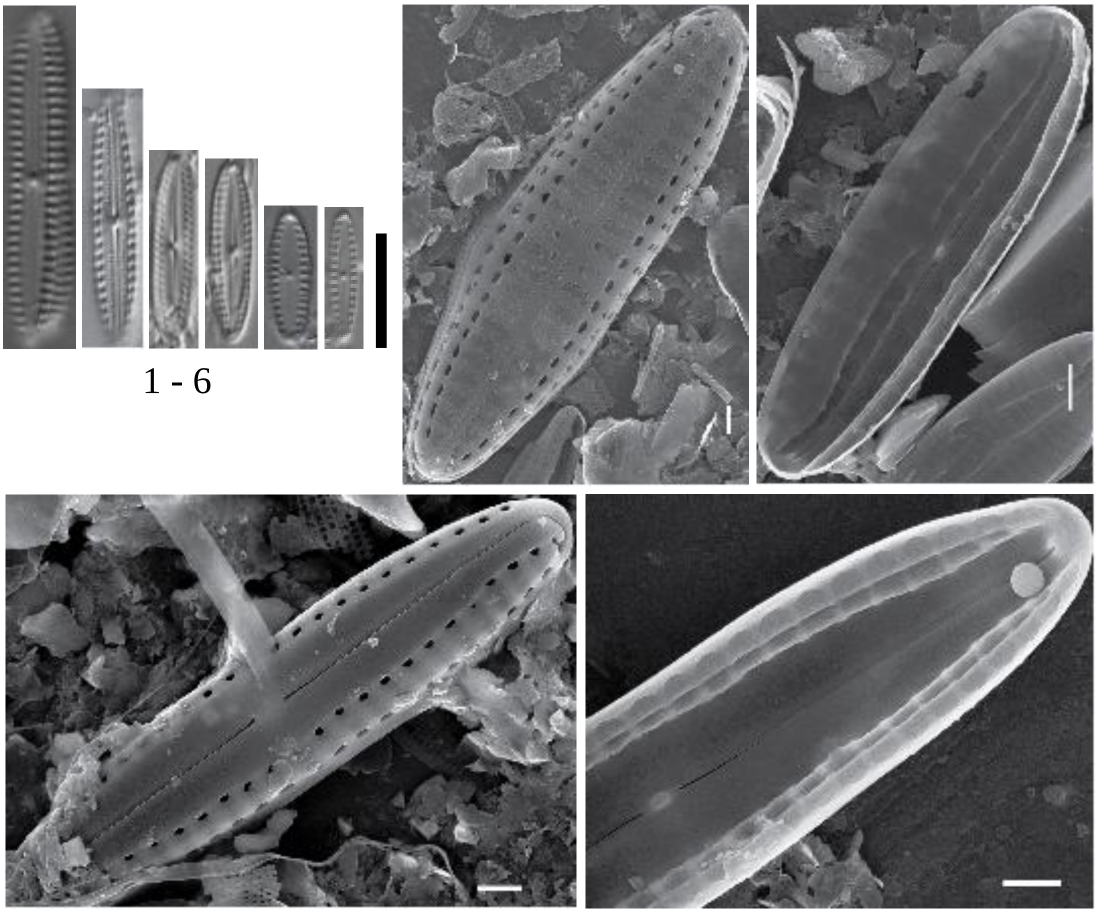


10 - 19

Plate 143 (Scale bars: Figs 1-6=10 µm; Figs 7-10=1 µm)

Biremis lucens (Hustedt) Sabbe, Witkowski & Vyverman

Lit.: Sabbe, Witkowski & Vyverman 1995, p. 380; fig. 4-19, 20-24, 27-29, 36-37



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7 - 10

Plate 143 (Scale bars: Figs 1-6=10 µm; Figs 7-9=1 µm)

Fallacia pygmaea (Kützing) Stickle & Mann

Lit.:Round, Crawford & Mann 1990, p. 668; Hustedt 1961-1966, p.537, fig.1574 (as *Navicula pygmaea*); Simonsen 1975, p.168-178, fig.1-32; Krammer & Lange-Bertalot 1986, p.171, fig.65:1-6 (as *Navicula pygmaea*); Round et al. 1990, p.544; Witkowski, Lange-Bertalot, Metzeltin 2000, p.211, pl.72:28-30

Basionym: *Navicula pygmaea* Kützing

Synonyms:

Navicula minutula W. Smith 1853

Navicula rotundata Hantzsch fide Grunow in Van Heurck 1880

Navicula hudsonis Grunow in Cleve 1892

Fallacia hudsonis (Grunow ex Cleve) Stickle & Mann in Round, Crawford & Mann 1990

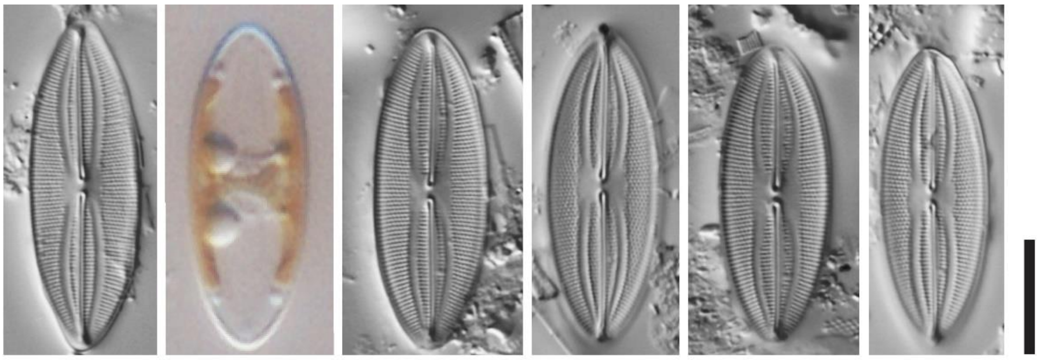
Diploneis hudsonis (Grunow in Cleve) Cleve 1894

Schizonema hudsonis (Grunow) Kuntze 1898

Figs 1,3-6: Sample BBDC0046, Barnegat Bay, NJ.

Fig. 2: Great Bay, NJ.

Figs 7-9: Sample BBDC0038, Barnegat Bay, NJ.



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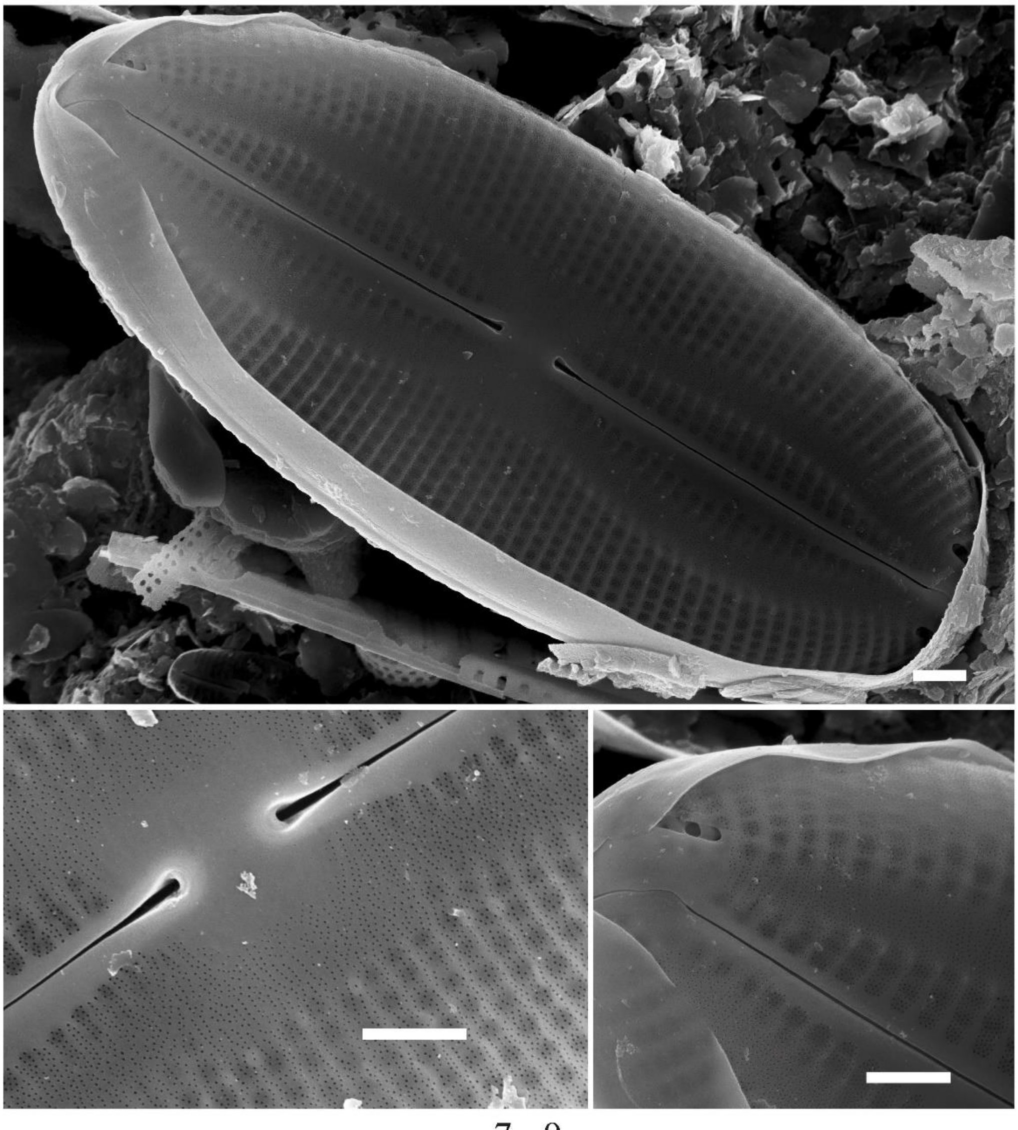


7 - 9

Plate 144 (Scale bars: Figs 1-17; 19-23=10 µm; Figs 18; 24=1 µm)

Figs 1-5: ***Fallacia pseudolitoricola*** (Håkansson) Håkansson

Lit.: Håkansson 1982, p. 90-91; pl. 1, fig. 4-7, pl. 2, fig. 8-12; Snoeijs & Vilbaste 1994, v. 16b: p. 45

Basionym: *Navicula pseudolitoricola* Håkansson

Fig. 1: Sample BBDC0080, Barnegat Bay, NJ.
Fig. 2: Sample BBEDC058, Cattus Island, NJ.
Fig. 3: Sample BB0002, Barnegat Bay, NJ.
Fig. 4: Sample RUTG0870, Eugene Furey, NJ.
Fig. 5: Sample BBDC0001, Barnegat Bay, NJ.

Figs 6-8: ***Fallacia* sp. 8**

Fig. 6: Sample RUTG0131, Cape May Courthouse, NJ.
Fig. 7: Sample RUTG0857, Pilot Drive, NJ.
Fig. 8: Sample BBDC0065, Barnegat Bay, NJ.

Figs 9-18: ***Fallacia litoricola*** (Hustedt) Mann

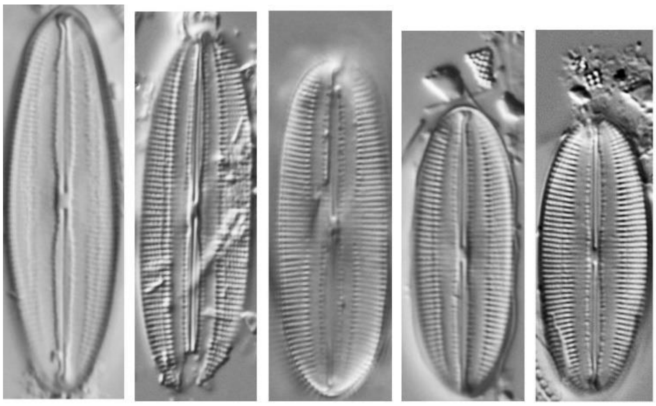
Lit.:Husted 1955, p.23. pl.8, figs 13-14; Simonsen 1987, p.409, fig.612:1-4; Round, Crawford & Mann 1990, p.668; Witkowski, Lange-Bertalot, Metzeltin 2000, p.206, pl.71(?7,8), pl.72:31-34.

Basionym: *Navicula litoricola* Hustedt

Figs 9-10: Sample BBDC0045, Barnegat Bay, NJ.
Fig. 11: Sample COAST008, Peconic Bay, NY.
Fig. 12: Sample COAST052, Barnegat Bay, NJ.
Fig. 13: Sample BBDC0003, Barnegat Bay, NJ.
Fig. 14: Sample BBDC0009, Barnegat Bay, NJ.
Figs 15-17: Sample COAST025, Great South Bay, NY.
Fig. 18: Sample BBDC0051, Barnegat Bay, NJ.

Figs 19-24: ***Fallacia* sp. 7**

Fig. 19: Sample BBDC0007, Barnegat Bay, NJ.
Figs 20,22: Sample BBDC0051, Barnegat Bay, NJ.
Fig. 21: Sample BBDC0008, Barnegat Bay, NJ.
Fig. 23: Sample BBDC0003, Barnegat Bay, NJ.
Fig. 24: Sample COAST003, Peconic Bay, NY.



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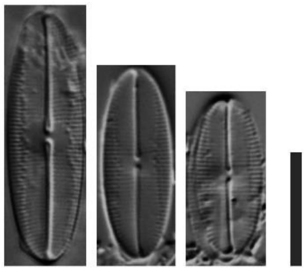
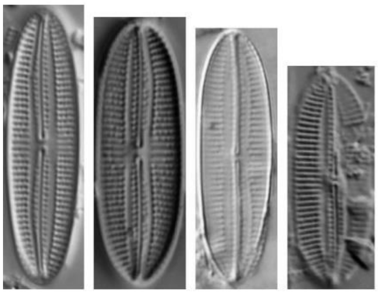
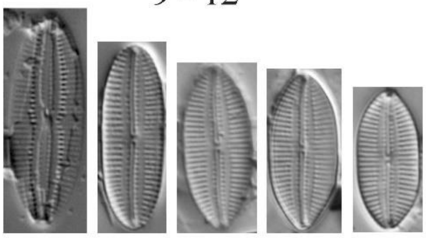


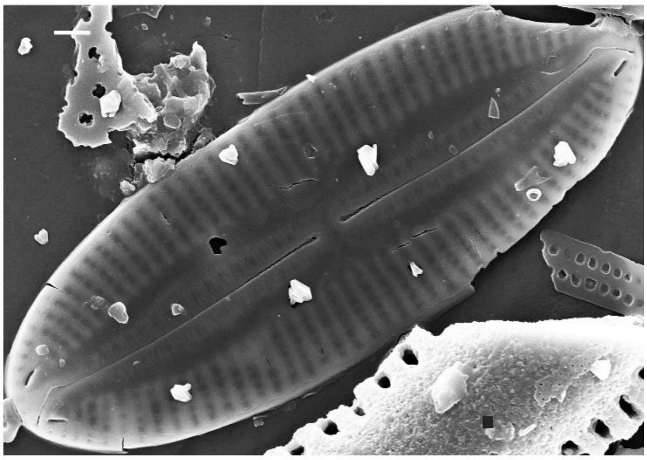
6 - 8



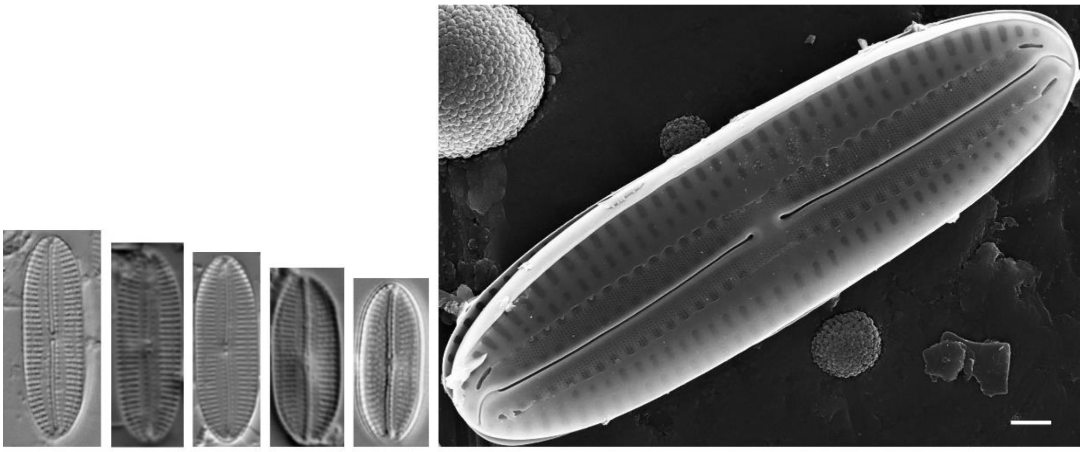
9 - 12



13 - 17



18



19 - 24

Plate 145 (Scale bars: Figs 1-5, 7-9, 11-16, 18-20=10 µm; Figs 6, 10, 17, 21=1 µm)

Figs 1-6: ***Fallacia forcipata*** (Greville) Stickle & Mann

Lit.: Hustedt 1961-1966, p.531, fig.1568, Krammer & Lange-Bertalot 1986, p.172, fig.65:12,13; Round, Crawford & Mann 1990, p.668; Witkowski, Lange-Bertalot, Metzeltin 2000, p.205, pl.72:2-9.

Basionym: *Navicula forcipata* Greville 1859

Synonyms:

Navicula lyra var. *forcipata* (Greville) O'Meara 1875

Schizonema forcipatum (Greville) Kuntze 1898

Fig. 1: Sample BBDC0012, Barnegat Bay, NJ.
Fig. 2: Sample BBDC0009, Barnegat Bay, NJ.
Fig. 3: Sample COAST052, Barnegat Bay, NJ.
Fig. 4: Sample BBDC0046, Barnegat Bay, NJ.
Fig. 5: Sample BBDC0003, Barnegat Bay, NJ.
Fig. 6: Sample COAST096, Cape May Peninsula, NJ.

Figs 7-10: ***Fallacia scaldensis*** Sabbe & Muylaert

Lit.: Sabbe, Vyverman & Muylaert 1999, p. 18; fig. 52-58, 71; Witkowski, Lange-Bertalot, Metzeltin 2000, p.212, pl.70:35-36.

Fig. 7: Sample COAST005, Peconic Bay, NY.
Fig. 8: Sample BBDC0012, Barnegat Bay, NJ.
Fig. 9: Sample BBDC0018, Barnegat Bay, NJ.
Fig. 10: Sample COAST022, Great South Bay, NY.

Figs 11-17: ***Fallacia* sp. 14**

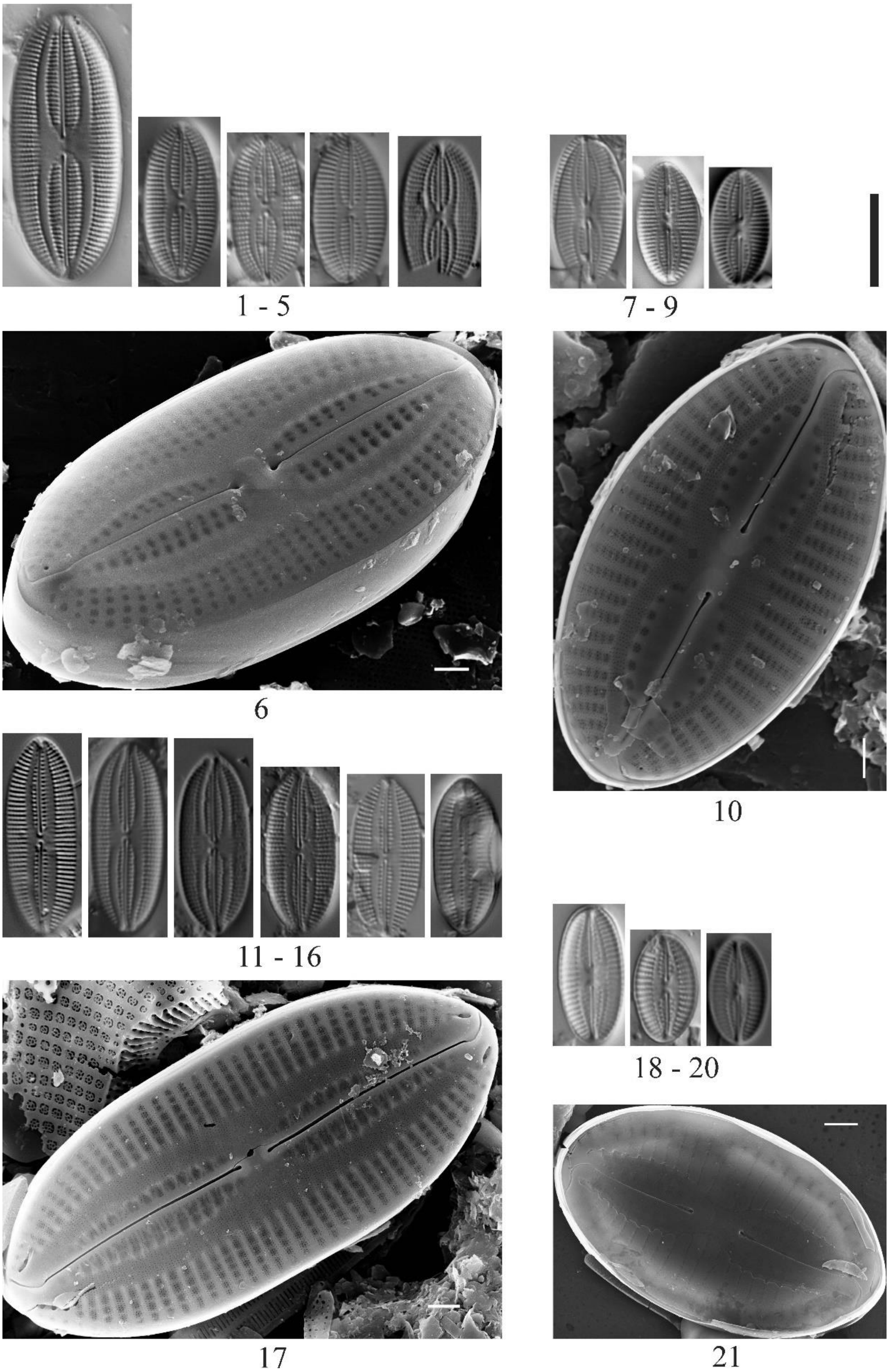
Fig. 11: Sample BBDC0003, Barnegat Bay, NJ.
Fig. 12: Sample BBDC0017, Barnegat Bay, NJ.
Fig. 13: Sample BBDC0041, Barnegat Bay, NJ.
Fig. 14: Sample BBDC0005, Barnegat Bay, NJ.
Fig. 15: Sample COAST025, Great South Bay, NY.
Fig. 16: Sample BBDC0002, Barnegat Bay, NJ.
Fig. 17: Sample BBDC0106, Great Bay, NJ.

Figs 18-21: ***Fallacia veterana*** (Hustedt ex Simonsen) Mann

Lit.: Round, Crawford & Mann 1990, p. 669; Simonsen 1987, p.491, pl.751, figs 8-12

Basionym: *Navicula veterana* Hustedt 1964

Fig. 18: Sample COAST002, Peconic Bay, NY.
Fig. 19: Sample BBDC0009, Barnegat Bay, NJ.
Fig. 20: Sample BBDC0108, Great Bay, NJ.
Fig. 21: Sample BBDC0047, Barnegat Bay, NJ.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17
21

Plate 146 (Scale bars: Figs 1-11, 15-25=10 µm; Figs 12-14, 26-27=1 µm)

Figs 1-14: ***Fallacia nyella*** (Hustedt ex Simonsen) Mann

Lit.: Hustedt 1961-1966, p.660, fig.1571; Simonsen 1987, p.490,fig.751; Round, Crawford & Mann 1990, p. 669; Witkowski, Lange-Bertalot, Metzeltin 2000, p.209, pl.70:1-7.

Basionym: *Navicula nyella* Hustedt 1964

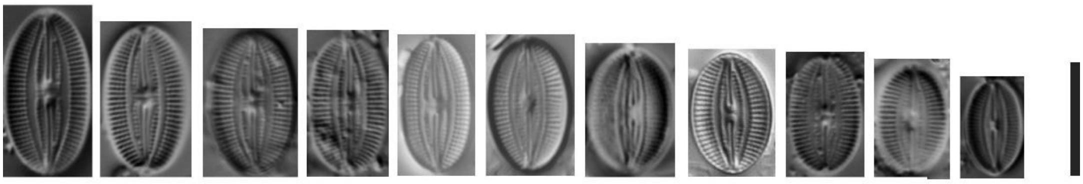
Figs 1,9,11: Sample BBDC0041, Barnegat Bay, NJ.
Fig. 2: Sample BBDC0049, Barnegat Bay, NJ.
Figs 3,14: Sample BBDC0047, Barnegat Bay, NJ.
Fig. 4: Sample BB0057, Barnegat Bay, NJ.
Fig. 5: Sample COAST002, Peconic Bay, NY.
Fig. 6: Sample COAST010, Great South Bay, NY.
Fig. 7: Sample BB0004, Barnegat Bay, NJ.
Fig. 8: Sample BBDC0012, Barnegat Bay, NJ.
Fig. 9: Sample BB0004, Barnegat Bay, NJ.
Fig. 12: Sample BBDC0054, Barnegat Bay, NJ.
Fig. 13: Sample COAST054, Barnegat Bay, NJ.

Figs 15-27: ***Fallacia florinae*** (Moeller) Witkowski

Lit.: Moller 1950, p. 204; fig. 9; Hustedt 1961-1966, p.660, fig.1660; Witkowski 1993, p. 215-219; Witkowski, Lange-Bertalot, Metzeltin 2000, p.204, pl.71:45-49.

Basionym: *Navicula florinae* Moller 1950

Fig. 15: Sample BBDC0008, Barnegat Bay, NJ.
Fig. 16: Sample BBDC0003, Barnegat Bay, NJ.
Fig. 17: Sample BBDC0007, Barnegat Bay, NJ.
Fig. 18: Sample BBDC0028, Barnegat Bay, NJ.
Figs 19,21: Sample BBDC0018, Barnegat Bay, NJ.
Fig. 20,24: Sample COAST052, Barnegat Bay, NJ.
Fig. 22: Sample BBDC0036, Barnegat Bay, NJ.
Fig. 23: Sample BB0055, Barnegat Bay, NJ.
Fig. 25: Sample BB0057, Barnegat Bay, NJ.
Figs 26-27: Sample COAST054, Barnegat Bay, NJ.



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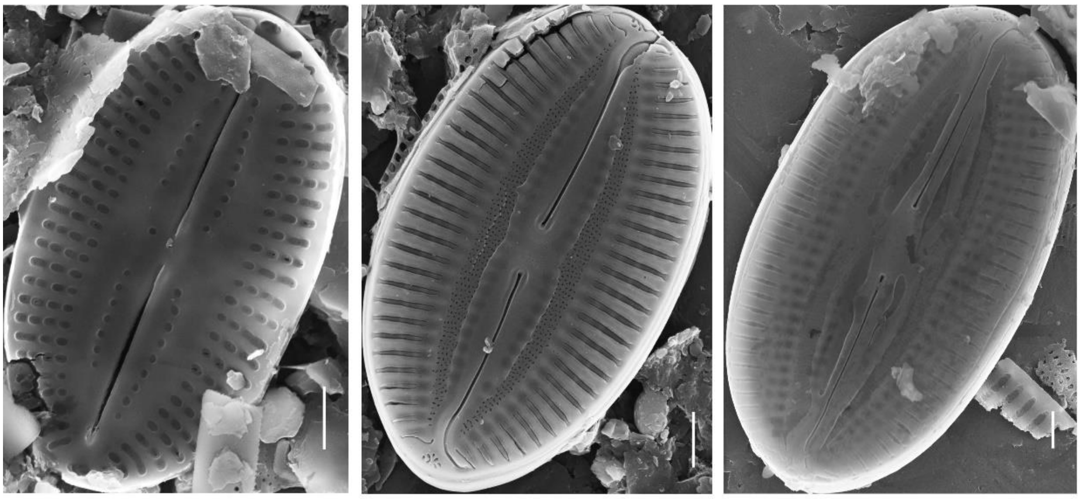
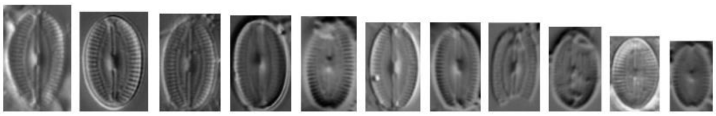
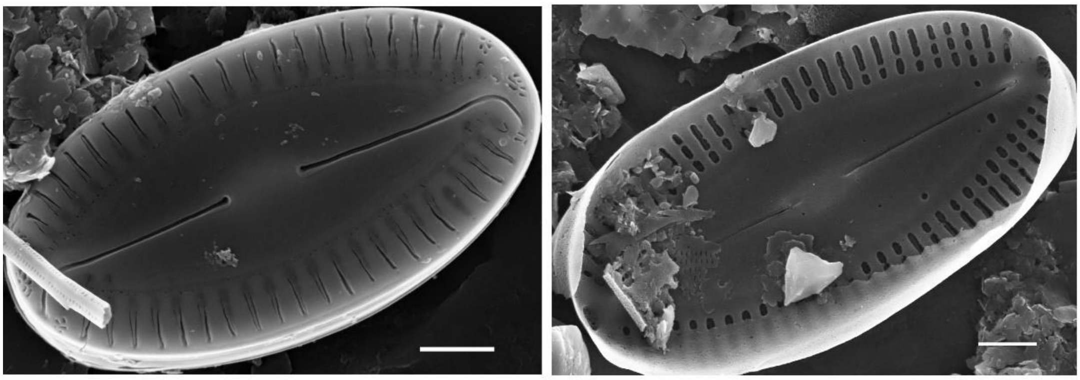


12 - 14



15 - 25



26 - 27

Plate 147 (Scale bars: Figs 1-15, 18-30=10 µm; Figs 16-17, 31=33 µm)

Figs 1-17: ***Fallacia cryptolyra*** (Brockmann) Stickle & Mann

Lit.: Brockmann 1950, p. 19; pl. 3, fig. 22, 23; Round, Crawford & Mann 1990, p. 668; Krammer & Lange-Bertalot 1986, p.172, fig.65:7-9; Round, Crawford & Mann 1990, p. 668; Witkowski, Lange-Bertalot, Metzeltin 2000, p.203, pl.70:42-45.

Basionym: *Navicula cryptolyra* Brockmann 1950

Synonyms:

Navicula inattigens Simonsen 1959

Fallacia inattigens (Simonsen) Mann 1990

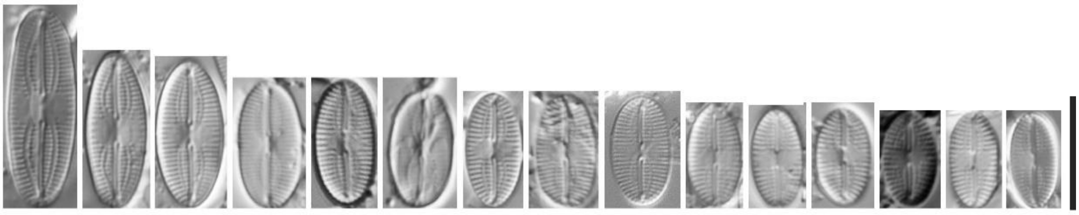
Figs 1,8,10: Sample BBDC0009, Barnegat Bay, NJ.
Fig. 2: Sample COAST054, Barnegat Bay, NJ.
Figs 3,10: Sample COAST025, Great South Bay, NY.
Fig. 4: Sample BBDC0046, Barnegat Bay, NJ.
Figs 5-6,9: Sample BBDC0001, Barnegat Bay, NJ.
Fig. 7: Sample COAST031, Western Bay, NY.
Fig. 8: Sample BB0067, Barnegat Bay, NJ.
Fig. 11: Sample COAST029, Western Bay, NY.
Fig. 12: Sample BBDC0095, Great Bay, NJ.
Fig. 13: Sample BB0054, Barnegat Bay, NJ.
Fig. 14: Sample COAST028, Great South Bay, NY.
Fig. 15: Sample COAST003, Peconic Bay, NY.
Fig. 16: Sample BBDC0016, Barnegat Bay, NJ.
Fig. 17: Sample BBDC0047, Barnegat Bay, NJ.

Figs 18-33: ***Fallacia melanocephala*** (Giffen) Witkowski, Lange-Bertalot & Metzeltin

Lit.: Giffen 1975, p. 84; fig. 78-80; Witkowski 1993, p. 215-219; Witkowski, Lange-Bertalot, Metzeltin 2000, p.208, pl.71:5.

Basionym: *Navicula melanocephala* Giffen 1975

Figs 18-22,26-30: Sample COAST025, Great South Bay, NY.
Fig. 23: Sample COAST004, Peconic Bay, NY.
Fig. 24: Sample BBDC0045, Barnegat Bay, NJ.
Fig. 25: Sample COAST002, Peconic Bay, NY.
Figs 31,33: Sample BBDC0054, Barnegat Bay, NJ.
Fig. 32: Sample COAST022, Great South Bay, NY.



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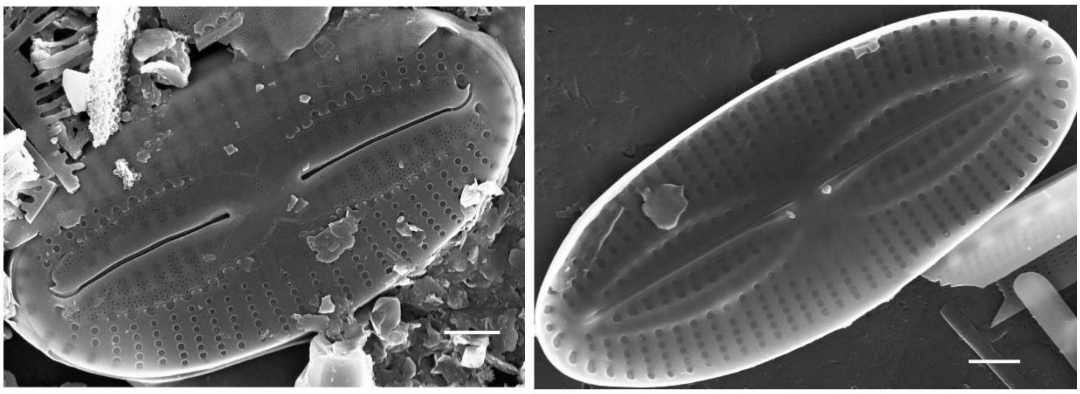
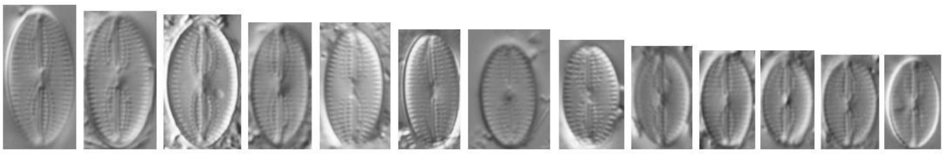
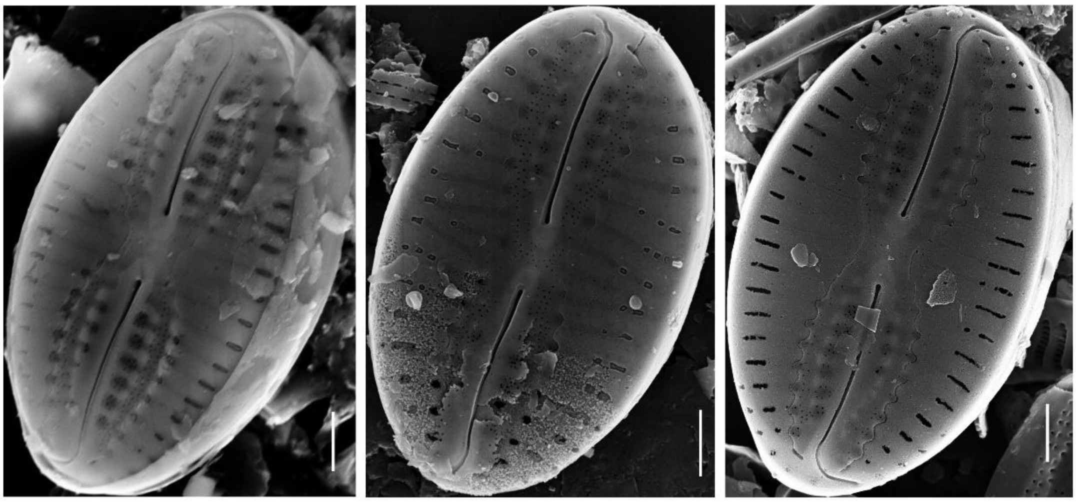


16 - 17



18 - 30



31 - 33

Plate 148 (Scale bars: Figs 1-15, 18-27=10 µm; Figs 16-17, 28-30=1 µm)

Figs 1-17: ***Fallacia amphipleuroides*** (Hustedt) Mann

Lit.: Hustedt 1955, p.30, pl.5, figs 33-34; Håkansson & Stabell 1977, p.478, fig.1A; Simonsen 1987, p.415, pl.619, figs 20-26; Sabbe et al. 1999, p.11, figs 22-25; Round, Crawford & Mann 1990, p. 668; Witkowski, Lange-Bertalot, Metzeltin 2000, p.200, pl.71:43,44.

Basionym: *Navicula amphipleuroides* Hustedt 1955

Synonyms: *Navicula margin-ornata (margniornata)* Salah 1955

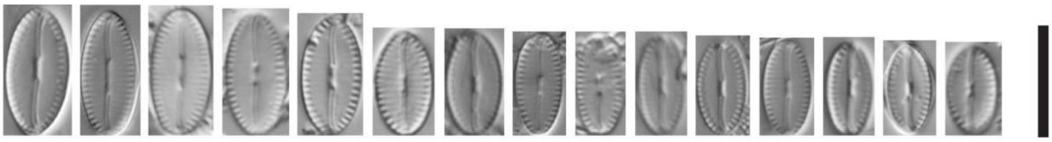
Maybe conspecific with *Navicula fenestrella* Hustedt

Figs 1,12: Sample COAST002, Peconic Bay, NY.
Figs 2,10-11,16-17: Sample BBDC0003, Barnegat Bay, NJ.
Fig. 3: Sample BB0174, Tuckerton Bay, NJ.
Figs 4,7: Sample BBDC0054, Barnegat Bay, NJ.
Fig. 5: Sample COAST005, Peconic Bay, NY.
Fig. 6,13,15: Sample COAST001, Peconic Bay, NY.
Fig. 8: Sample BBDC0012, Barnegat Bay, NJ.
Fig. 9: Sample BBDC0095, Great Bay, NJ.
Fig. 14: Sample BBDC0009, Barnegat Bay, NJ.

Figs 18-30: ***Fallacia margino-punctata*** Sabbe & Vyverman

Lit.: Sabbe, Vyverman & Muylaert 1999, p. 15, 17; fig. 19-21, 28-33, 62-65; Witkowski, Lange-Bertalot, Metzeltin 2000, p.207, pl.71:18-20

Fig. 17: Sample COAST062, Great Bay, NJ.
Figs 18,22: Sample COAST002, Peconic Bay, NY.
Fig. 19: Sample BBDC0048, Barnegat Bay, NJ.
Figs 20,24,28: Sample BBDC0095, Great Bay, NJ.
Fig. 21: Sample COAST001, Peconic Bay, NY.
Figs 23,25: Sample COAST025, Great South Bay, NY.
Fig. 26: Sample COAST053, Barnegat Bay, NJ.
Figs 27,29: Sample COAST022, Great South Bay, NY.



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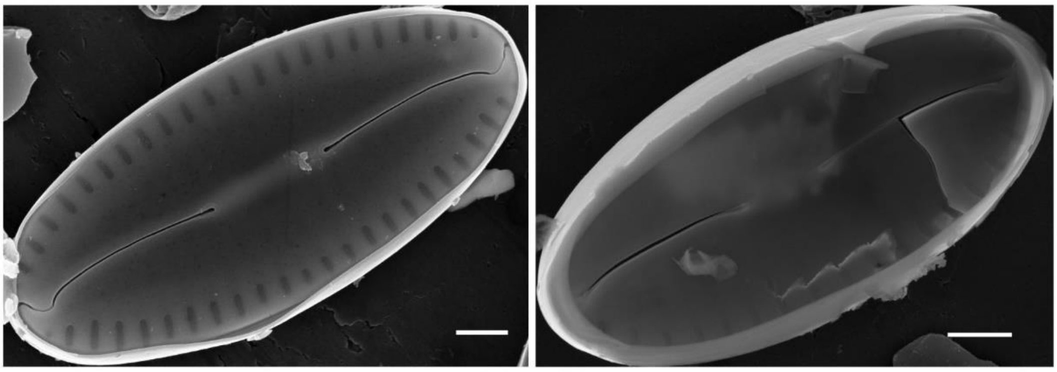
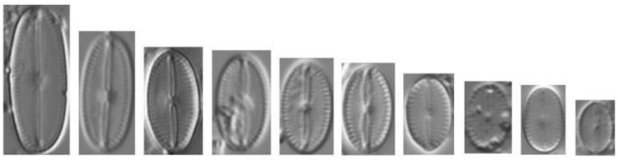
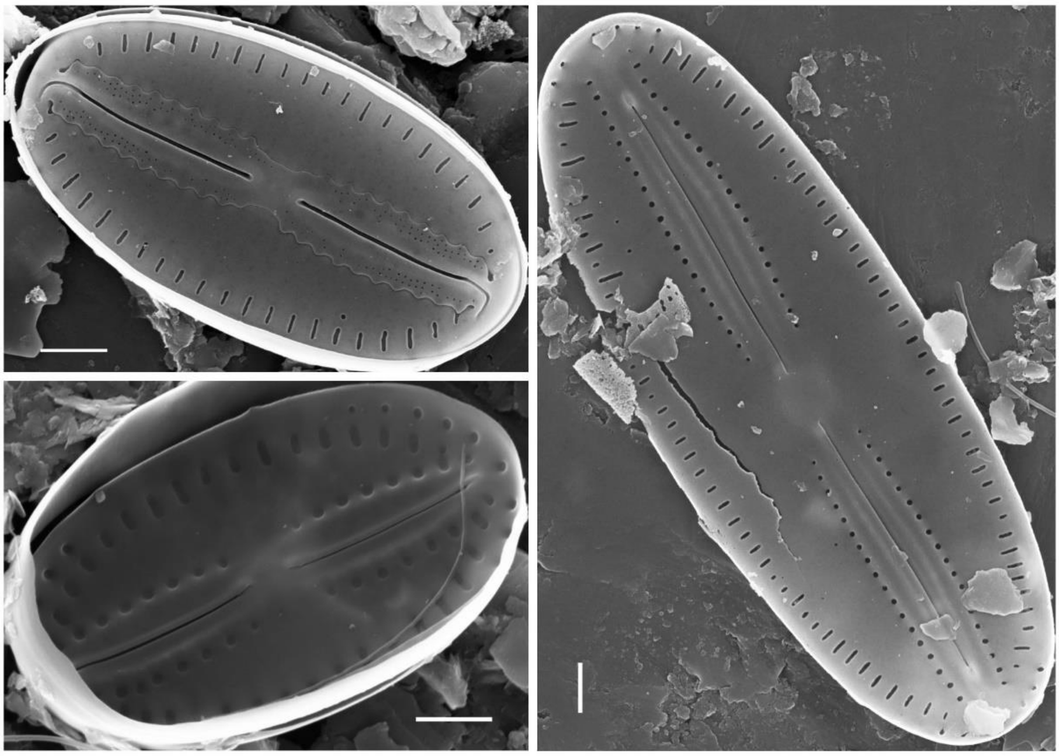


16 - 17



18 - 27



28- 30

Plate 149 (Scale bars: Figs 1-8, 10-20, 22-29, 31-37=10 µm; Figs 9, 21, 30=1 µm)

Figs 1-9: ***Fallacia* sp. 1 (F. wuestii sensu Witkowski)**

Fig. 1: Sample BBDC0044, Barnegat Bay, NJ.
Figs 2,3,8: Sample COAST052, Barnegat Bay, NJ.
Figs 4,5: Sample BBDC0051, Barnegat Bay, NJ.
Fig. 6: Sample BBDC0001, Barnegat Bay, NJ.
Fig. 7: Sample BBDC0012, Barnegat Bay, NJ.
Fig. 9: Sample BBDC0080, Barnegat Bay, NJ.

Figs 10-13: ***Fallacia* cf. *tenera*** sensu Sabbe,Vyverman, Muylaert; sensu Snoeijs

Lit.: Sabbe et al. 1999, p.18, figs 1-4,75,78,82; Snoeijs & Vilbaste 1994, v. 3: p. 54

Fig. 10: Sample BBDC0003, Barnegat Bay, NJ.
Fig. 11: Sample COAST051, Barnegat Bay, NJ.
Figs 12: Sample BB0063, Barnegat Bay, NJ.
Figs 13: Sample BB0058, Barnegat Bay, NJ.

Fig. 14: ***Fallacia tenera*** Hustedt

Lit.: Schmidt et al. 1936, pl. 405, footnote; Simonsen 1987, p.162, pl.255, figs 6-10; Round, Crawford & Mann 1990, p. 668

Basionym: *Navicula tenera* Hustedt in Schmidt et al. 1936

Fig. 14: Sample BBDC0046, Barnegat Bay, NJ.

Figs 15-21: ***Fallacia* cf. *teneroides*** sensu Sabbe,Vyverman, Muylaert

Lit.: Sabbe et al. 1999, p.10, figs 5,6.

Figs 15-16,18: Sample COAST002, Peconic Bay, NY.
Fig. 17: Sample COAST001, Peconic Bay, NY.
Fig. 19: Sample BB0055, Barnegat Bay, NJ.
Fig. 20: Sample COAST003, Peconic Bay, NY.
Fig. 21: Sample COAST054, Barnegat Bay, NJ.

Fig. 22: ***Fallacia teneroides*** (Hustedt) Mann

Lit.: Hustedt 1956, p. 117; fig. 42-43; Simonsen 1987, p.162, pl.654, figs 1-9; Round, Crawford & Mann 1990, p. 669

Basionym: *Navicula tenera* Hustedt 1956

Fig. 22: Sample BBDC0006, Barnegat Bay, NJ.

Figs 23-30: ***Fallacia auriculata*** (Hustedt) Mann

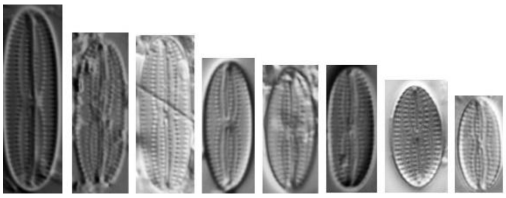
Lit.: Hustedt 1944, p. 273; fig. 4; Simonsen 1987, p.314, pl.472, figs 10-12, p.194 pl.303, figs 30-35 as *Navicula dissipata*.

Basionym: *Navicula auriculata* Hustedt 1944

Fig. 23: Sample BB0061, Barnegat Bay, NJ.
Fig. 24: Sample BBDC0048, Barnegat Bay, NJ.
Fig. 25: Sample BBDC0002, Barnegat Bay, NJ.
Fig. 26: Sample BBDC0004, Barnegat Bay, NJ.
Fig. 27: Sample BBDC0007, Barnegat Bay, NJ.
Fig. 28: Sample BBDC0005, Barnegat Bay, NJ.
Fig. 29: Sample COAST052, Barnegat Bay, NJ.
Fig. 30: Sample BBDC0051, Barnegat Bay, NJ.

Figs 31-37: ***Fallacia* sp. 12**

Fig. 31: Sample BBDC0005, Barnegat Bay, NJ.
Fig. 32: Sample BBDC0006, Barnegat Bay, NJ.
Fig. 33: Sample BBDC0028, Barnegat Bay, NJ.
Fig. 34: Sample BBDC0009, Barnegat Bay, NJ.
Fig. 35: Sample BB0006, Barnegat Bay, NJ.
Figs 36,37: Sample BBDC0008, Barnegat Bay, NJ.



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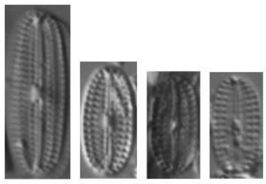

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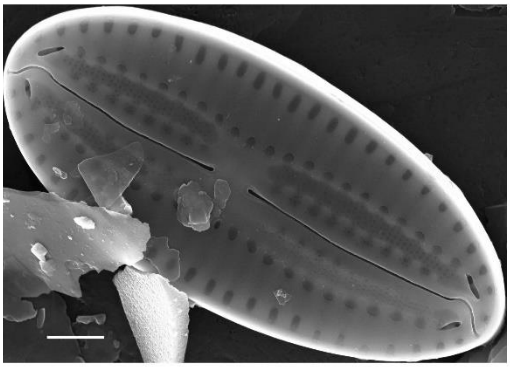

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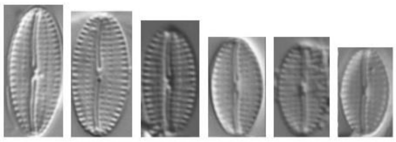
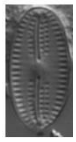


15 - 20



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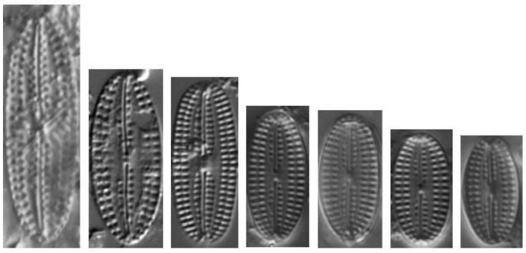
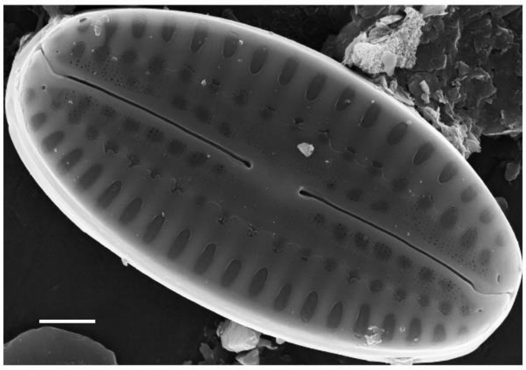


23 - 29



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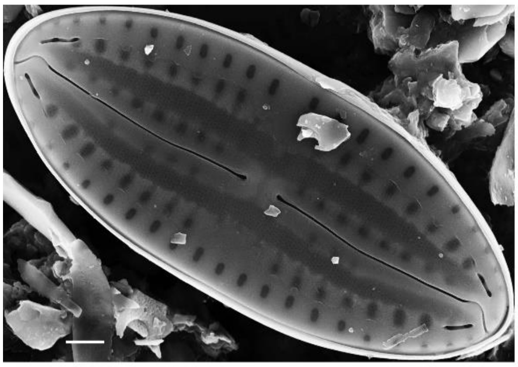

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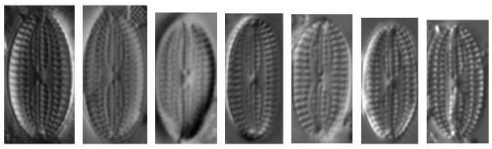


31 - 37

Plate 150 (Scale bars: Figs 1-14, 16-37=10 µm; Figs 15, 38-39=1 µm)

Figs 1-3: ***Fallacia* sp. 9**

Fig. 1: Sample BB0076, Barnegat Bay, NJ.
Fig. 2: Sample COAST029, Western Bay, NY.
Fig. 3: Sample BBDC0051, Barnegat Bay, NJ.

Figs 4-5: ***Fallacia wuestii*** (Simonsen) Sabbe & Muylaert

Lit.: Simonsen 1959, p. 77; pl. 11, fig. 16-18; Sabbe, Vyverman & Muylaert 1999, p. 19, figs. 34-36.

Fig. 4: Sample BBDC0044, Barnegat Bay, NJ.
Fig. 5: Sample COAST051, Barnegat Bay, NJ.

Fig. 6: ***Fallacia* sp. 11**

Fig. 6: Sample BBDC0004, Barnegat Bay, NJ.

Fig. 7: ***Fallacia* sp. 16**

Fig. 7: COAST044, Barnegat Bay, NJ.

Fig. 8: ***Fallacia* sp. 3**

Fig. 8: Sample BBDC0062, Barnegat Bay, NJ.

Figs 9-12: ***Fallacia fracta*** (Hustedt ex Simonsen) Mann

Lit.: Hustedt 1961, p. 127; fig. 1259; Crawford & Mann 1990, p. 668

Basionym: *Navicula fracta* Hustedt 1961

Fig. 9: Sample BB0009, Barnegat Bay, NJ.
Figs 10-12: Sample RUTG0867, Pilot Drive, NJ.

Figs 13-15: ***Fallacia pulchella*** Hustedt

Lit.: Sabbe, Vyverman & Muylaert 1999, p. 17; fig. 46, 47, 66-68, 72, 74; Witkowski, Lange-Bertalot, Metzeltin 2000, p.211, pl.71:50,51

Fig. 13: Sample BBDC0008, Barnegat Bay, NJ.
Fig. 14: Sample BB0052, Barnegat Bay, NJ.
Fig. 15: Sample BBDC0054, Barnegat Bay, NJ.

Fig. 16: ***Fallacia* sp. 2**

Fig. 12: Sample BBDC0062, Barnegat Bay, NJ.

Figs 17-19: ***Fallacia* sp. 10**

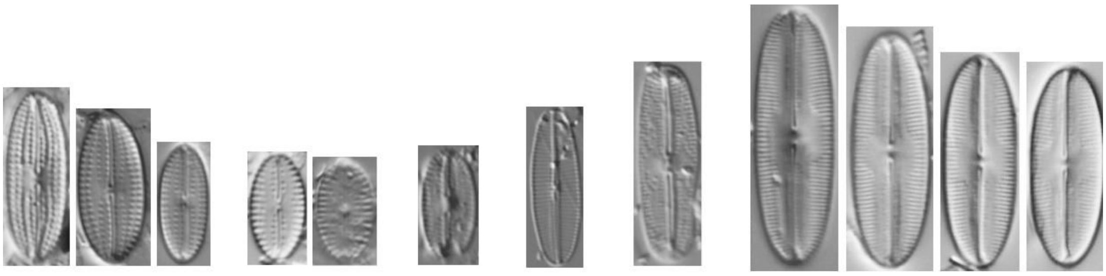
Fig. 17: Sample RUTG0004, Cape May Courthouse, NJ.
Figs 18-19: Sample RUTG0860, Pilot Drive, NJ.

Figs 20-39: ***Fallacia aequorea*** (Hustedt) Mann

Lit.: Hustedt 1939, p. 621; fig. 57-60; Simonsen 1987, p.256, pl.379, figs 8-14; Witkowski, Lange-Bertalot, Metzeltin 2000, p.200, pl.71:35,36

Basionym: *Navicula aequorea* Hustedt 1939

Figs 20-21,27,29: Sample COAST025, Great South Bay, NY.
Fig. 22: Sample BBDC0012, Barnegat Bay, NJ.
Fig. 23: Sample BBDC0053, Barnegat Bay, NJ.
Fig. 24: Sample COAST054, Barnegat Bay, NJ.
Fig. 25: Sample BB0064, Barnegat Bay, NJ.
Fig. 26: Sample COAST003, Peconic Bay, NY.
Fig. 28: Sample BBDC0047, Barnegat Bay, NJ.
Fig. 30,32: Sample COAST052, Barnegat Bay, NJ.
Fig. 31,36: Sample BBDC0002, Barnegat Bay, NJ.
Fig. 33: Sample BB0063, Barnegat Bay, NJ.
Fig. 34: Sample BB0057, Barnegat Bay, NJ.
Fig. 35: Sample BBDC0018, Barnegat Bay, NJ.
Fig. 37: Sample BBDC0041, Barnegat Bay, NJ.
Fig. 38: Sample BBDC0080, Barnegat Bay, NJ.
Fig. 39: Sample BBDC0045, Barnegat Bay, NJ.



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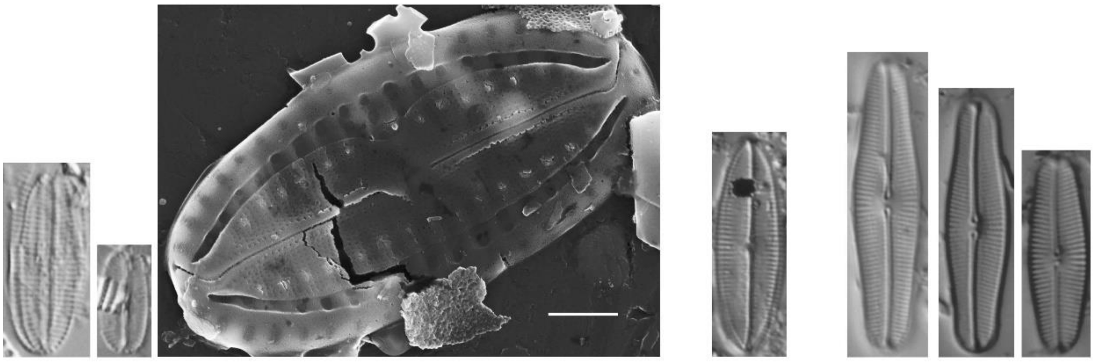
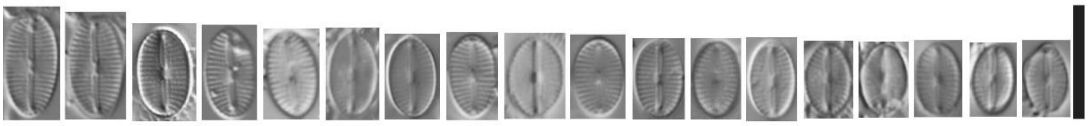
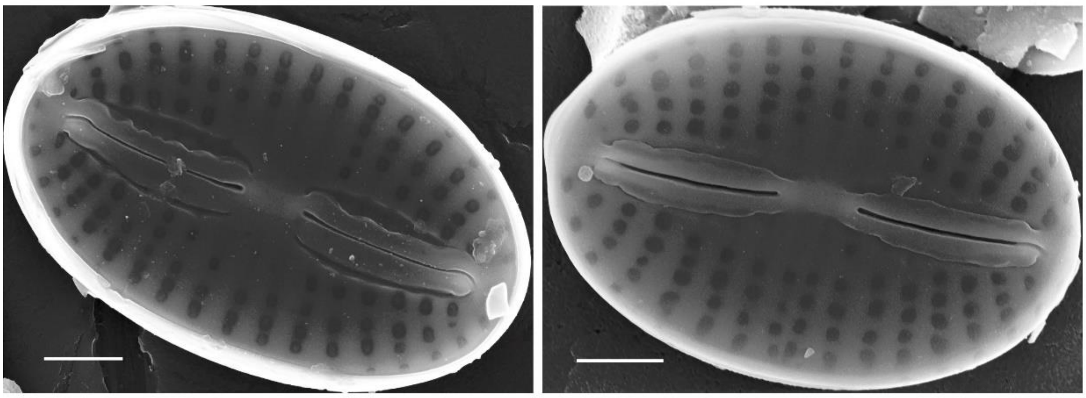


13 - 14 15 16 17 - 19



20 - 37



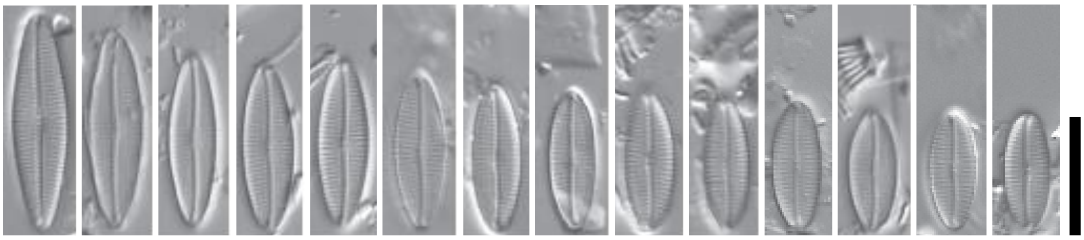
38 - 39

Plate 151 (Scale bars: Figs 1-14=10 µm; Figs 15-19=1 µm)

Fallacia gemmifera (Simonsen) Mann

Lit.: Simonsen 1960, p. 128; pl. 1, fig. 11-12; Round, Crawford & Mann 1990, p. 668; Witkowski, Lange-Bertalot, Metzeltin 2000, p.279, pl791:13-18.

Basionym: *Navicula gemmifera* Simonsen 1960



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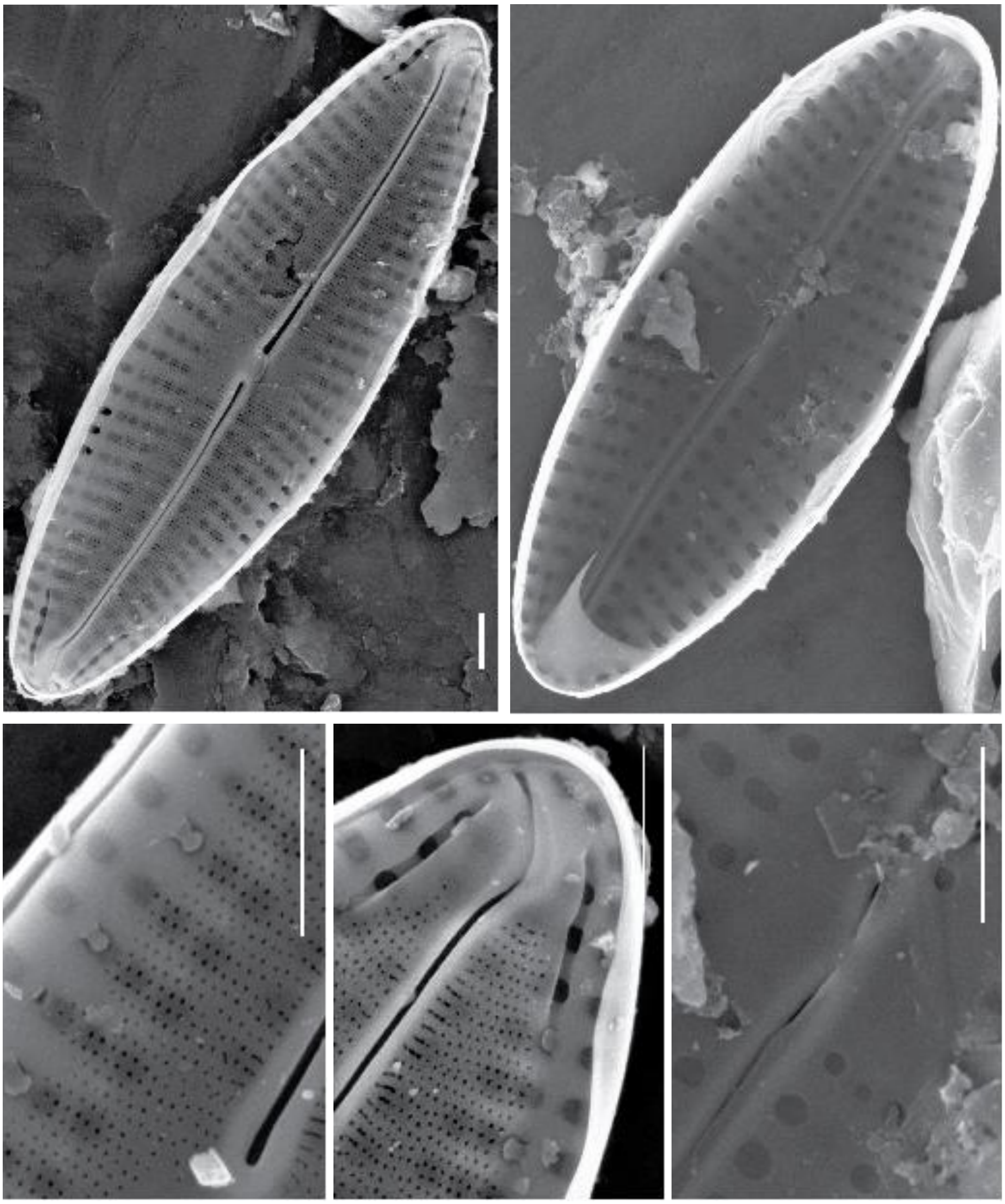
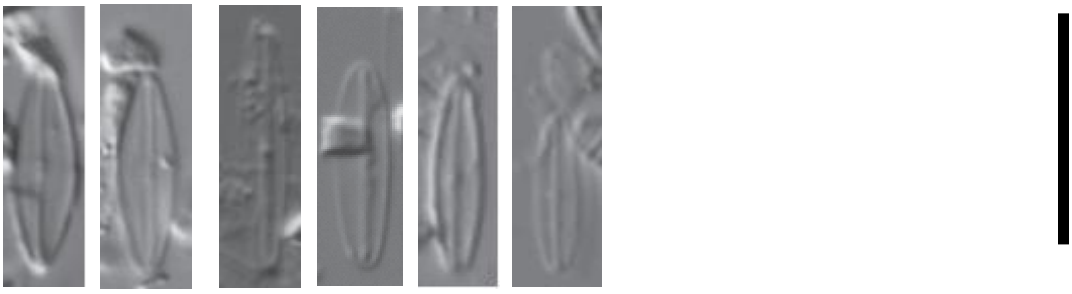


15 - 19

Plate 152 (Scale bars: Figs 1-6=10 µm; Figs 7-9=1 µm)

Fallacia cf. *fossulae*

Figs 1-2: Sample BBDC0056, Barnegat Bay, NJ.
Fig. 3: Sample BBDC0041, Barnegat Bay, NJ.
Fig. 4: Sample BBDC0052, Barnegat Bay, NJ.
Fig. 5: Sample COAST052, Barnegat Bay, NJ.
Fig. 6: Sample BBDC0053, Barnegat Bay, NJ.
Figs 7-9: Sample BBDC0080, Barnegat Bay, NJ.



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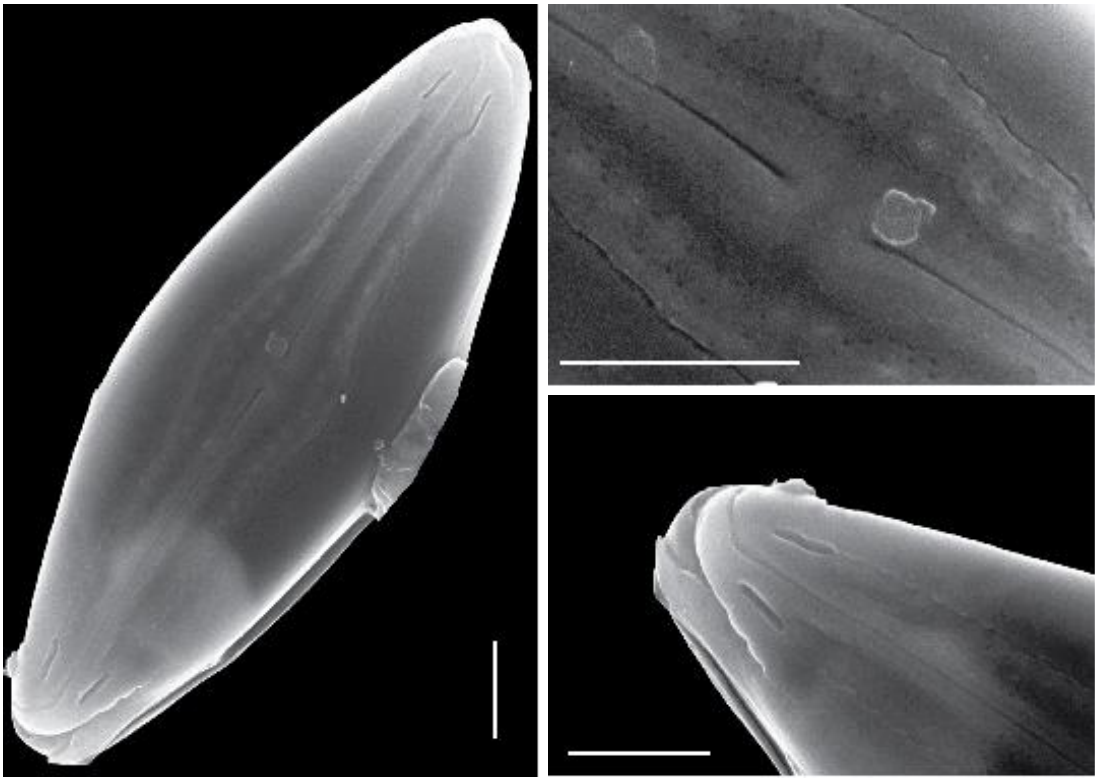


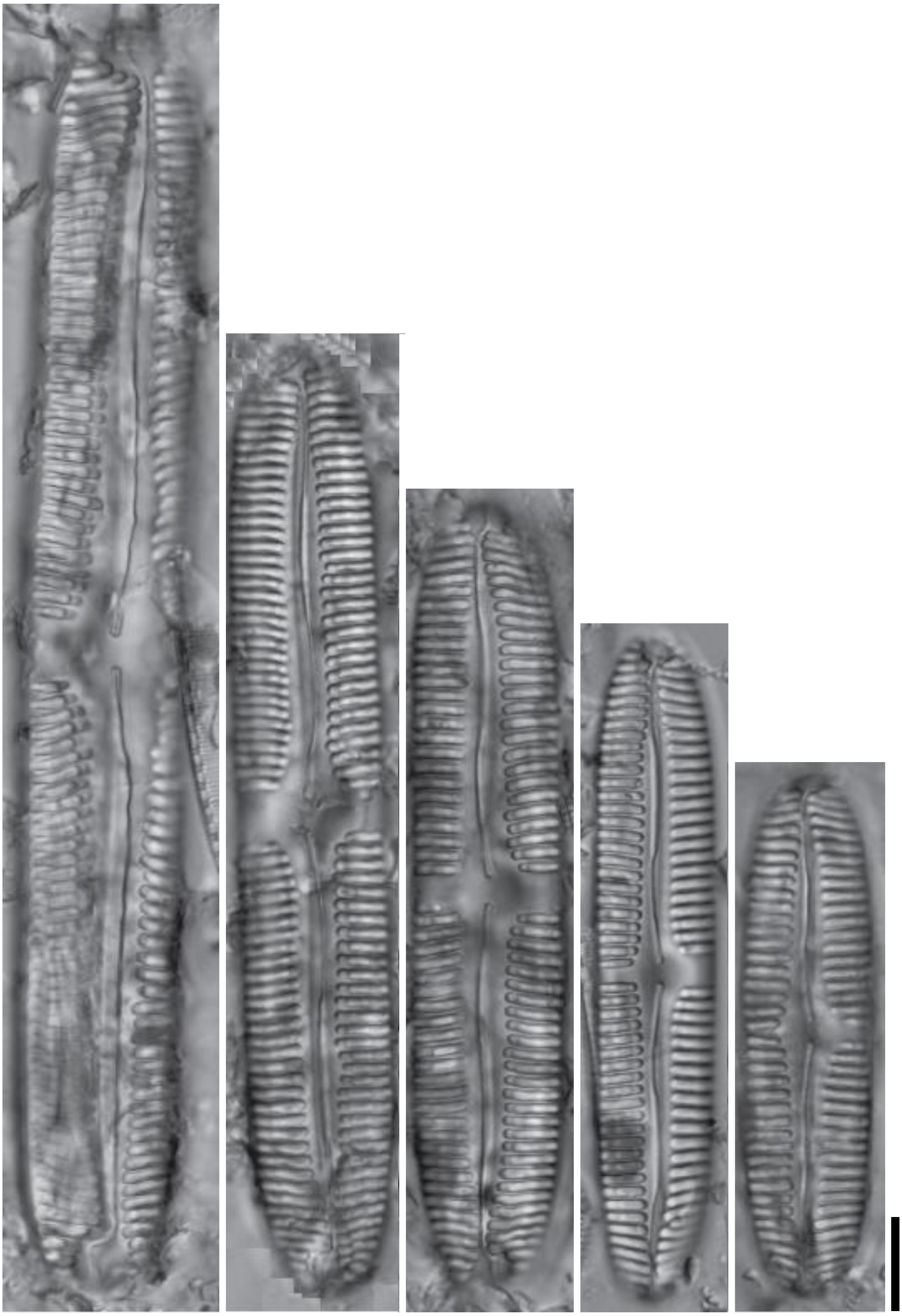
7 - 9

Plate 153 (Scale bar: Figs 1-5=10 μm)

Pinnularia aestuarii Cleve

Lit.:Cleve 1895, p. 93; pl. 1, fig. 16

Figs 1-5: Sample RUTG0340, Cheesequake State Park, NJ.



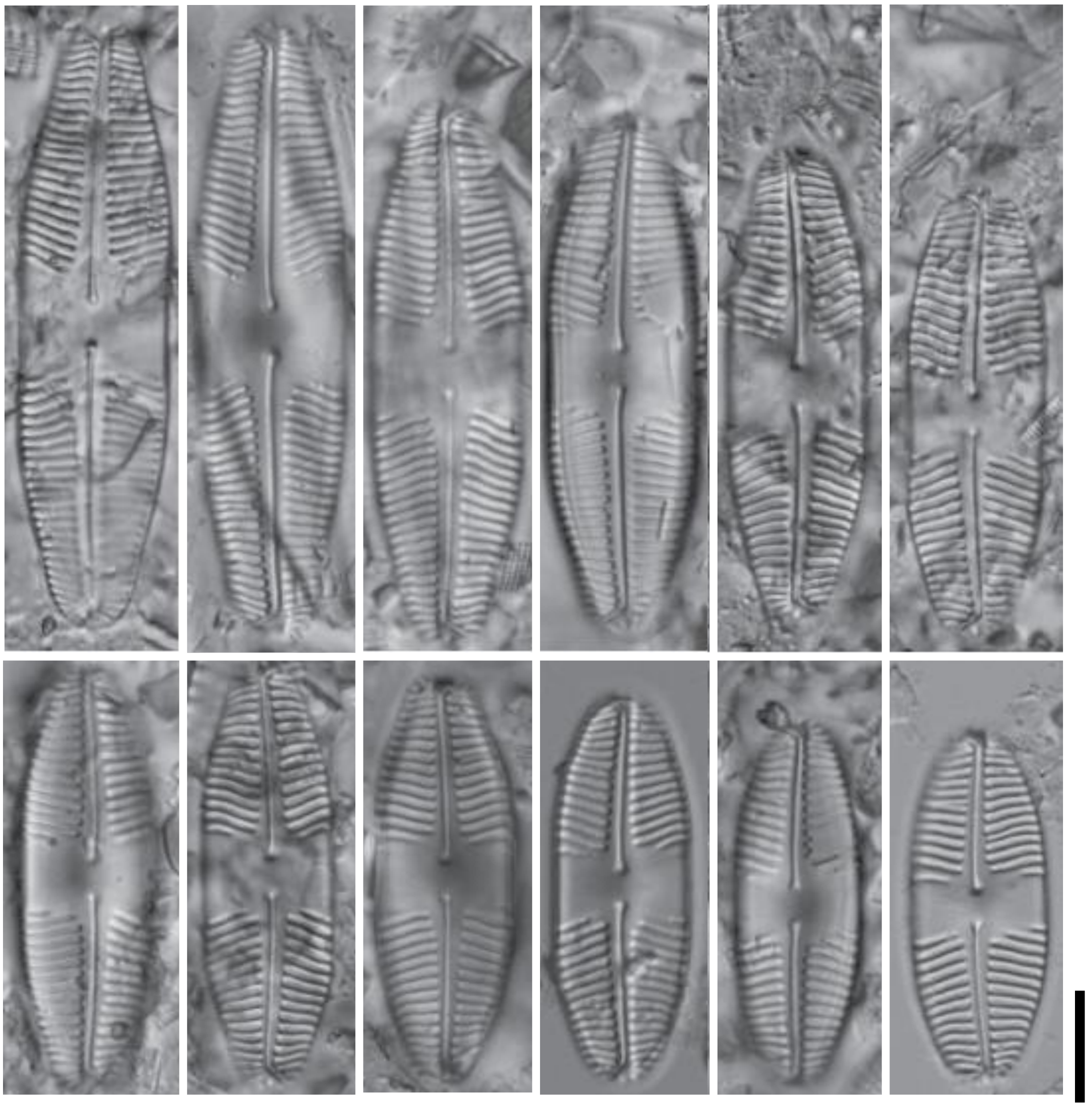
1 - 5

Plate 154 (Scale bars: Figs 1-12=10 µm)

Pinnularia birnirkiana Patrick & Freese

Lit.:Patrick & Freese 1961, p. 235; pl. 3, fig. 14

Figs 1-12: Sample RUTG0340, Cheesequake State Park, NJ.



1 - 12

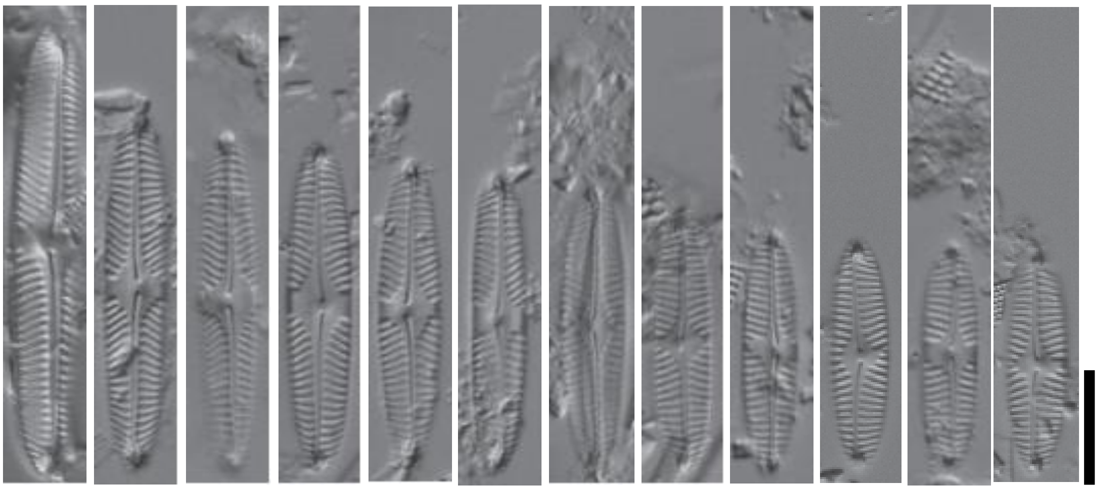
Plate 155 (Scale bars: Figs 1-32=10 µm)

Figs 1-12: ***Pinnularia* cf. *brebissonii* var. *minuta***

Fig.1: Sample BB0010, Barnegat Bay, NJ.
Figs 2-12: Sample BB0085, Tuckerton Bay, NJ.

Figs 13-24: ***Pinnularia* cf. *divergentissima***

Figs 25-32: ***Pinnularia quadratera* var. *quadratera*** (Schmidt) Cleve
Lit.:Cleve 1895, p. 95



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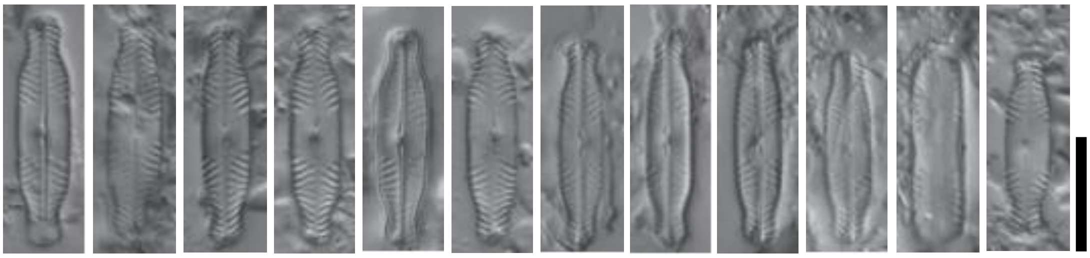
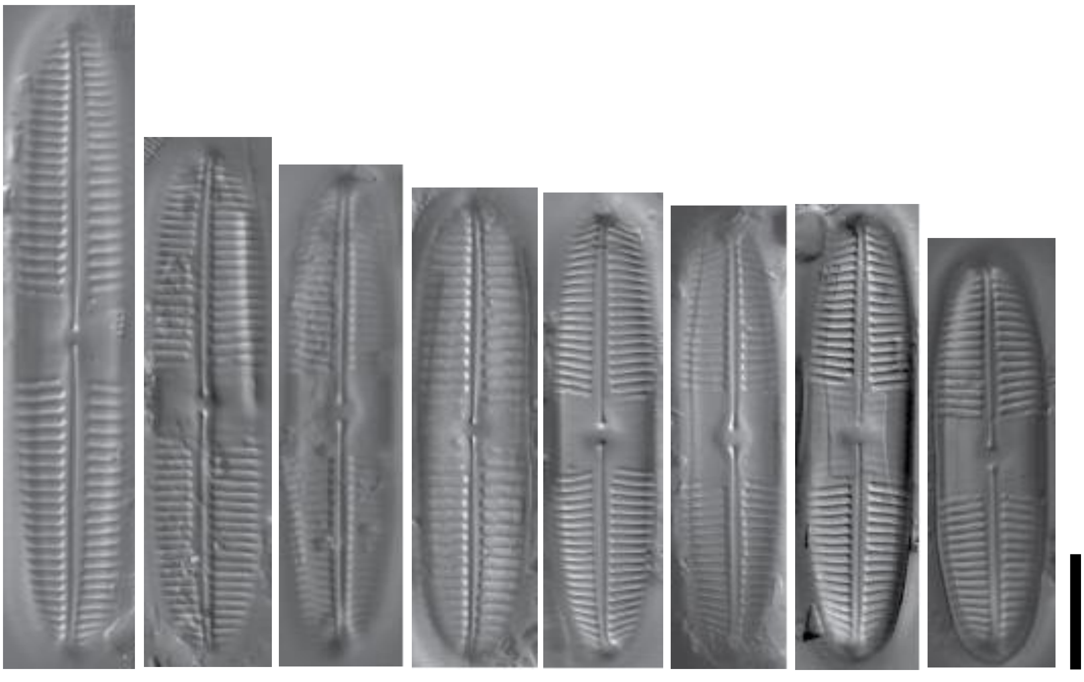


13 - 24



25 - 32

Plate 156 (Scale bar: Figs 1-2=10 µm)

Pinnularia viridiformis Krammer

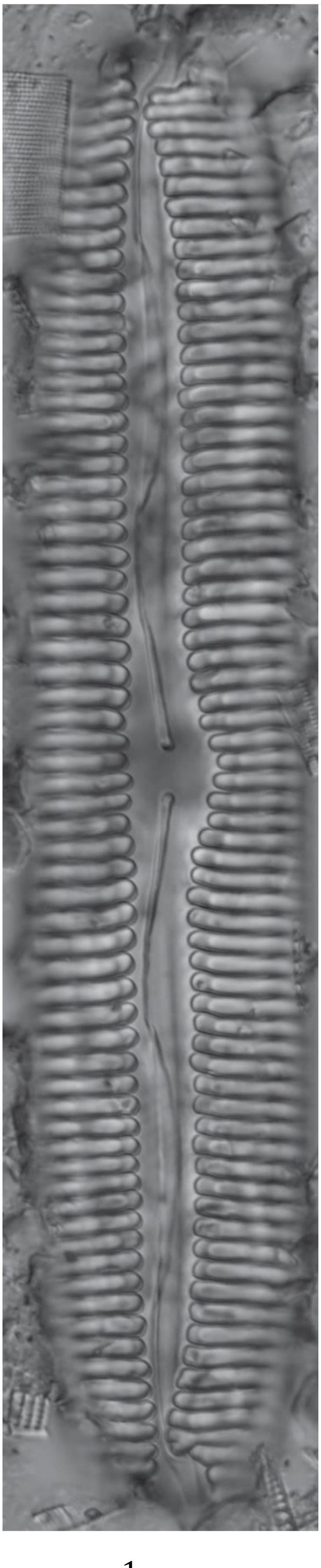
Lit.:Krammer 1992, p. 160-161; pl. 1, fig. 4, pl. 4, fig. 1-4, pl. 68, fig. 1-4, pl. 69, fig. 1-5

Figs 1-2: Sample BBDC0056, Barnegat Bay, NJ.

Plate 157 (Scale bar: Figs 1=10 µm)

Pinnularia viridis Ehrenberg

Lit.:Ehrenberg 1845, p. 62, 64

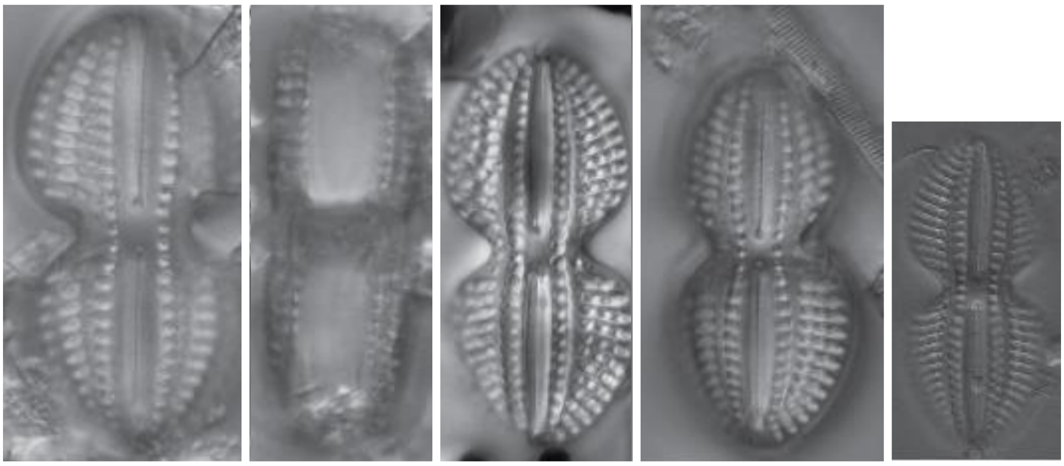


1

Plate 158 (Scale bar: Figs 1-10=10 µm)

Figs 1-5: ***Diploneis bombus*** Cleve-Euler
Lit.:Backman & Cleve-Euler 1922, p. 68; fig. 30

Figs 6-10: ***Diploneis didyma*** (Schmidt Lit.:Schmidt et al.) Mills
Lit.:Mills 1934, p. 613



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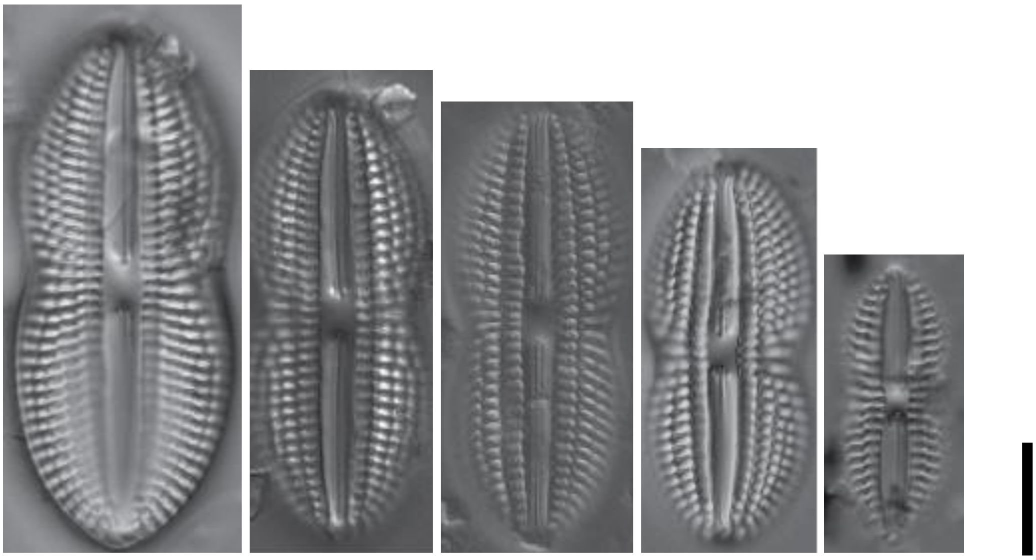


6 - 10

Plate 159 (Scale bars: Figs 1-9=10 µm; Fig. 10=1 µm)

Diploneis stroemi Hustedt
Lit.:Hustedt 1937, p. 608; fig. 1022

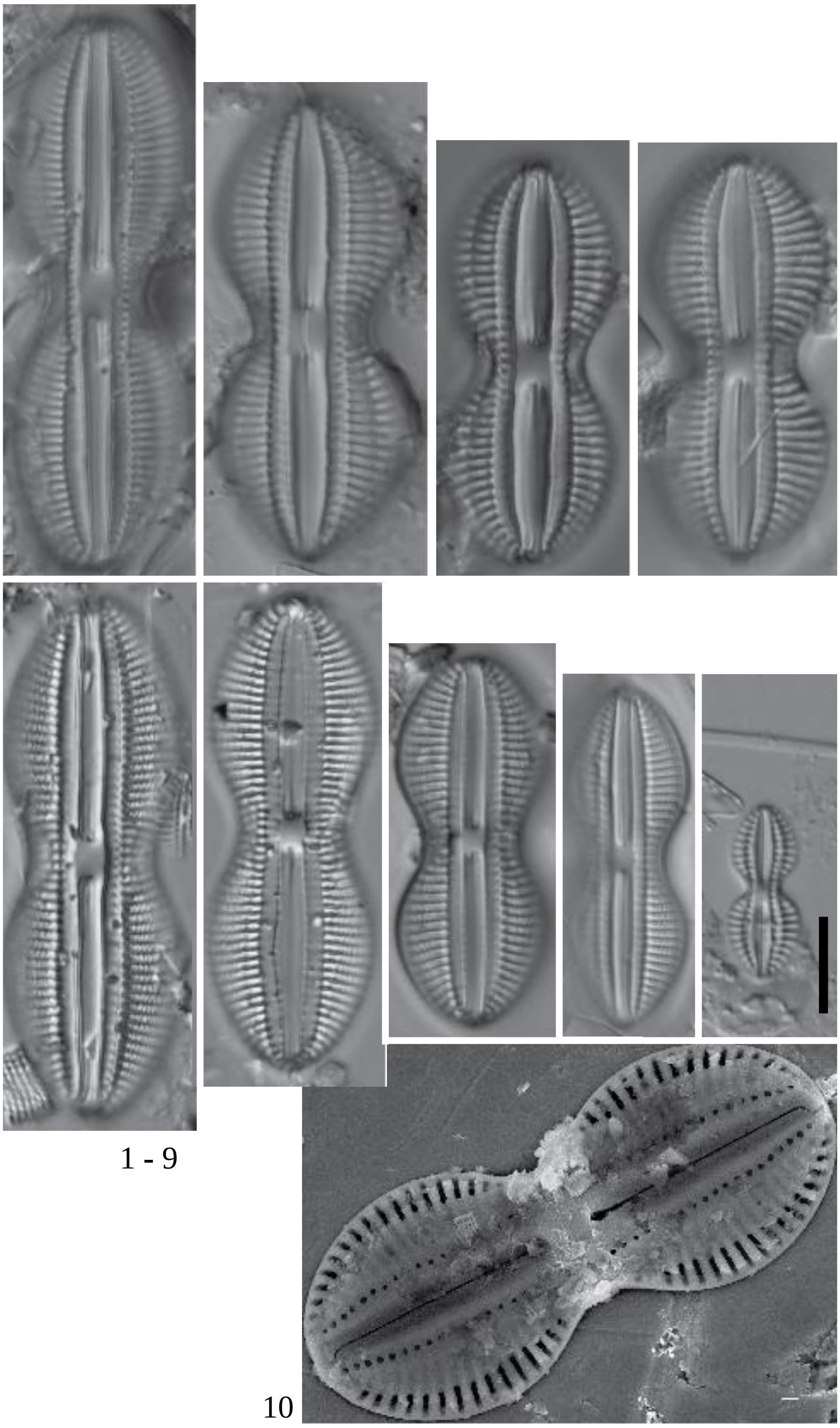
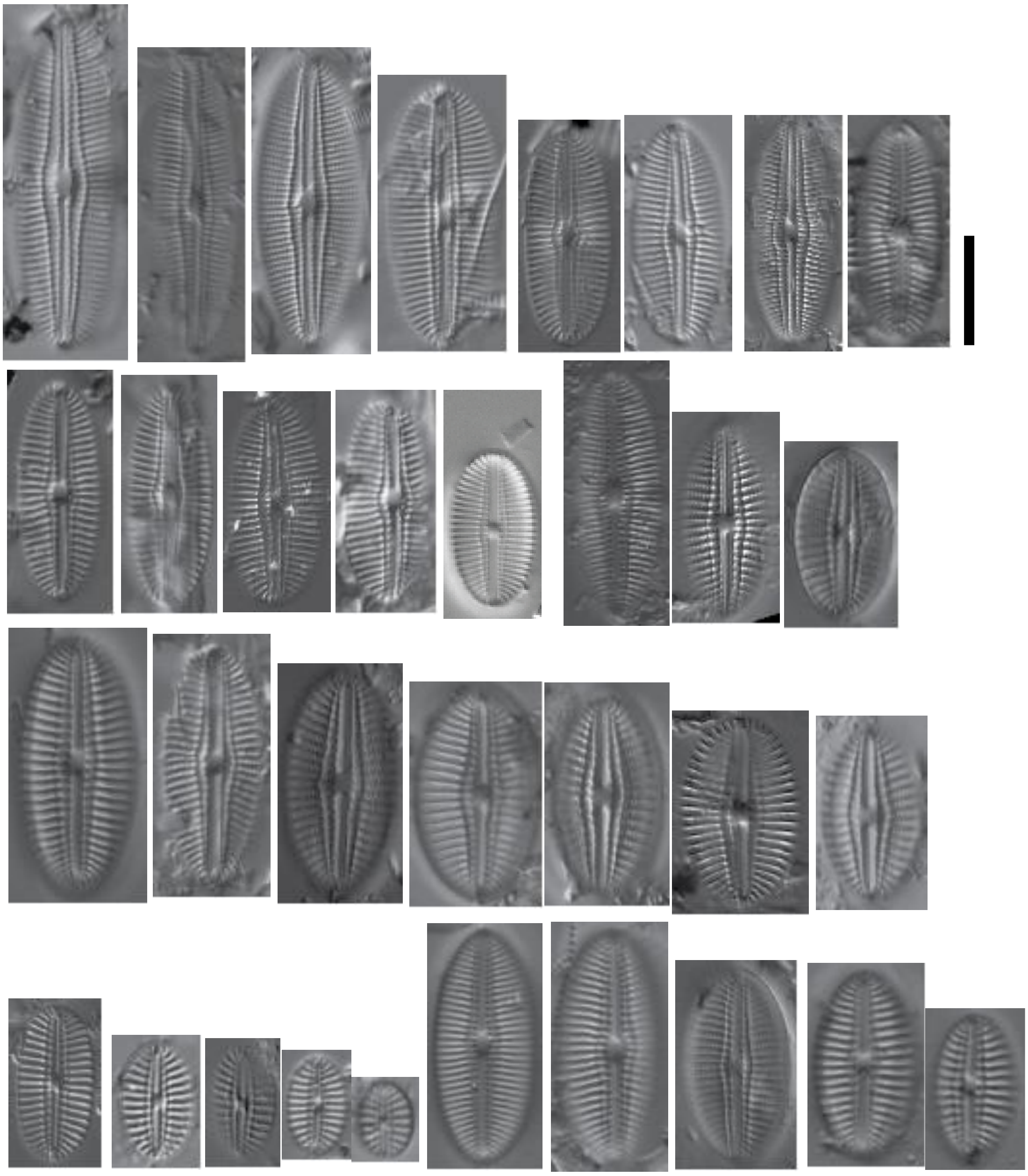

1 - 9
10

Plate 160 (Scale bar: Figs 1-33=10 µm)

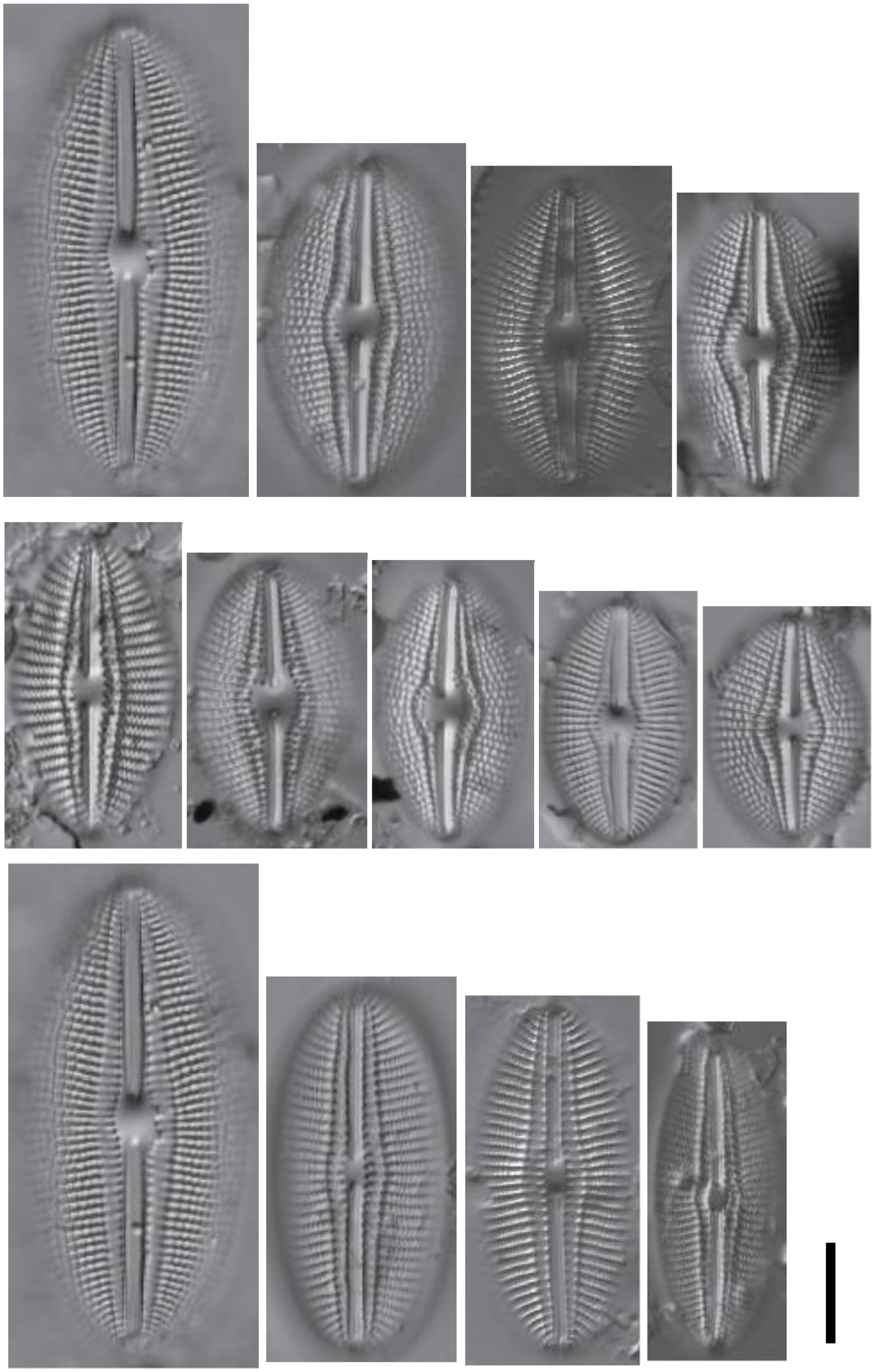
Diploneis* cf. *litoralis



1 - 33

Plate 161 (Scale bar: Figs 1-13=10 µm)

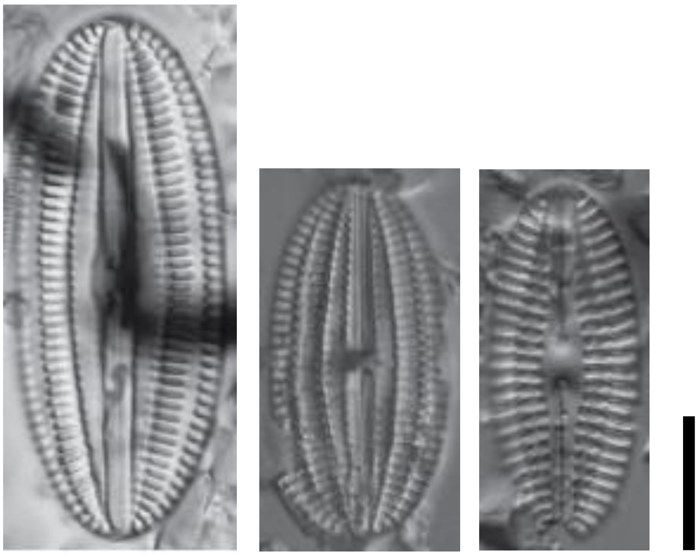
Diploneis* cf. *smithii



1 - 13

Plate 162 (Scale bar: Figs 1-3=10 µm)

Diploneis* cf. *sejuncta



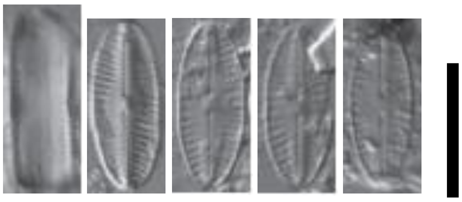
1 - 3

Plate 163 (Scale bar: Figs 1-5=10 µm)

Mayamaea fossalis var. *obsialis* (Hustedt) Lange-Bertalot

Lit.: Lange-Bertalot 1997, p. 72

Basionym: *Navicula obsidialis* Hustedt 1942
Synonym: *Navicula fossalis* var. *obsidialis* (Hustedt) Lange-Bertalot in Krammer & Lange-Bertalot 1985



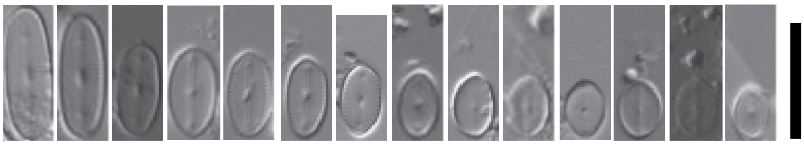
1 - 5

Plate 164 (Scale bars: Figs 1-14=10 µm, 15-16=1 µm)

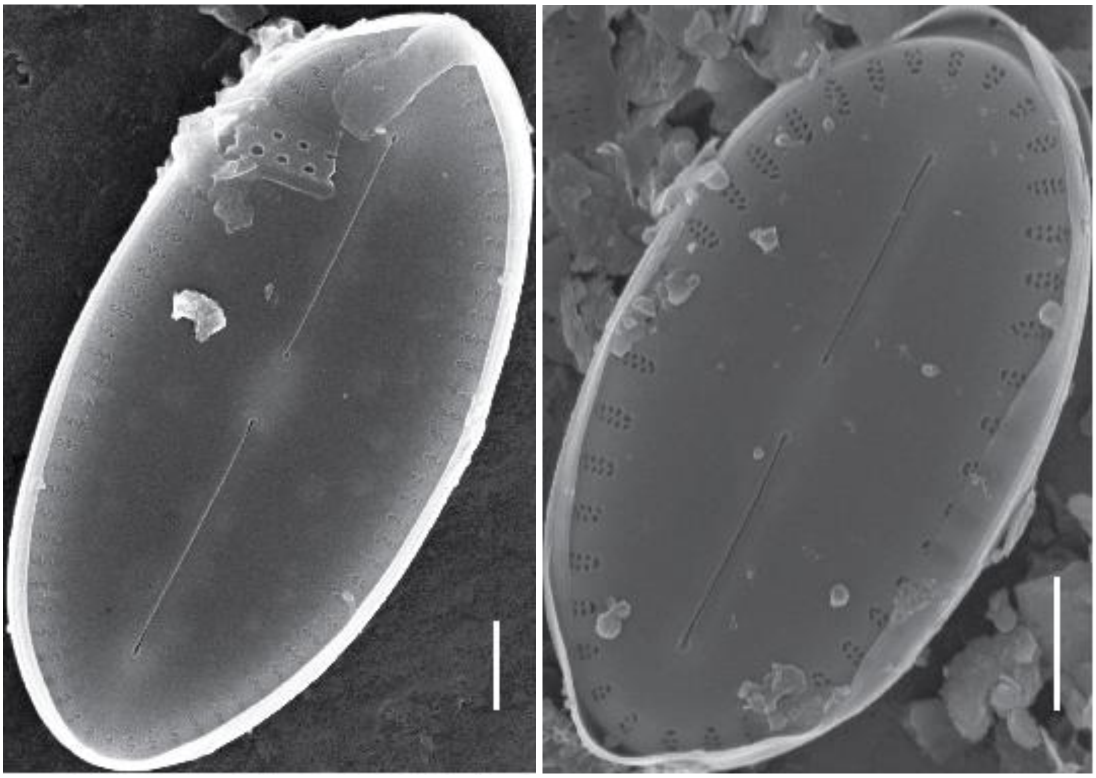
Amicula specululum (Witkowski) Witkowski

Lit.: Witkowski, Lange-Bertalot & Metzeltin 2000, p. 127

Basionym: *Navicula specululum* Witkowski 1994



1 - 14



15 - 16

Plate 165 (Scale bars: Figs 1-8; 12-27; 29-40; 43-47; 48-51=10 µm; Figs 9-11; 28; 41-42; 47; 52=1 µm)

Figs 1-11: *Chamaepinnularia* aff. *begeri*

Figs 12-19: *Chamaepinnularia* sp. 7

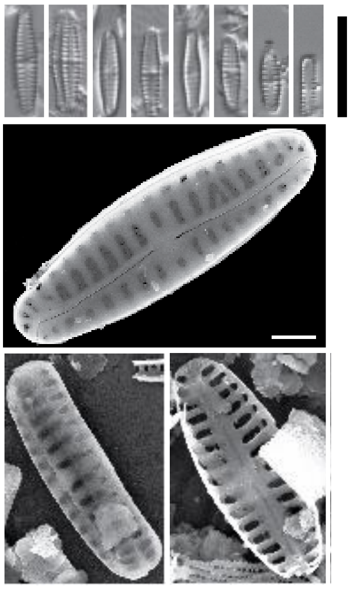
Figs 20-28: *Chamaepinnularia* sp. 12

Figs 29-32: *Chamaepinnularia* sp. 14

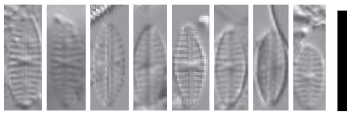
Figs 33-42: *Chamaepinnularia* sp. 8

Figs 43-47: *Chamaepinnularia* sp

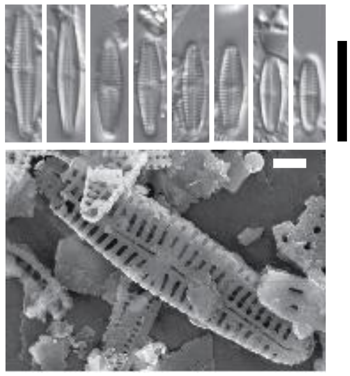
Figs 48-52: *Chamaepinnularia wiktoriae*



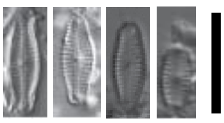
1 - 11



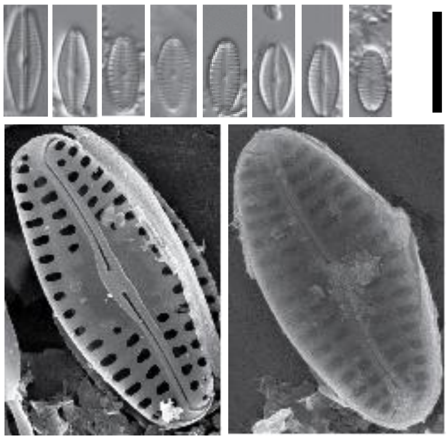
12 - 19



20 - 28



29 - 32



33 - 42

43 - 47

48 - 52

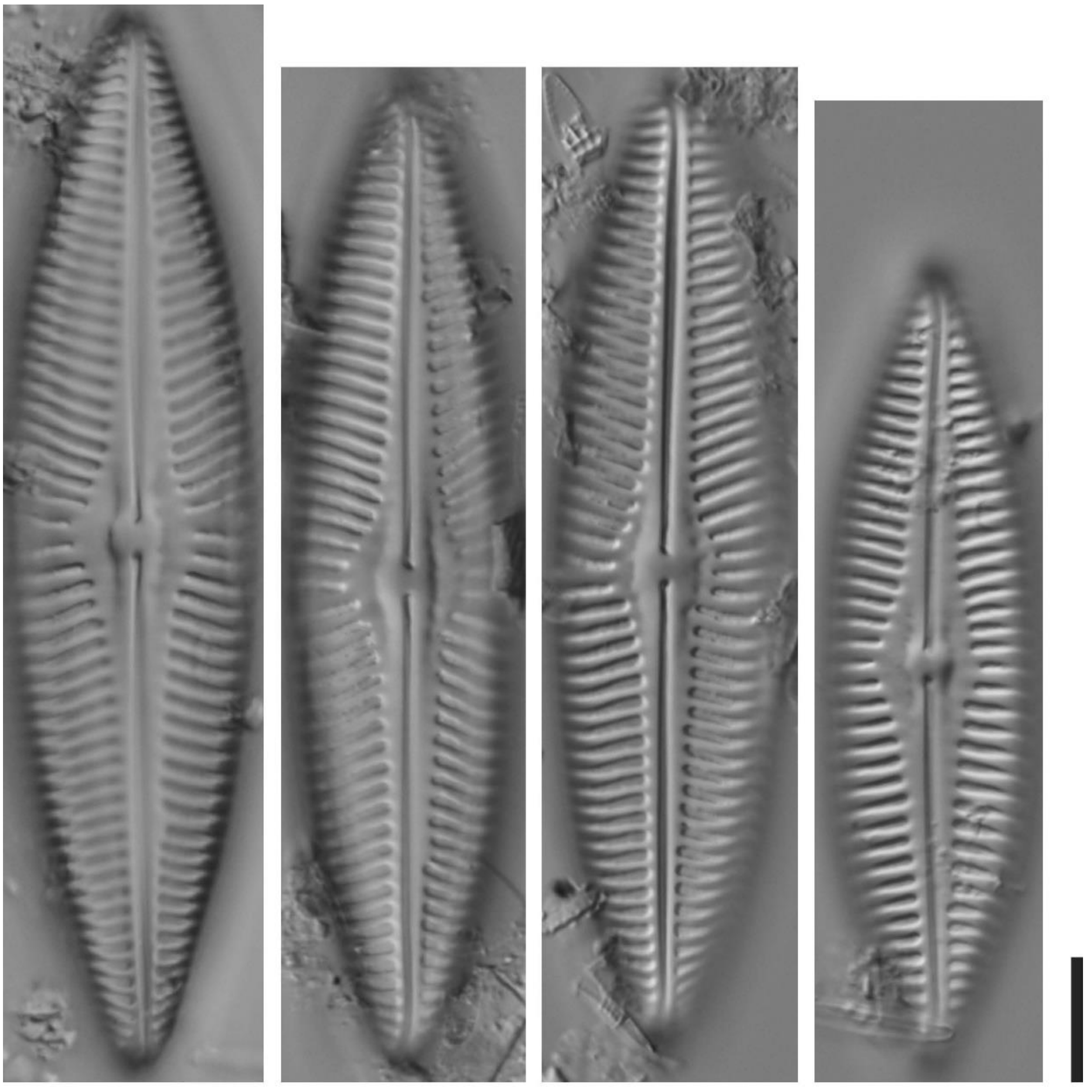
Plate 166 (Scale bar: Figs 1-4=10 µm)

Navicula palpebralis Brébisson

Lit.: Wm. Smith 1853, p. 50; pl. 31, fig. 273; Brockmann 1950, fig 3:14,16; Hendey 1964, p.216, fig.XXXIV: 13-19; Witkowski, Lange-Bertalot, Metzeltin 2000, p.294, pl.139:9, pl.140:1-3.

Synonyms: *Schizonema palpebrale* (Brébisson ex W. Smith) Kuntze 1898

Fig. 1: Sample BBDC0037, Barnegat Bay, NJ.
Fig. 2: Sample BB0002, Barnegat Bay, NJ.
Fig. 3: Sample BBDC0106, Great Bay, NJ.
Fig. 4: Sample BBDC0034, Barnegat Bay, NJ.



1 - 4

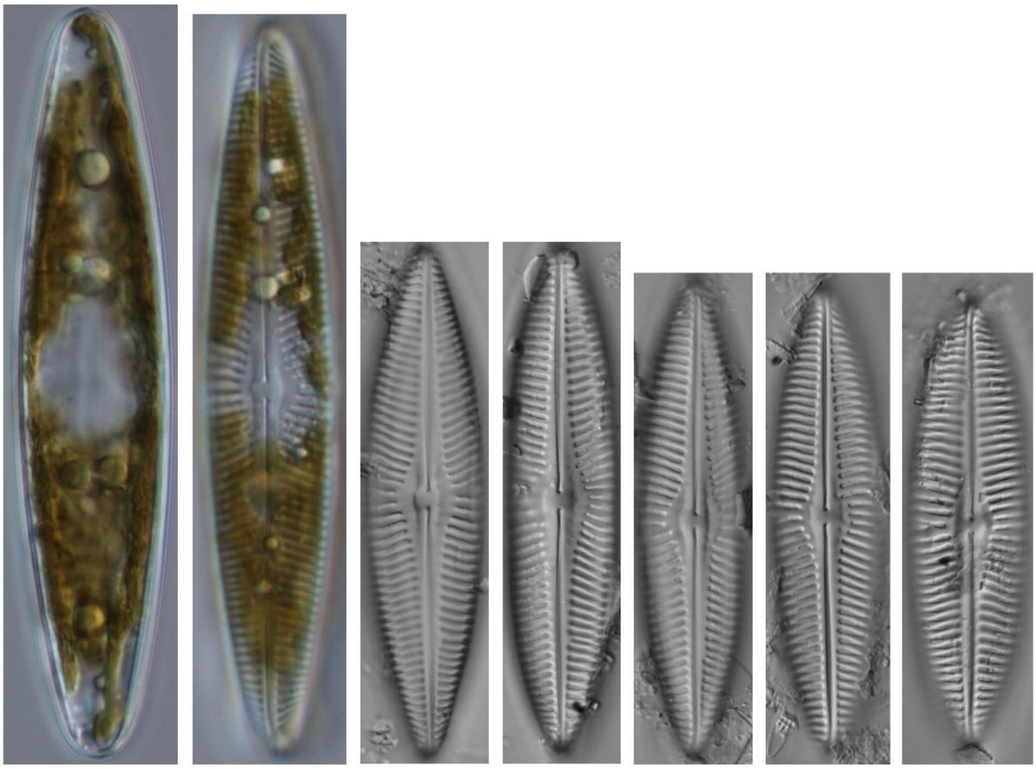
Plate 167 (Scale bar: Figs 1-14=10 µm)

Navicula palpebralis Brébisson

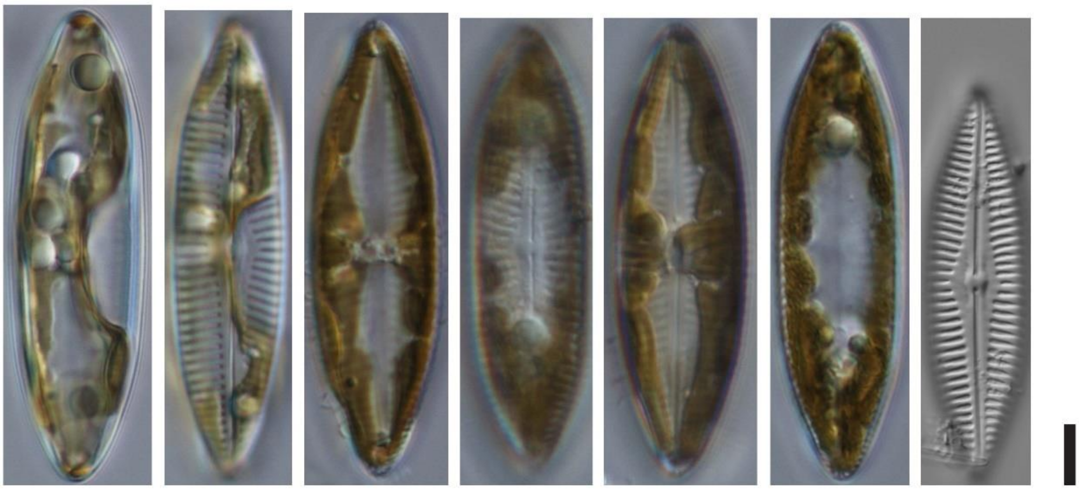
Lit.: Wm. Smith 1853, p. 50; pl. 31, fig. 273; Brockmann 1950, fig 3:14,16; Hendey 1964, p.216, fig.XXXIV: 13-19; Witkowski, Lange-Bertalot, Metzeltin 2000, p.294, pl.139:9, pl.140:1-3.

Synonyms: *Schizonema palpebrale* (Brébisson ex W. Smith) Kuntze 1898

Figs 1-2: Barnegat Bay, NJ.
Fig. 3: Sample BBDC0037, Barnegat Bay, NJ.
Fig. 4: Sample BBDC0022, Barnegat Bay, NJ.
Fig. 5: Sample BB0002, Barnegat Bay, NJ.
Fig. 6: Sample BBDC0106, Great Bay, NJ.
Fig. 7: Sample BBDC0016, Barnegat Bay, NJ.
Figs 8-13: Barnegat Bay, NJ.
Fig. 14: Sample BBDC0034, Barnegat Bay, NJ.



1 - 7



8 - 14

Plate 168 (Scale bar: Figs 1-11=10 µm)

Navicula digitoradiata (Gregory) Ralfs

Lit.: Pritchard 1861, p. 904; Hendey 1964, p.216, fig.XXIX: 8,9.; Hustedt 1930, p.301, fig.518; Krammer & Lange-Bertalot 1986, p. 108, fig.34:1-9; Witkowski, Lange-Bertalot, Metzeltin 2000, p.274, pl.114:1-6

Basionym: *Pinnularia digitoradiata (digito-radiata)* Gregory 1856

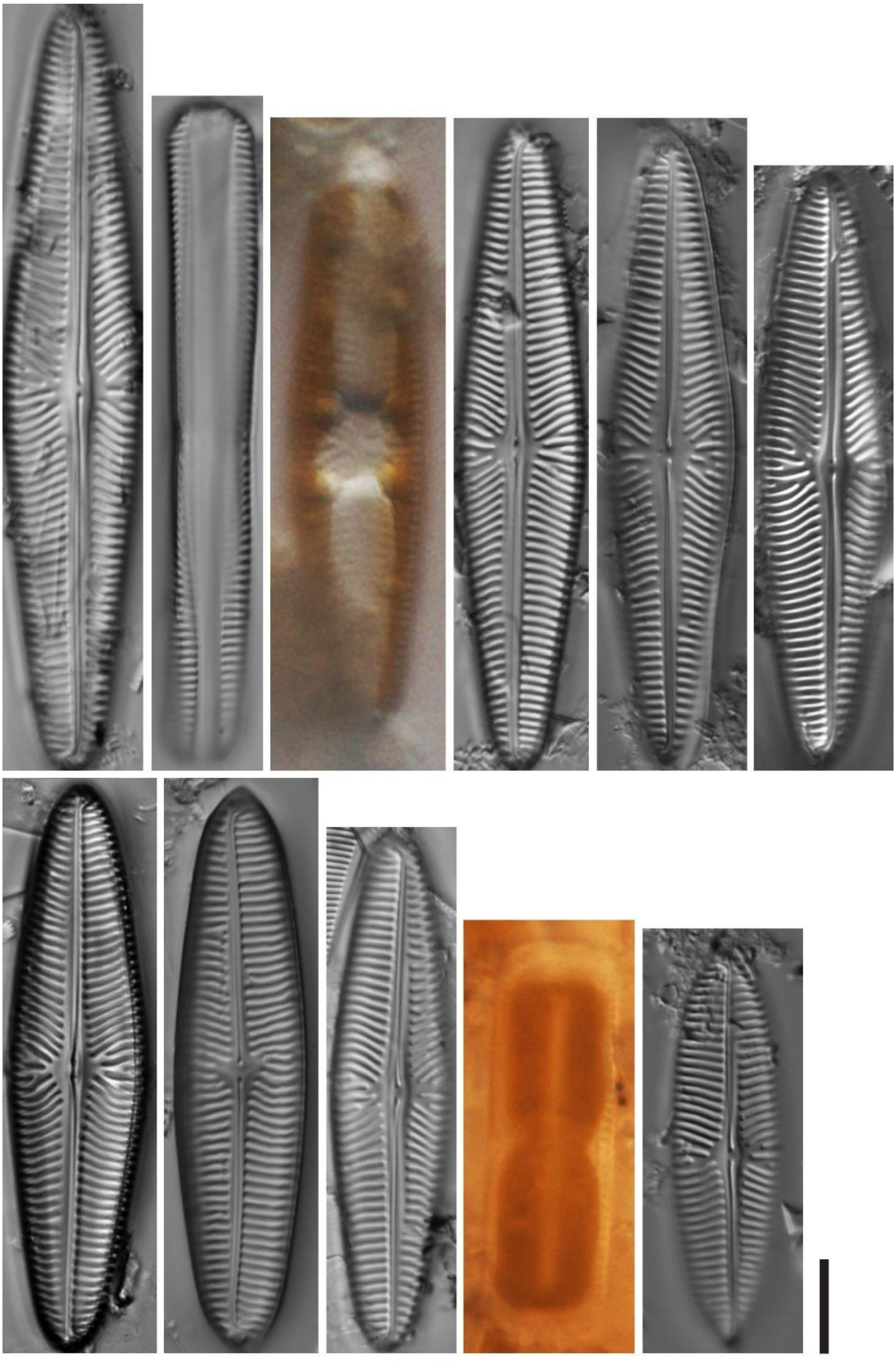
Synonyms:

Navicula cyprinus sensu Boyer 1916, p.95, pl.26, fig.21; Boyer 1927, p.395, non (Ehrenberg) Kützing; Hendey 1951, p.47, pl.9, fig.9

Navicula cyprinus sensu Grunow in Van Heurck (Type de Synopsis 137)

Pinnularia cyprinus sensu W. Smith 1853, p.57, pl.18, fig.176, non Ehrenberg.

Figs 1,4,9: Sample BBDC0007, Barnegat Bay, NJ.
Fig. 2: Sample BBDC0055, Barnegat Bay, NJ.
Fig. 3,10: Barnegat Bay, NJ.
Fig. 5: Sample BBDC0009, Barnegat Bay, NJ.
Fig. 6: Sample BBDC0004, Barnegat Bay, NJ.
Fig. 7: Sample BBDC0001, Barnegat Bay, NJ.
Figs 8, 11: Sample BBDC0058, Barnegat Bay, NJ.



1 - 11

Plate 169 (Scale bar: Figs 1-4=10 μm)

Navicula peregrina (Ehrenberg) Kützing

Lit.: Kützing 1844, p. 97; pl. 28, fig. 52 c; Hendey 1951, p.52, pl.16, fig.5, pl.17, fig.12; Hendey 1964 pl. XXX, figs 12,13; Krammer & Lange-Bertalot 1986, p. 100, fig.30:1; Witkowski, Lange-Bertalot, Metzeltin 2000, p.297, pl.111:1-4.

Basionym: *Pinnularia peregrina* Ehrenberg 1843

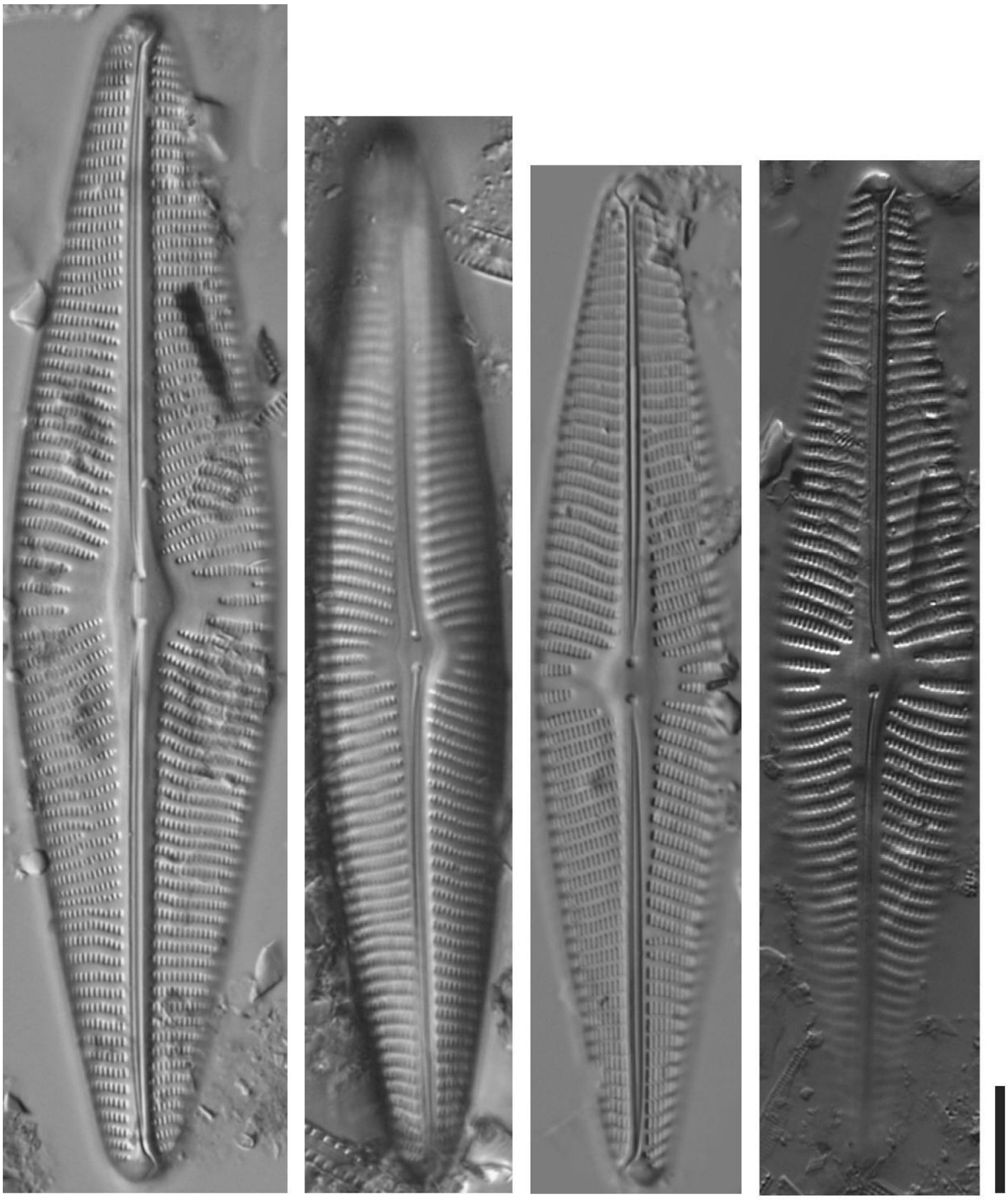
Synonyms: *Schizonema peregrinum* (Ehrenberg) Kuntze 1898

Fig. 1: Sample RUTG0080, Cape May Courthouse, NJ.

Fig. 2: Sample BB0036, Barnegat Bay, NJ.

Fig. 3: Sample RUTG0461, Cape May Courthouse, NJ.

Fig. 4: Sample BBDC0005, Barnegat Bay, NJ.



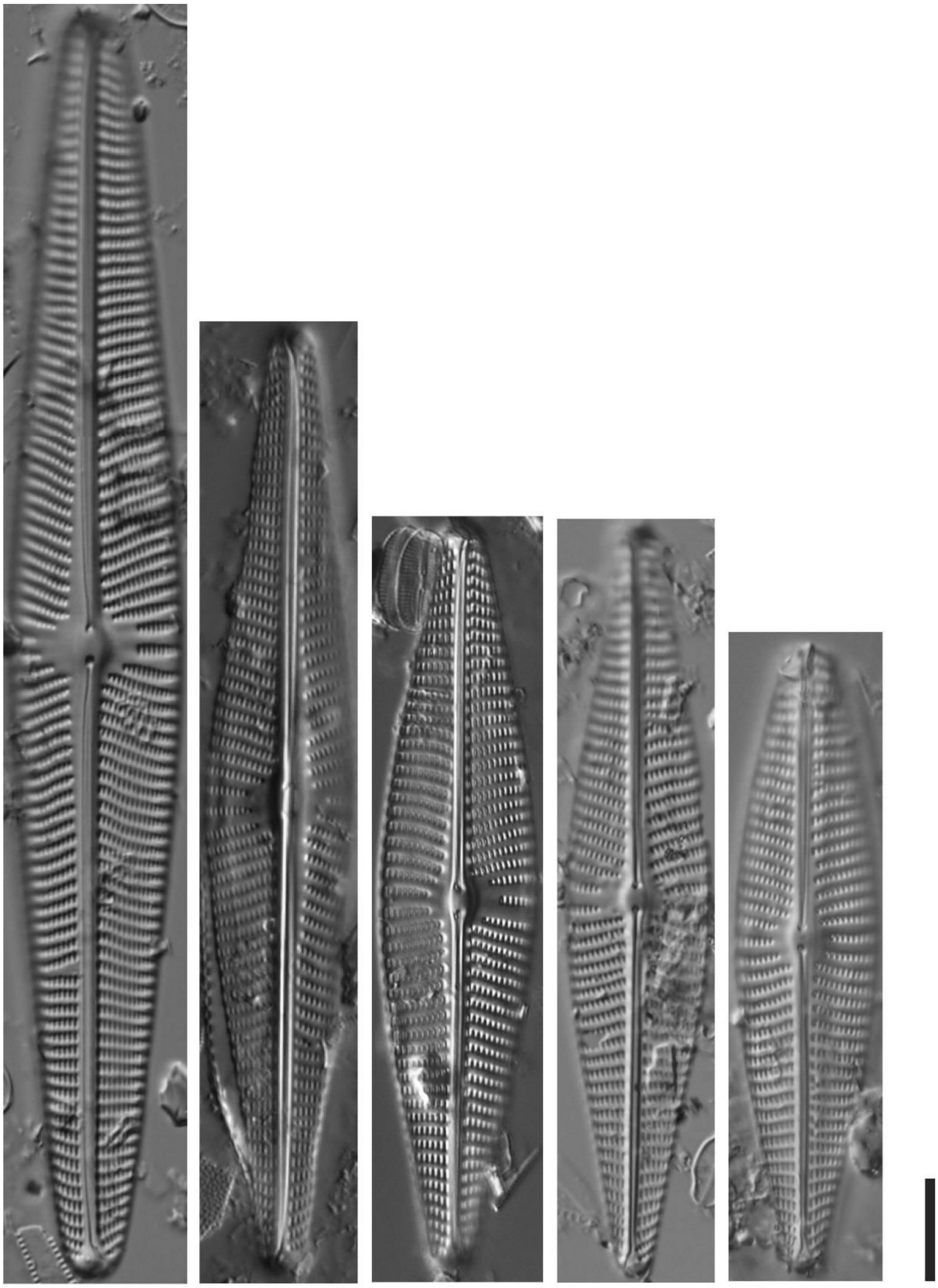
1 - 4

Plate 170 (Scale bar: Figs 1-5=10 µm)

Navicula peregrinopsis Lange-Bertalot & Witkowski

Lit: Witkowski, Metzeltin & Lange-Bertalot 2000, p. 297, 435; pl. 112, fig. 5-7

Figs 1,4: Sample BBDC0007, Barnegat Bay, NJ.
Fig. 2: Sample BBDC0008, Barnegat Bay, NJ.
Fig. 3: Sample BBDC0004, Barnegat Bay, NJ.
Fig. 5: Sample BB0059, Barnegat Bay, NJ.



1 - 5

Plate 171 (Scale bar: Figs 1-5=10 µm)

Navicula kefvingensis (Ehrenberg) Kützing

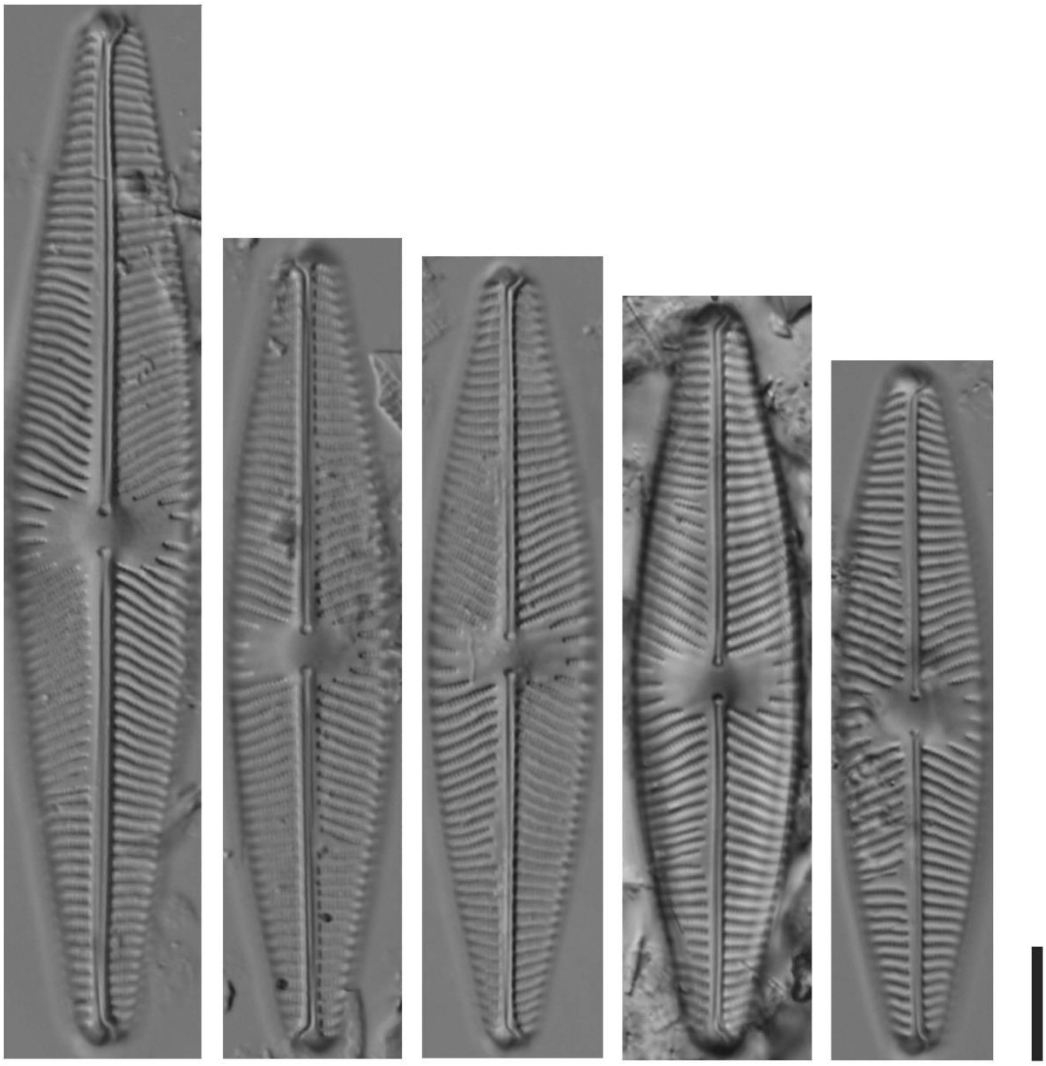
Lit.: Kützing 1844, p. 97; Lange-Bertalot 1993, p.117, figs 65:4,5; Witkowski, Metzeltin & Lange-Bertalot 2000, p. 286; pl. 117, fig. 1-6.

Basionym: *Pinnularia kefvingensis* Ehrenberg 1840

Synonyms: *Navicula peregrina* var. *kefvingensis* (Ehrenberg) Cleve 1895

Figs 1-3,5: Sample RUTG0461, Cape May Courthouse, NJ.

Fig. 4: Sample RUTG0340, Cheesequake State Park, NJ.



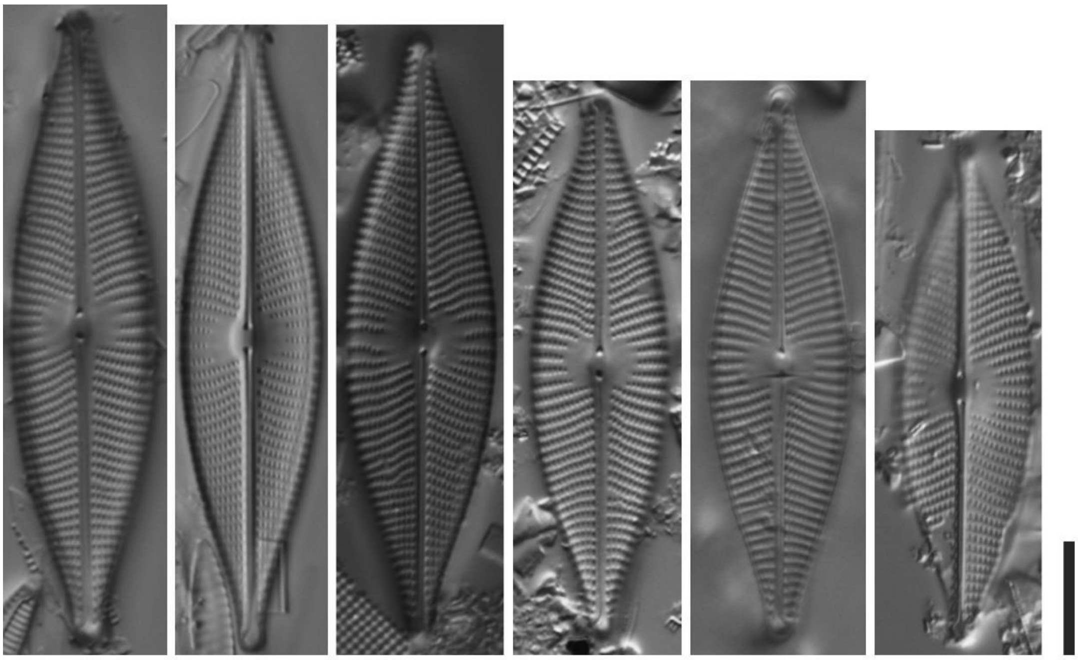
1 - 5

Plate 172 (Scale bars: Figs 1-6=10 µm; Fig 7-9=1 µm)

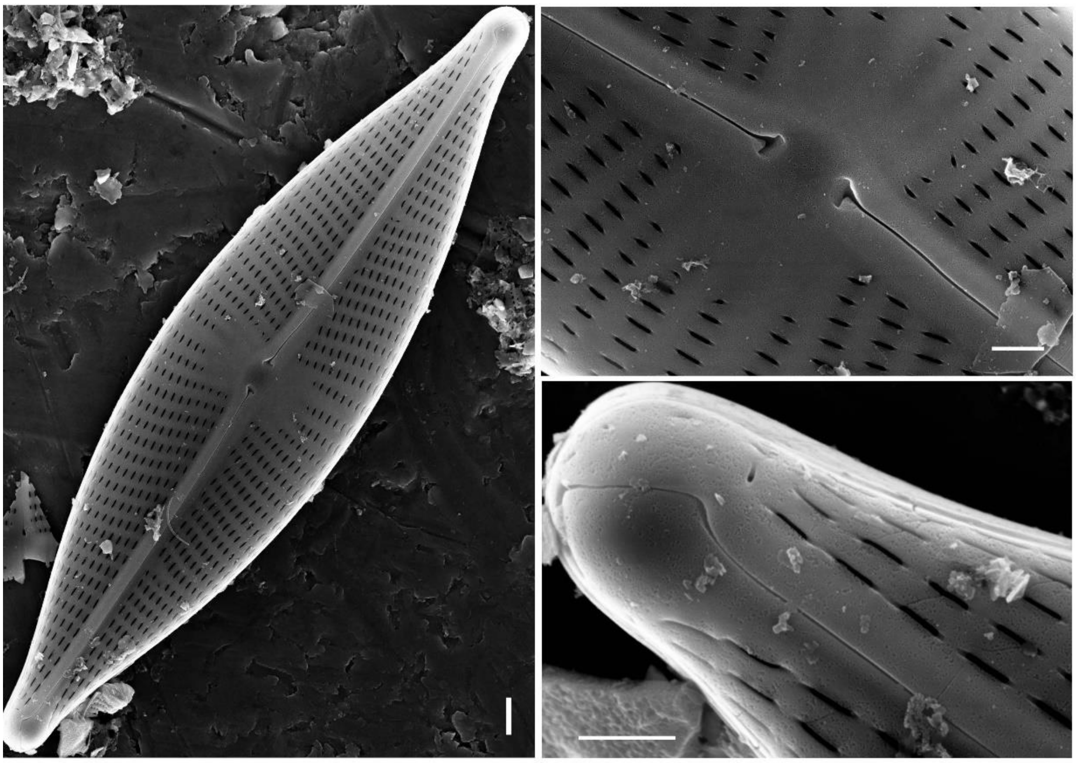
Navicula hanseatica Lange-Bertalot & Stachura

Lit.: Witkowski, Lange-Bertalot & Stachura 1998, p. 87-88; fig. 23-27; Witkowski, Metzeltin & Lange-Bertalot 2000, p. 282; pl. 120, figs 7-10.

Figs 1-2: Sample RUTG0860, Pilot Drive, NJ.
Figs 3-5: Sample BB0001, Barnegat Bay, NJ.
Fig. 6: Sample BB0002, Barnegat Bay, NJ.
Figs 7-9: Sample RUTG0001, Cape May Courthouse, NJ.



1 - 6



7 - 9

Plate 173 (Scale bar: Figs 1-20=10 µm)

Figs 1-12: ***Navicula sieminskiae*** Lange-Bertalot & Witkowski

Lit.: Lange-Bertalot 2001, p. 67, 228; pl. 15, fig. 8-13; Witkowski, Metzeltin & Lange-Bertalot 2000, p. 305; pl. 119:7-12.

Synonyms: *Navicula meniscus* auct. partim non Schumann.

Figs 1,9: Sample RUTG0860, Pilot Drive, NJ.
Fig. 2: Sample BBDC0007, Barnegat Bay, NJ.
Figs 3,11: Sample RUTG0843, Leeds Point, NJ.
Fig. 4: Sample BBDC0009, Barnegat Bay, NJ.
Fig. 5: Sample RUTG0857, Pilot Drive, NJ.
Figs 6-7: Sample RUTG0822, Cape May Courthouse, NJ.
Fig. 8: Sample BB0011, Barnegat Bay, NJ.
Fig. 10: Sample RUTG0816, Cape May Courthouse, NJ.
Fig. 12: Sample BB002, Barnegat Bay, NJ.

Figs 13-15: ***Navicula vaneeii*** Lange-Bertalot

Lit.: Witkowski, Lange-Bertalot & Stachura 1998, p. 89; fig. 28-32; Witkowski, Metzeltin & Lange-Bertalot 2000, p. 313; pl. 111:6-10.

Fig. 13: Sample BBDC0002, Barnegat Bay, NJ.
Fig. 14: Sample BB0054, Barnegat Bay, NJ.
Fig. 15: Sample BB0007, Barnegat Bay, NJ.

Figs 16-18: ***Navicula lindae*** Sullivan & Reimer

Lit.: Sullivan & Reimer 1975, v. 17: p. 119; pl. 1 & 2, fig. 2

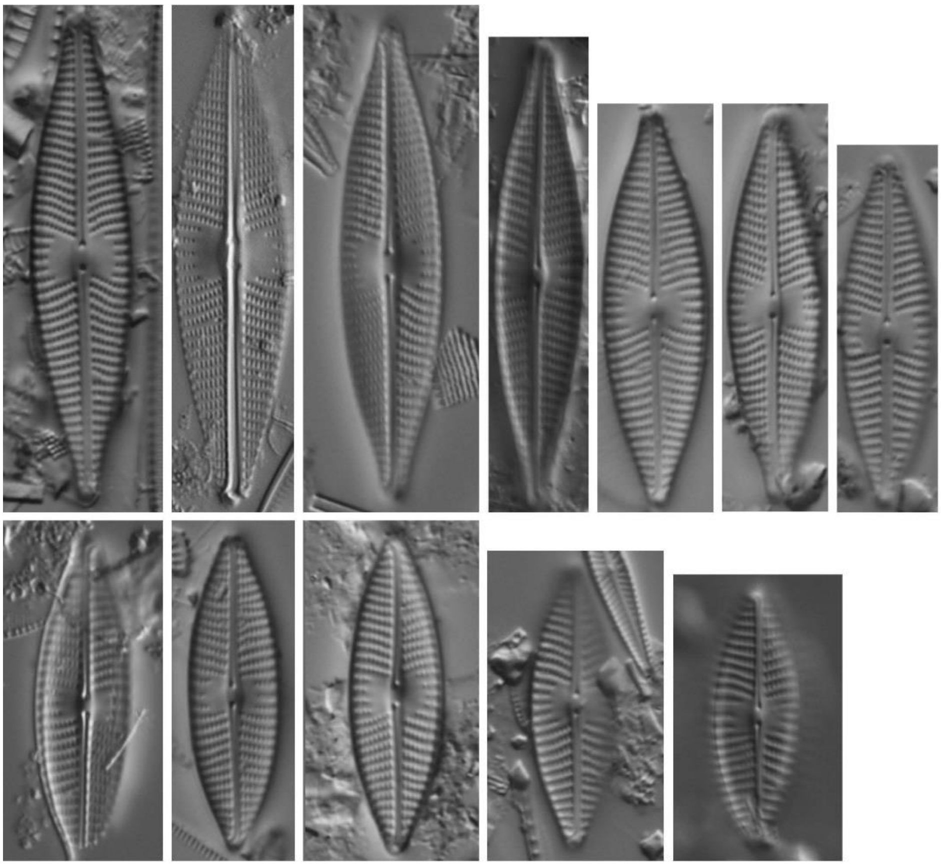
Fig. 16: Sample BBDC0072, Barnegat Bay, NJ.
Fig. 17: Sample BBDC0064, Barnegat Bay, NJ.
Fig. 18: Sample BB0073, Barnegat Bay, NJ.

Fig. 19: ***Navicula* cf. *valida* var. *minuta***

Fig. 19: Sample COAST013, Great South Bay, NY.

Fig. 20: ***Navicula* sp. 104**

Fig. 20: Sample COAST003, Peconic Bay, NY.



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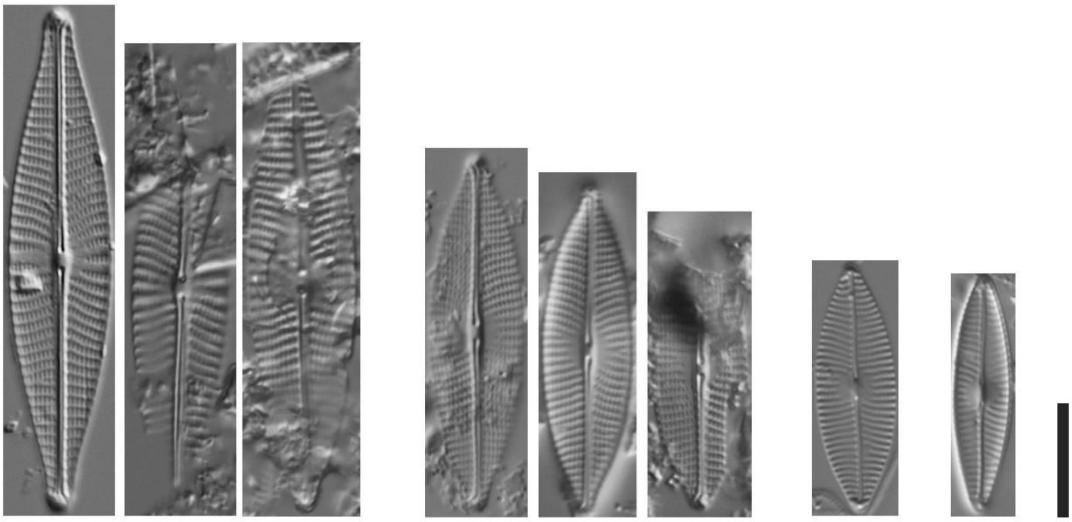
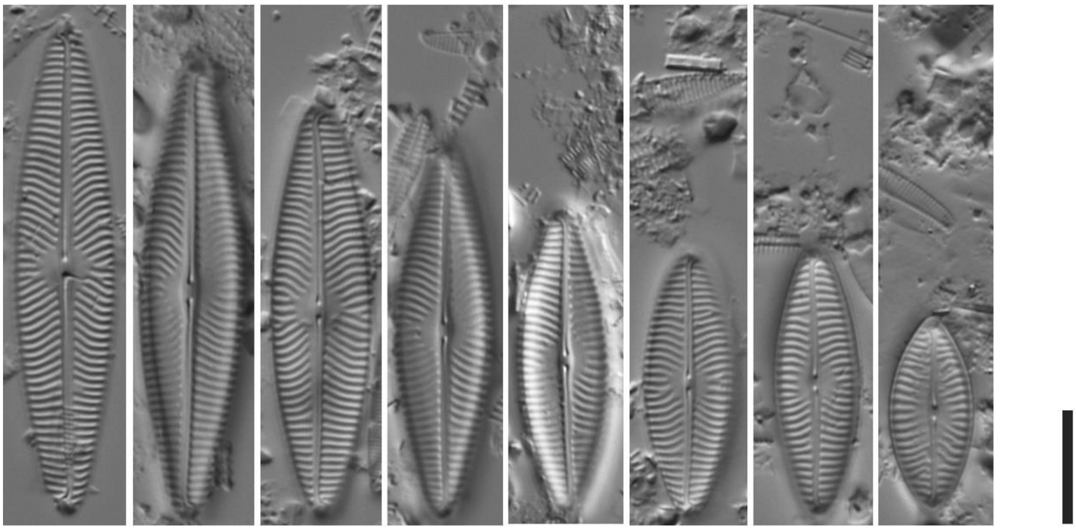


13 - 15 16 - 18 19 20

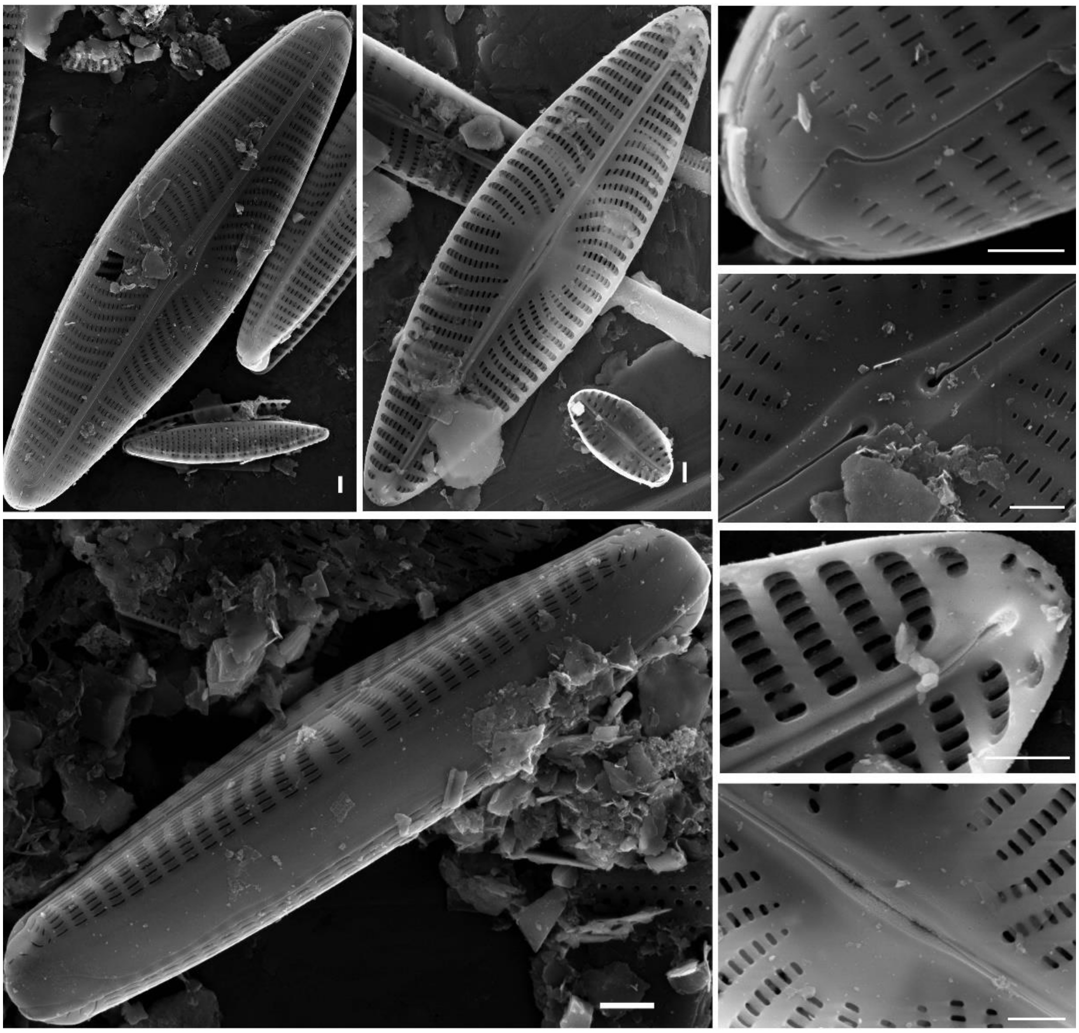
Plate 174 (Scale bars: Figs 1-8=10 μm; Figs 9-15=1 μm)

Navicula sp. 52

Fig. 1: Sample RUTG0027, Cape May Courthouse, NJ.
Figs 2-8: Sample RUTG0003, Cape May Courthouse, NJ.
Figs 9-15: Sample RUTG0001, Cape May Courthouse, NJ.



1 - 8



9 - 15

Plate 175 (Scale bar: Figs 1-26=10 µm)

Figs 1-9: ***Navicula digitoconvergens*** Lange-Bertalot

Lit.: Lange-Bertalot & Genkal 1999, p. 64 [ed. 2: 65]; pl. 15, figs. 1-9; pl. 16, figs. 4, 5; Witkowski, Metzeltin & Lange-Bertalot 2000, p.274; pl.114:7-14.

Synonyms:

Navicula digitoradiata auct. partim non (Gregory) Ralfs.

(?) *Navicula digitoradiata* var. *elliptica* auct. non Hustedt 1911

(?) *Navicula digitoradiata* fo. *minor* Foged 1953 non Cleve-Euler 1934

Fig. 1: Sample BB0049, Barnegat Bay, NJ.
Fig. 2: Sample BB0006, Barnegat Bay, NJ.
Fig. 3: Sample BBDC0062, Barnegat Bay, NJ.
Figs 4,6-7: Sample RUTG0080, Cape May Courthouse, NJ.
Fig. 5: Sample RUTG0027, Cape May Courthouse, NJ.
Fig. 8: Sample RUTG0150, Cape May Courthouse, NJ.
Fig. 9: Sample RUTG0210, Cape May Courthouse, NJ.

Figs 10-18: ***Navicula* cf. *digitoconvergens***

Figs 10,13: Sample RUTG0210, Cape May Courthouse, NJ.
Figs 11-12,14-15: Sample RUTG0150, Cape May Courthouse, NJ.
Fig. 16: Sample RUTG0190, Cape May Courthouse, NJ.
Fig. 17: Sample RUTG0159, Cape May Courthouse, NJ.
Fig. 18: Sample RUTG0070, Cape May Courthouse, NJ.

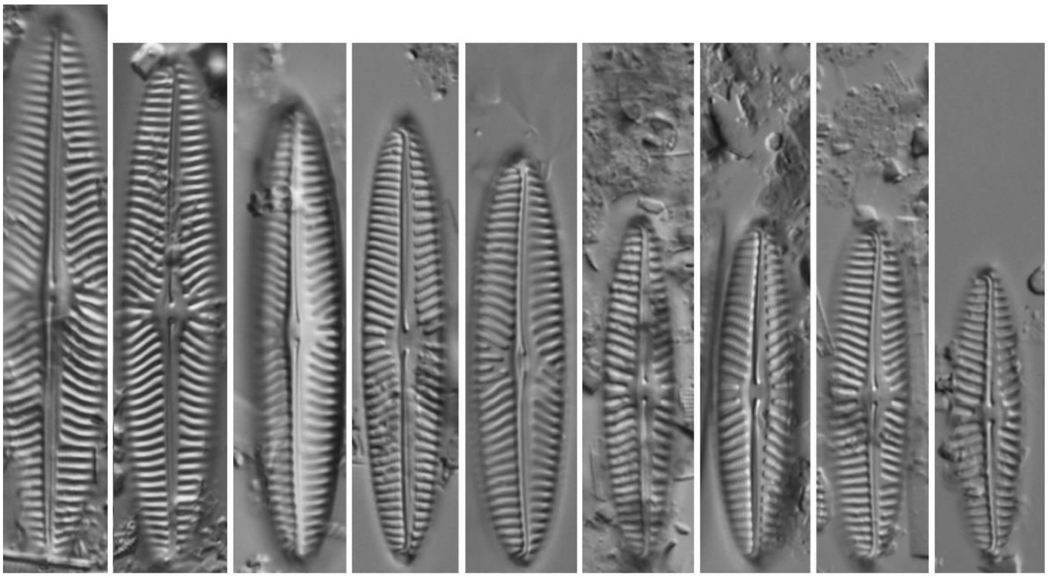
Figs 19-21: ***Navicula normalis*** Hustedt

Lit.: Hustedt 1955, p. 29; pl. 9, fig. 3; Simonsen 1987, p.414, fig.617:14; Witkowski, Metzeltin & Lange-Bertalot 2000, p.292; pl.121:15, pl.145:30.

Fig. 19: Sample RUTG0860, Pilot Drive, NJ.
Fig. 20: Sample BBDC0045, Barnegat Bay, NJ.
Fig. 21: Sample BBDC0003, Barnegat Bay, NJ.

Figs 22-26: ***Navicula* cf. *normalis***

Figs 22-26: Sample RUTG0027, Cape May Courthouse, NJ.



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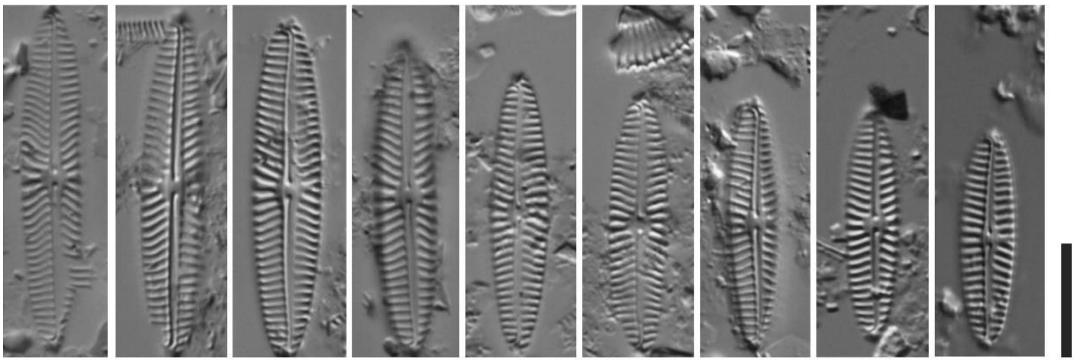
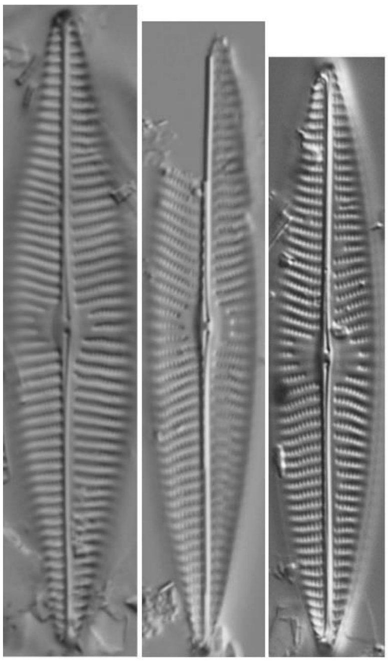
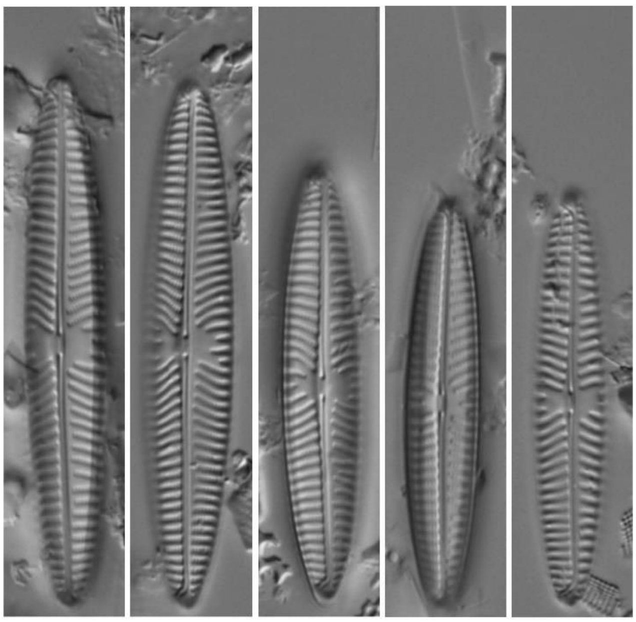


10 - 18



19 - 21



22 - 26

Plate 176 (Scale bars: Figs 1-24=10 µm; Fig. 25=1 µm)

Figs 1-10: ***Navicula microdigitoradiata*** Lange-Bertalot

Lit.: Lange-Bertalot 1993, p. 122-123; pl. 58, fig. 9-15, Bacill. 2/4, fig. 59: 23-24; Krammer & Lange-Bertalot 1986, pl.28, fig. 16; Krammer & Lange-Bertalot 1991, pl.59, figs 23,24; Witkowski, Metzeltin & Lange-Bertalot 2000, p.290; pl.126:1-7.

Synonyms:

Navicula cincta f. *minuta* Van Heurck

Navicula digitoradiata var. *minor* Krasske (partim)

Fig. 1,8,11: Sample BB0049, Barnegat Bay, NJ.

Fig. 2: Sample BB0072, Barnegat Bay, NJ.

Figs 3-7,9-10,12-13: Sample RUTG0029, Cape May Courthouse, NJ.

Figs 14-25: ***Navicula cincta*** (Ehrenberg) Ralfs

Lit.: Pritchard 1861, p. 901

Synonyms:

Pinnularia cincta Ehrenberg 1854

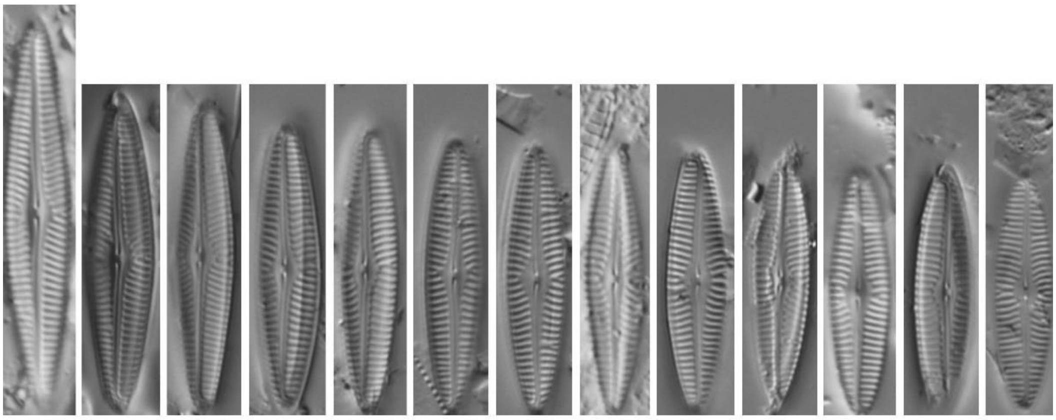
Schizonema cinctum (Ehrenberg) Kuntze 1898

Figs 13-21,23: Sample BBDC0052, Barnegat Bay, NJ.

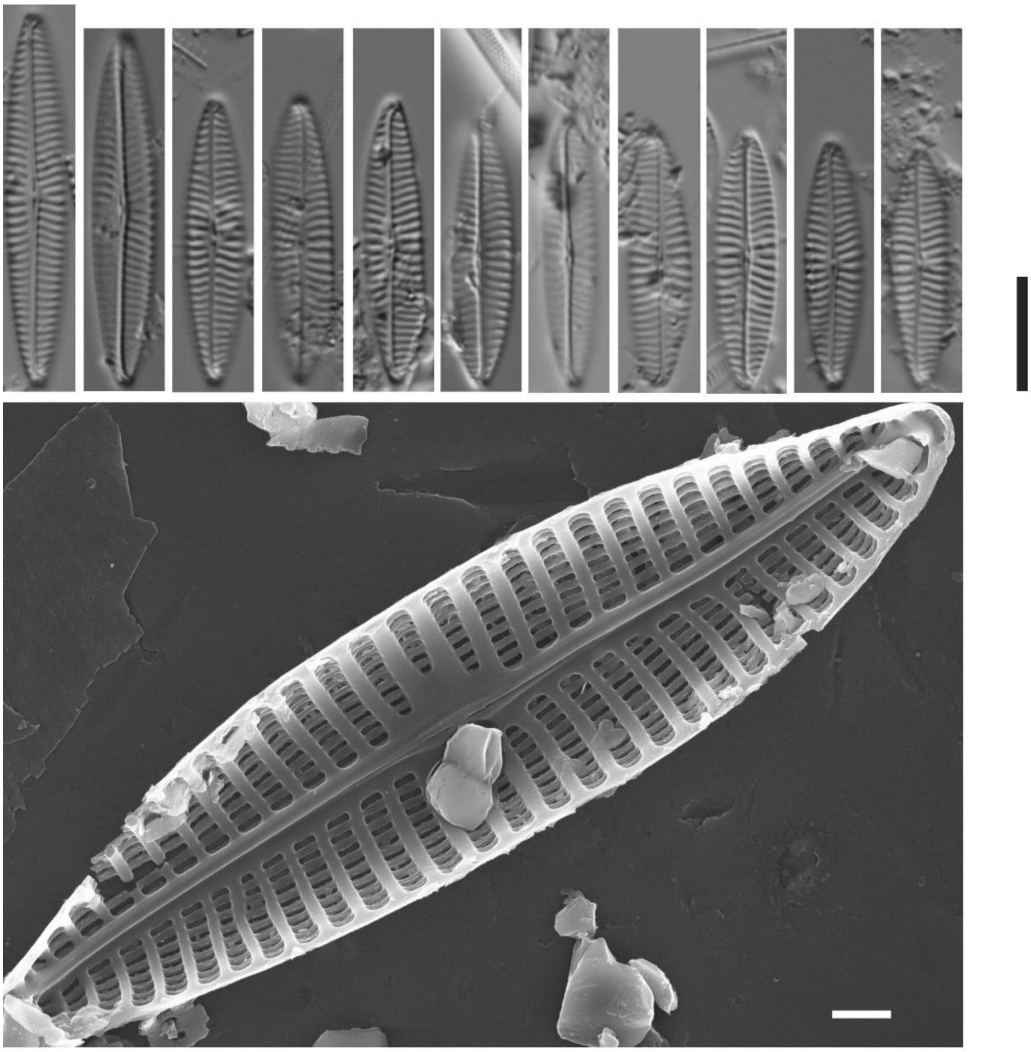
Fig. 22: Sample BBDC0084, Barnegat Bay, NJ.

Fig. 24: Sample BBDC0071, Barnegat Bay, NJ.

Fig. 25: Sample BBDC0045, Barnegat Bay, NJ.



1 - 13



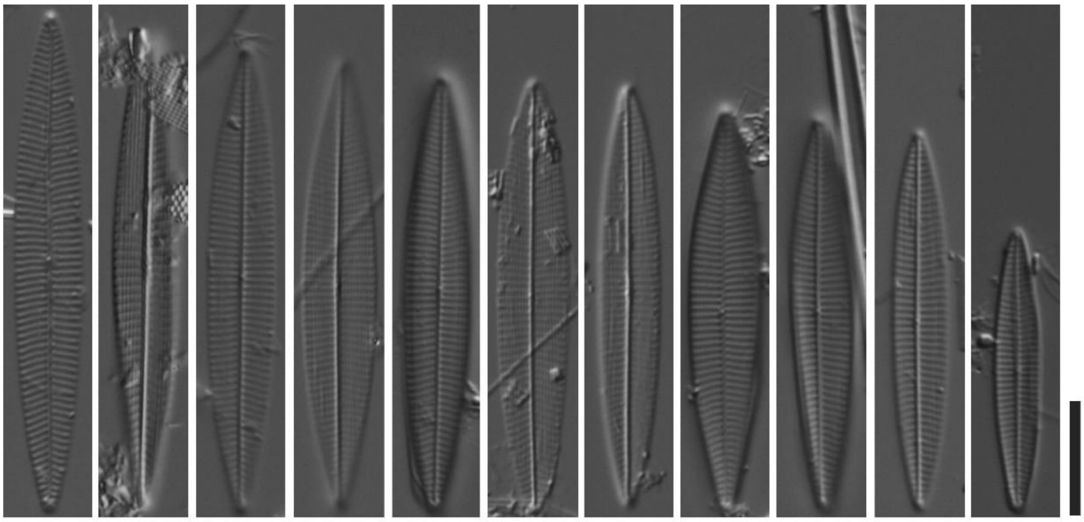
14 - 25

Plate 177 (Scale bars: Figs 1-11=10 μm; Figs 12-14=1 μm)

Navicula halinae Witkowski, Lange-Bertalot & Metzeltin

Lit.: Witkowski, Lange-Bertalot & Metzeltin 2000, p. 281, 432; pl. 130, fig. 1-4

Figs 1, 3-11: Sample RUTG0790, Tuckerton Bay,
NJ. Fig. 2: Sample BBDC0091, Barnegat Bay, NJ.
Figs 12-14: Sample BBDC0080, Barnegat Bay, NJ.



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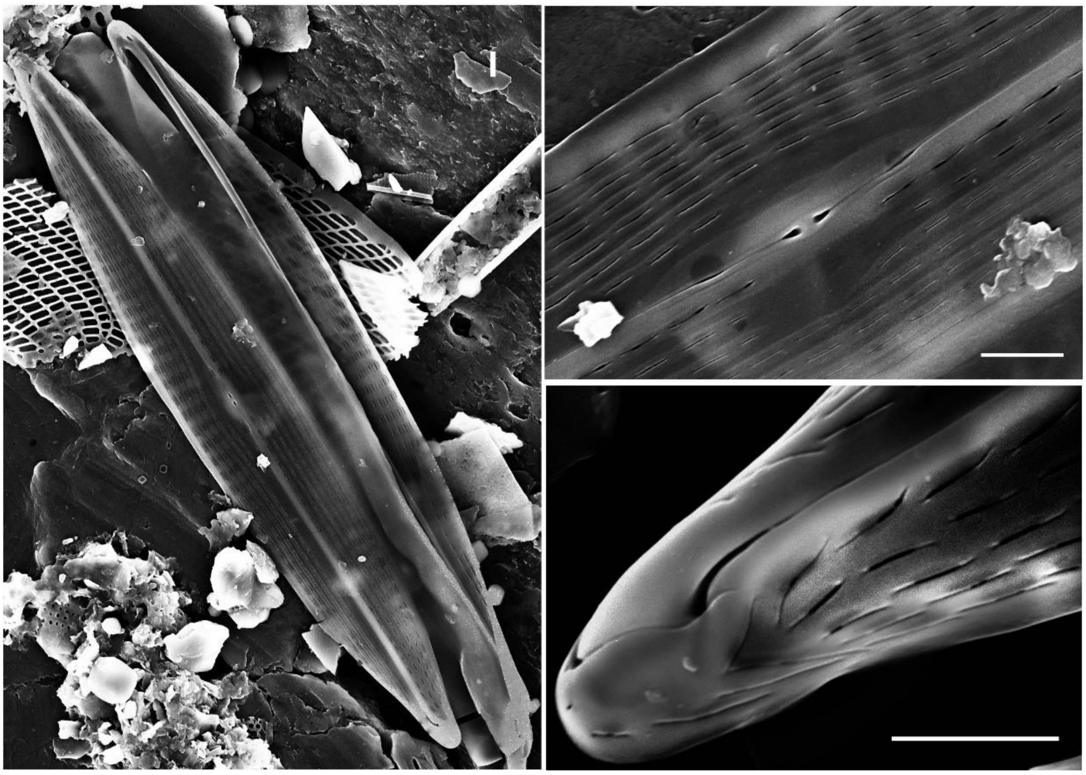


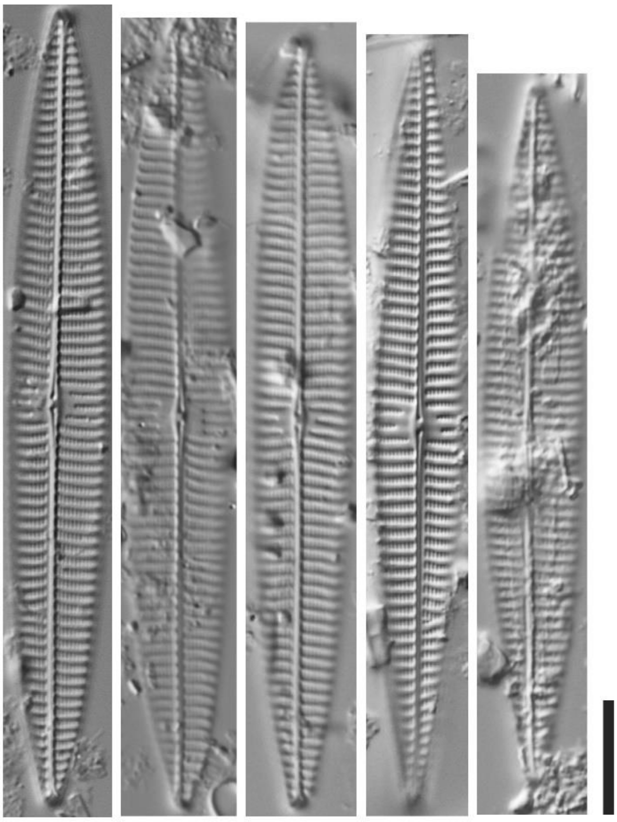
12 - 14

Plate 178 (Scale bar: Figs 1-5=10 µm; Figs 6-8=1 µm)

Navicula directa (Smith) Ralfs

Lit.: Pritchard 1861, p. 906

Figs 1,3: Sample BBDC0002, Barnegat Bay, NJ.
Fig. 2,5: Sample BBDC0044, Barnegat Bay, NJ.
Fig. 4: Sample BBDC0009, Barnegat Bay, NJ.
Figs 6-8: Sample BBDC0080, Barnegat Bay, NJ.



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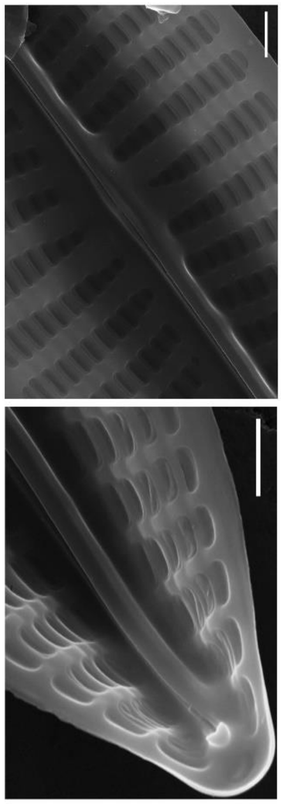
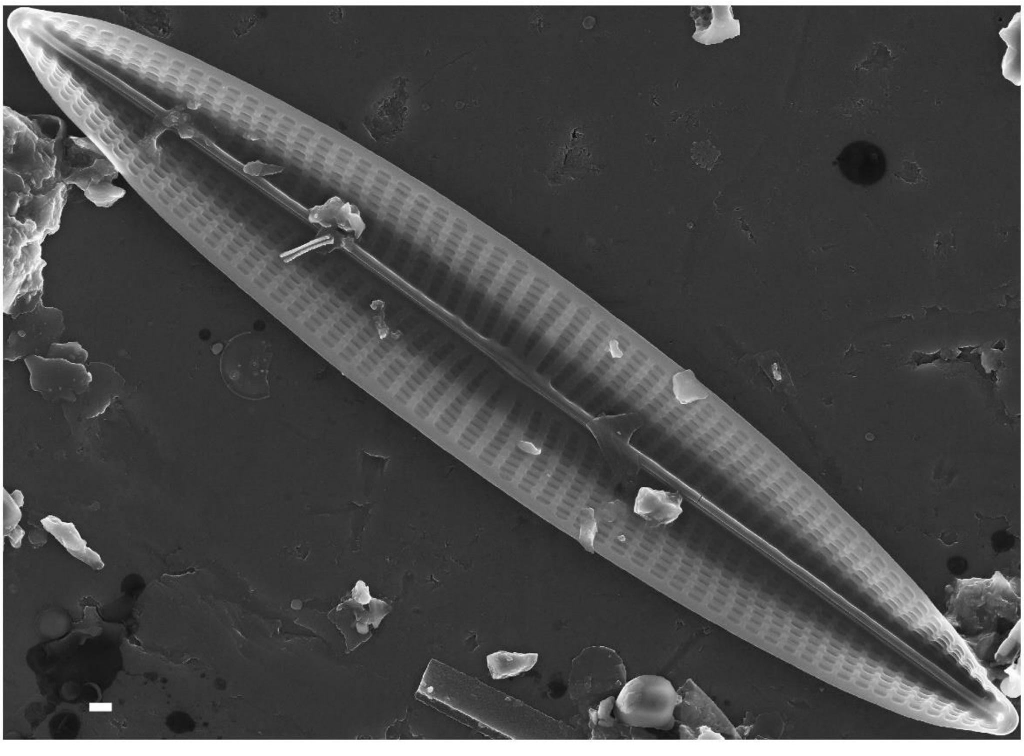


6 - 7



8

Plate 179 (Scale bars: Figs 1-14=10 µm; Figs 15-20=1 µm)

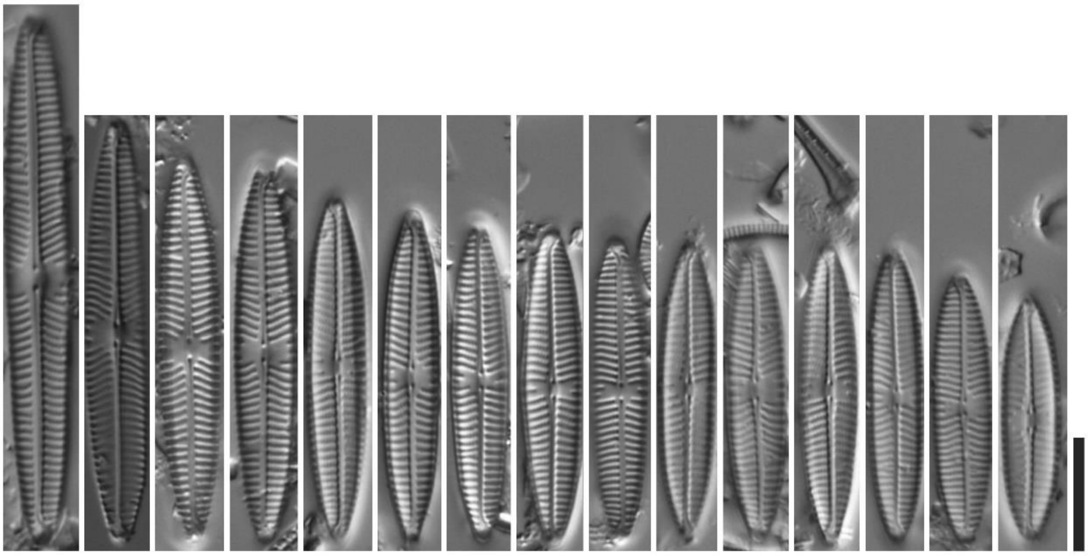
Navicula antverpiensis Van De Vijver & Lange-Bertalot

Lit.: Van De Vijver & Lange-Bertalot 2009, p. 416; fig. 1-17

Fig. 1: Sample RUTG0860, Pilot Drive, NJ.

Fig. 2: Sample BB0066, Barnegat Bay, NJ.

Figs 3-20: Sample RUTG0001, Cape May Courthouse, NJ.



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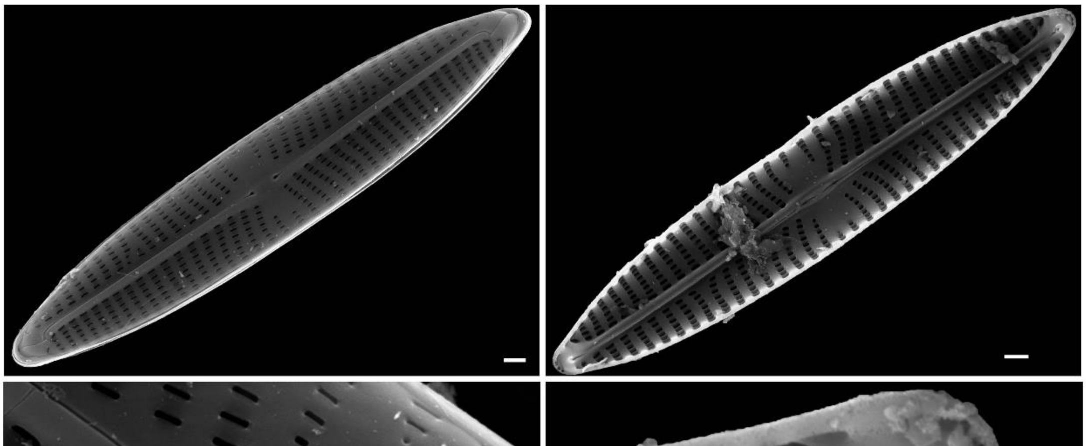


15 - 20

Plate 180 (Scale bar: Figs 1-18=10 µm)

Figs 1-8: ***Navicula* cf. *geronimensis***

Figs 1-4: Sample RUTG0210, Cape May Courthouse, NJ.
Figs 5-8: Sample RUTG0027, Cape May Courthouse, NJ.

Figs 9-12: ***Navicula agnita*** Hustedt

Lit.: Hustedt 1955, p. 27; pl. 9, fig. 13-16

Fig. 1: Sample BBDC0012, Barnegat Bay, NJ.
Fig. 2: Sample BBDC0056, Barnegat Bay, NJ.
Fig. 3: Sample BB0049, Barnegat Bay, NJ.
Fig. 4: Sample BBDC0064, Barnegat Bay, NJ.

Figs 13-14: ***Navicula* cf. *directa***

Fig. 13: Sample BBDC0001, Barnegat Bay, NJ.
Fig. 14: Sample GB023, Great Bay, NJ.

Figs 15-16: ***Navicula* sp. 62**

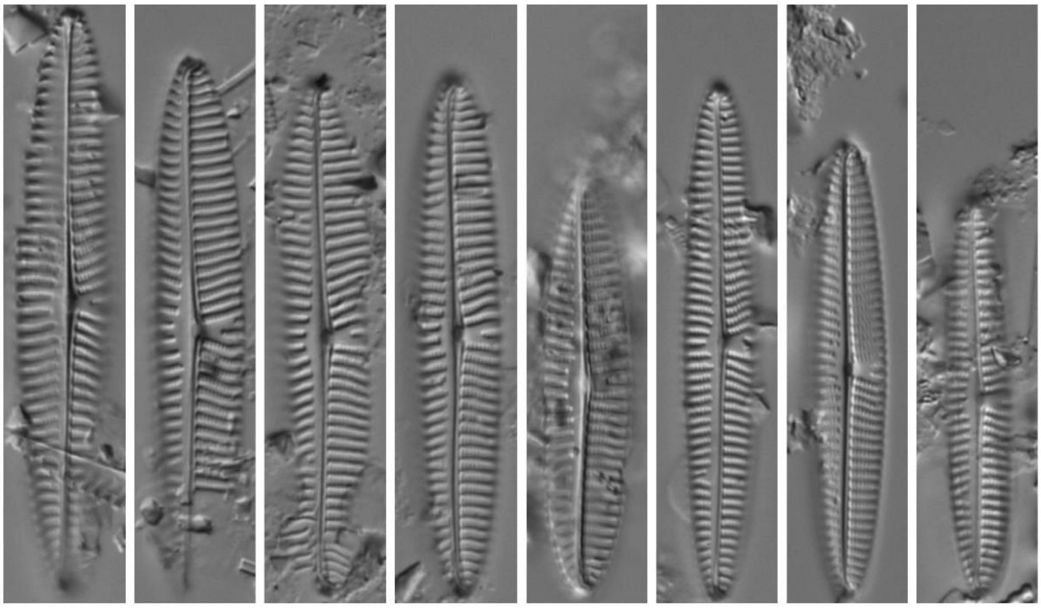
Figs 15-16: Sample BB0001, Barnegat Bay, NJ.

Fig. 17: ***Navicula* sp. 27**

Fig. 17: Sample BBDC0053, Barnegat Bay, NJ.

Fig. 18: ***Navicula* cf. *agnita***

Fig. 18: Sample BBDC0053, Barnegat Bay, NJ.



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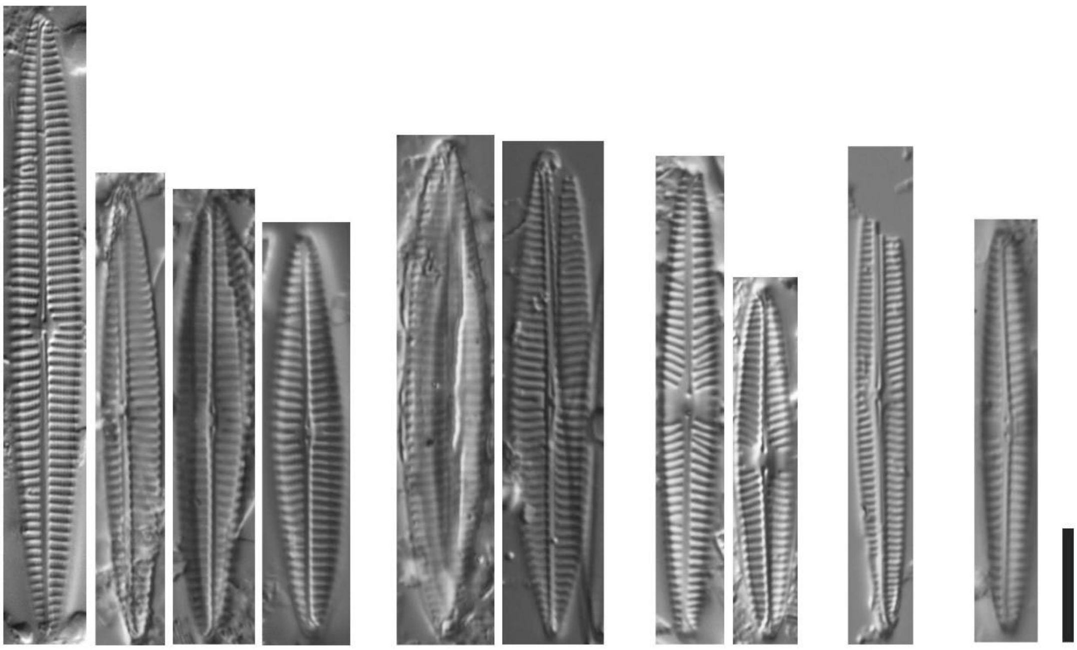


9 - 12 13 - 14 15 - 16 17 18

Plate 181 (Scale bar: Figs 1-7, Figs 9-23=10 μm; Fig. 8=1 μm)

Figs 1-7: ***Navicula salinarum*** Grunow

Lit.: Grunow 1880, p. 33; pl. 2, fig. 34

Figs 1-2: Sample BBDC0071, Barnegat Bay, NJ.
Fig. 3: Sample BBEDC048, Tuckerton Bay, NJ.
Fig. 4: Sample GB001, Great Bay, NJ.
Figs 5-6: Sample BBDC0046, Barnegat Bay, NJ.
Fig. 7: Sample BBDC0016, Barnegat Bay, NJ.
Fig. 8: Sample RUTG0814, Cape May Courthouse, NJ.

Figs 9-13: ***Navicula salinarum* var. *minima*** Kolbe

Lit.: Kolbe 1927, p. 74; pl. 1, fig. 16

Fig. 9: Sample BBEDC058, Cattus Island, NJ.
Fig. 10: Sample BBDC0008, Barnegat Bay, NJ.
Fig. 11: Sample BBEDC098, Cattus Island, NJ.
Figs 12-13: Sample BBDC0001, Barnegat Bay, NJ.

Figs 14-23: ***Navicula salinarum* var. *rostrata*** (Hustedt) Lange-Bertalot

Lit.: Lange-Bertalot 2001, p. 65

Figs 14: Sample BBEDC079, Cattus Island, NJ.
Fig. 15: Sample BB0059, Barnegat Bay, NJ.
Figs 16-18: Sample BBEDC079, Cattus Island, NJ.
Figs 19-20: Sample BBDC0016, Barnegat Bay, NJ.
Fig. 21: Sample BBEDC058, Cattus Island, NJ.
Fig. 22: Sample BBDC0005, Barnegat Bay, NJ.
Fig. 23: Sample BBDC0004, Barnegat Bay, NJ.

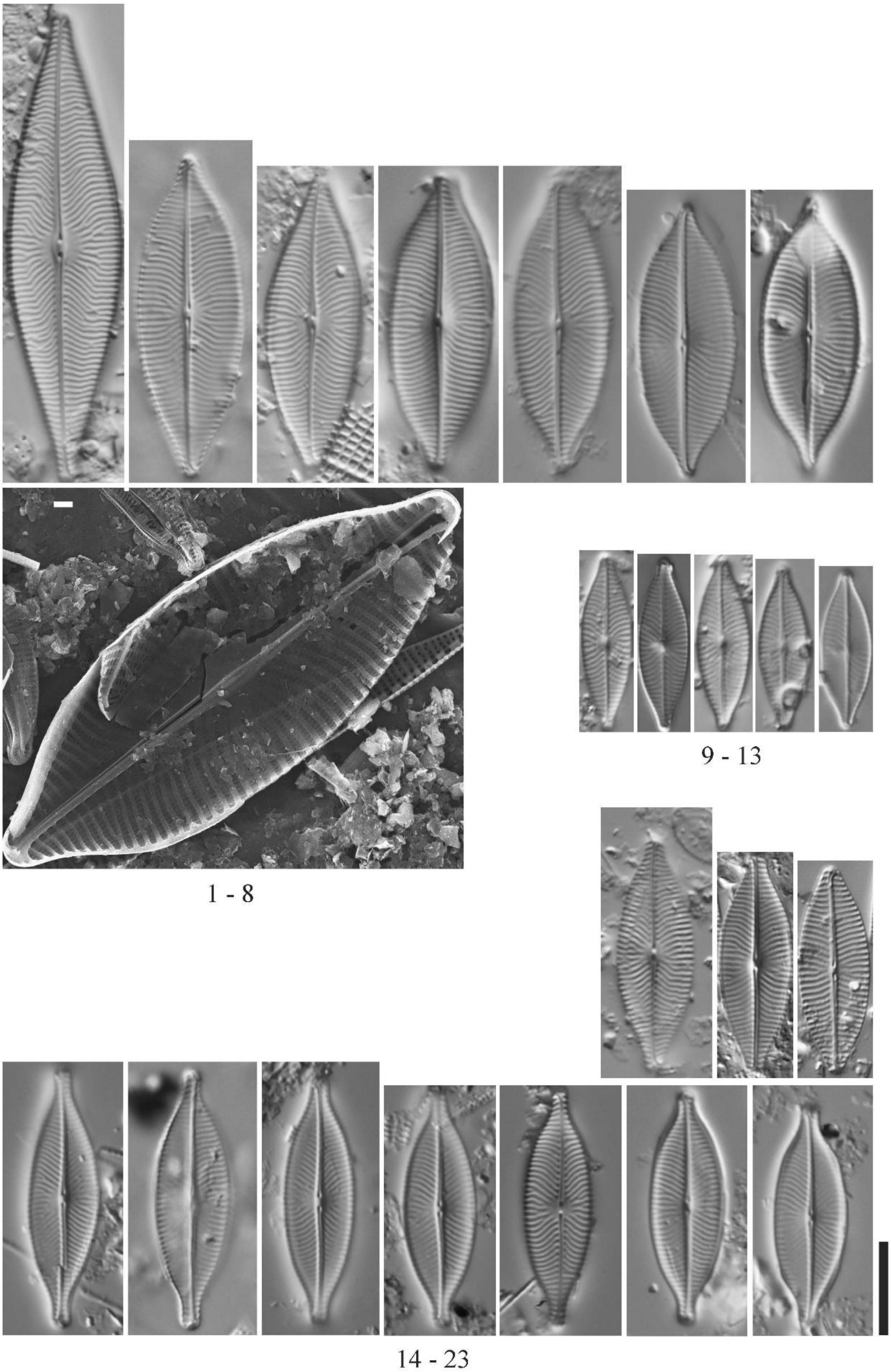

1 - 8
9 - 13
14 - 23

Plate 182 (Scale bars: Figs 1-11=10 µm; Figs 12-17=1 µm)

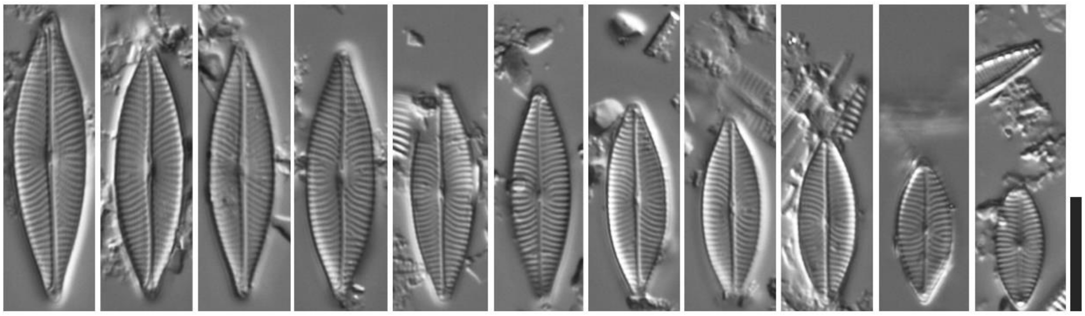
Navicula jonssonii Østrup

in Østrup 1918, p. 26; pl. 3, fig. 37

Figs 1-11: Sample RUTG0001, Cape May Courthouse, NJ.

Figs 12-14: Sample BBDC0080, Barnegat Bay, NJ.

Figs 15-17: Sample RUTG0001, Cape May Courthouse, NJ.



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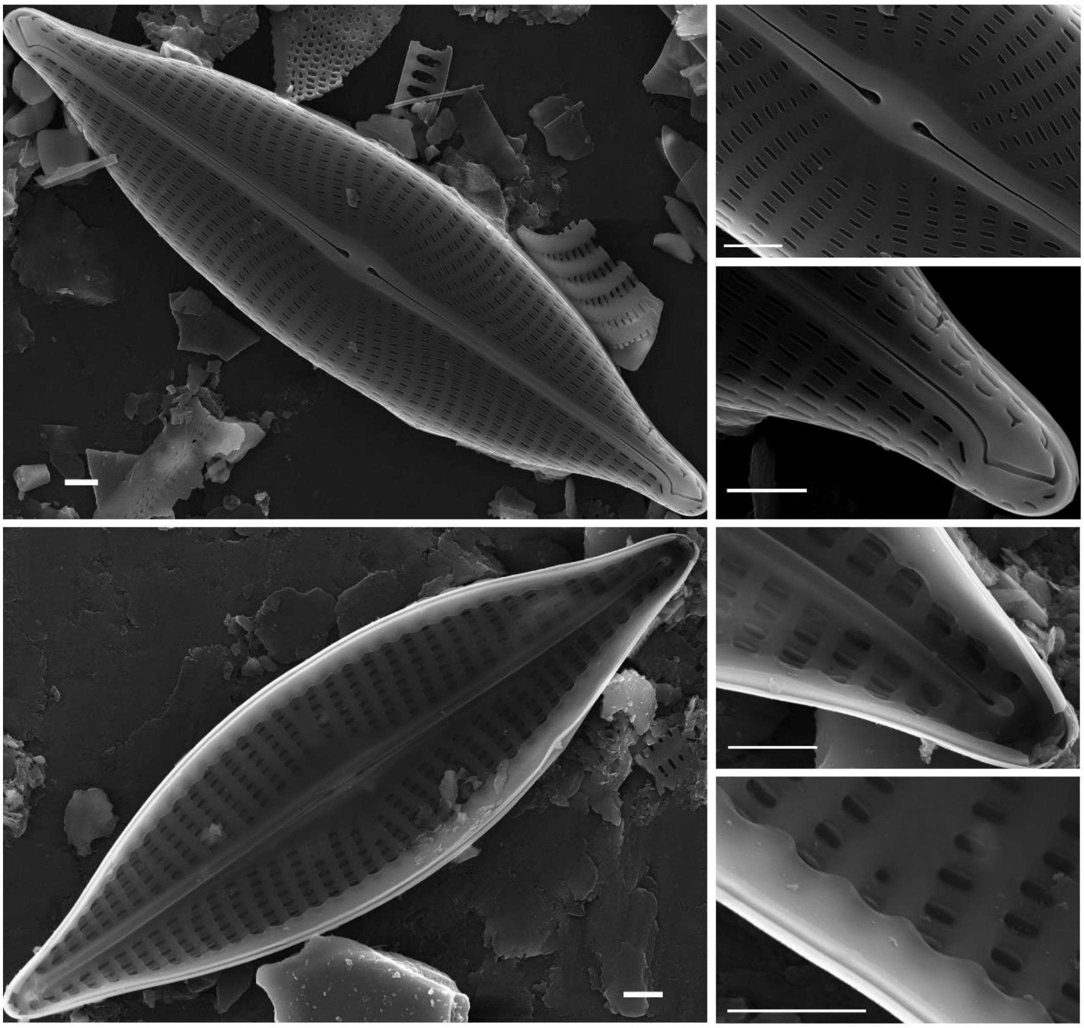


12 - 17

Plate 183 (Scale bars: Figs 1-17; 21-51=10 µm; Figs 18-20=1 µm)

Figs 1-20: ***Navicula willisiae*** Seddon & Witkowski

in Seddon et al. 2011, p. 874-875; fig. 8, a-m

Fig. 1: Sample BBDC0071, Barnegat Bay, NJ.
Figs 2-3,5-6,8-9,11-12: Sample BBDC0083, Barnegat Bay, NJ.
Figs 4,7,10,13-16: Sample BBEDC043, Tuckerton Bay, NJ.
Fig. 17: Sample RUTG0845, Bass River, NJ.
Figs 18-20: Sample RUTG0001, Cape May Courthouse, NJ.

Figs 21-24: ***Navicula* sp. 29**

Fig. 21: Sample BBDC0001, Barnegat Bay, NJ.
Fig. 22: Sample BBDC0018, Barnegat Bay, NJ.
Fig. 23: Sample BBDC0021, Barnegat Bay, NJ.
Fig. 24: Sample BBDC0036, Barnegat Bay, NJ.

Figs 25-34: ***Navicula* sp. 66**

Figs 25-26: Sample BBDC0012, Barnegat Bay, NJ.
Fig. 27: Sample BBDC0021, Barnegat Bay, NJ.
Figs 28,33-34: Sample BBDC0018, Barnegat Bay, NJ.
Fig. 29: Sample BBDC0017, Barnegat Bay, NJ.
Figs 30,32: Sample COAST053, Barnegat Bay, NJ.
Fig. 31: Sample BBDC0029, Barnegat Bay, NJ.

Figs 35-36: ***Navicula* sp. 58**

Fig. 24: Sample BBDC0017, Barnegat Bay, NJ.
Fig. 25: Sample BBDC0018, Barnegat Bay, NJ.

Figs 37-39: ***Navicula* sp. 18**

Fig. 37: Sample COAST012, Great South Bay, NY
Figs 38-39: Sample BBDC0009, Barnegat Bay, NJ.

Figs 40-45: ***Navicula* cf. *agatkae***

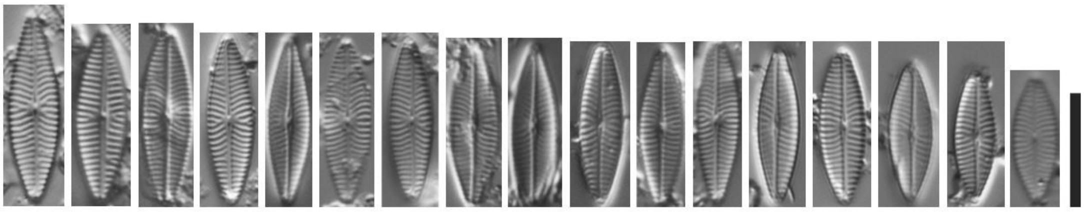
Fig. 40: Sample GB055, Great Bay, NJ.
Fig. 41: Sample BBDC0018, Barnegat Bay, NJ.
Fig. 42: Sample BBEDC0105, Cattus Island, NJ.
Fig. 43-44: Sample BBDC0037, Barnegat Bay, NJ.
Fig. 45: Sample BBEDC0058, Cattus Island, NJ.

Figs 46-49: ***Navicula* sp. 42**

Figs 46-47: Sample BBDC0002, Barnegat Bay, NJ.
Fig. 48: Sample BBDC0044, Barnegat Bay, NJ.
Fig. 49: Sample BBDC0017, Barnegat Bay, NJ.

Figs 50-51: ***Navicula* sp. 108**

Fig. 50: Sample BBDC0020, Barnegat Bay, NJ.
Fig. 51: Sample BBDC0017, Barnegat Bay, NJ.



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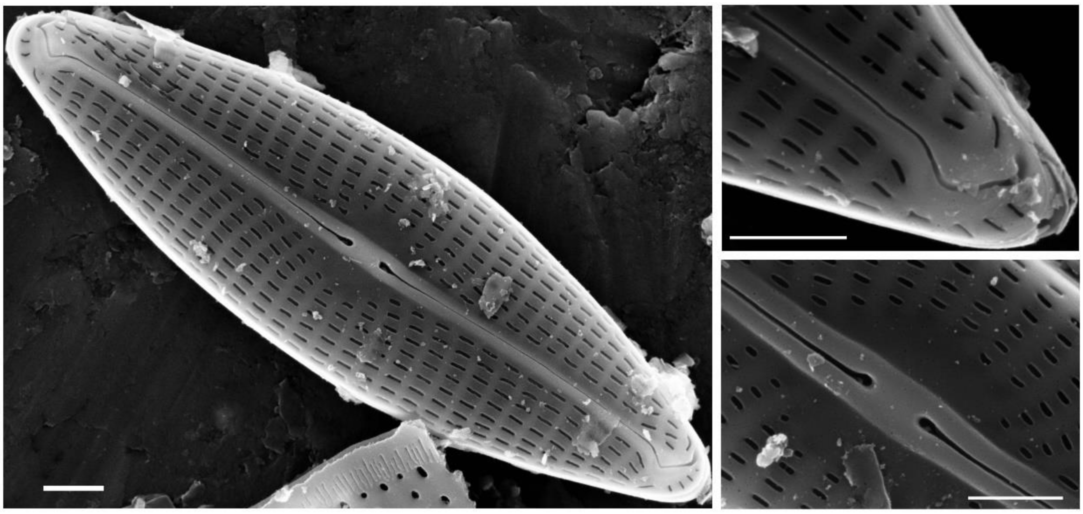
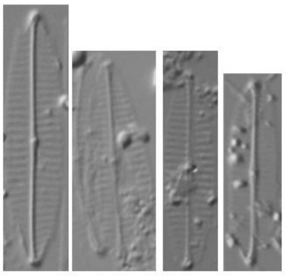
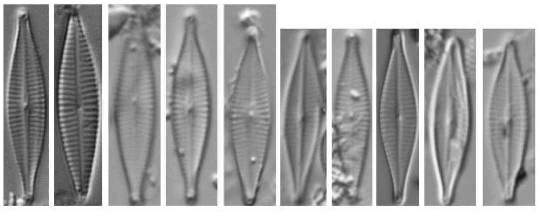


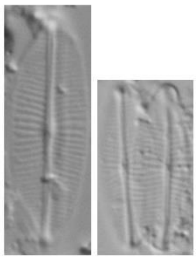
18 - 20



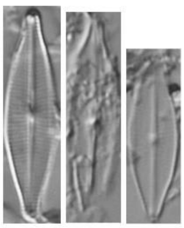
21 - 24



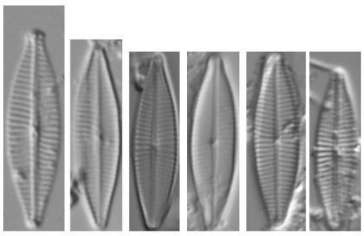
25 - 34



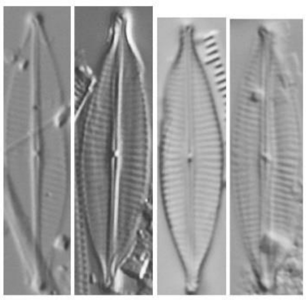
35 - 36



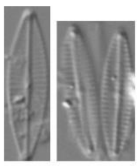
37 - 39



40 - 45



46 - 49



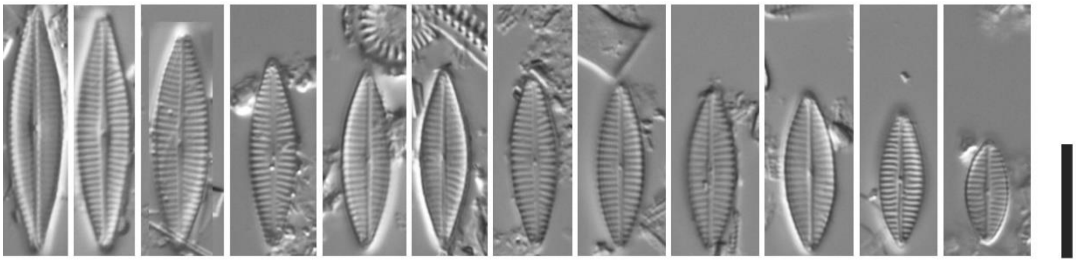
50 - 51

Plate 184 (Scale bars: Figs 1-12=10 µm; Figs 13-16=1 µm)

Navicula consentanea Hustedt

Lit.: Hustedt 1939, p. 625; fig. 98-100

Fig. 1,4-12: Sample RUTG0001, Cape May Courthouse, NJ.
Fig. 2: Sample BBDC0016, Barnegat Bay, NJ.
Fig. 3: Sample BBDC0037, Barnegat Bay, NJ.
Figs 13-14: Sample BBDC0037, Barnegat Bay, NJ.
Figs 15-16: Sample BBDC0051, Barnegat Bay, NJ.



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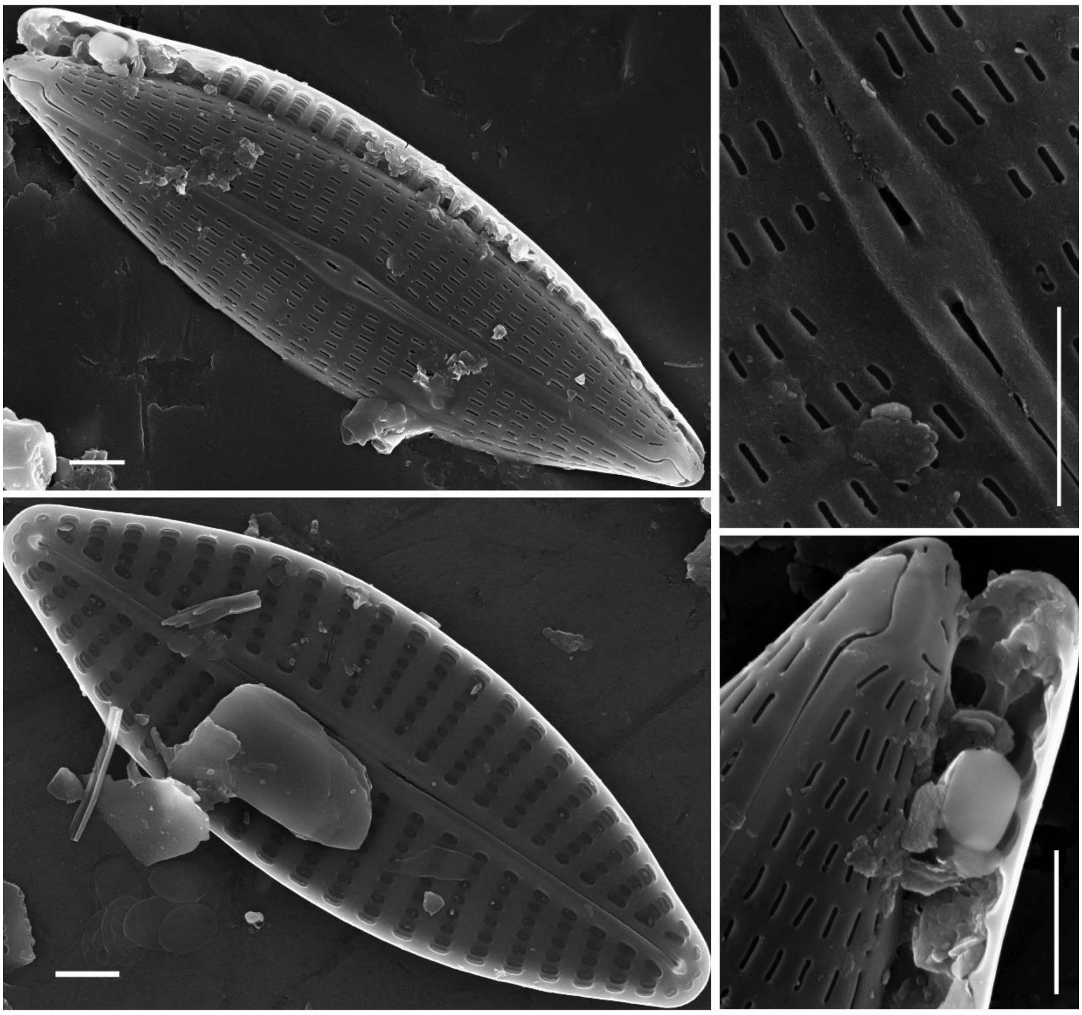


13 - 16

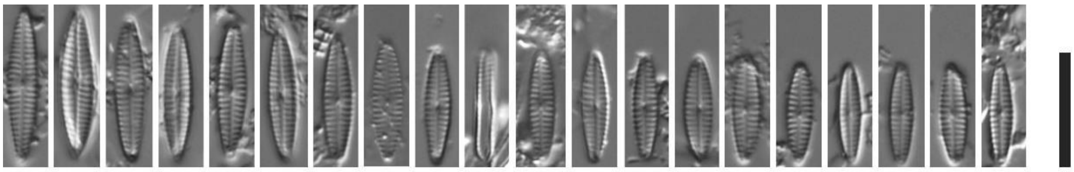
Plate 185 (Scale bars: Figs 1-20=10 µm; Figs 21-22=1 µm)

Navicula salinicola Hustedt

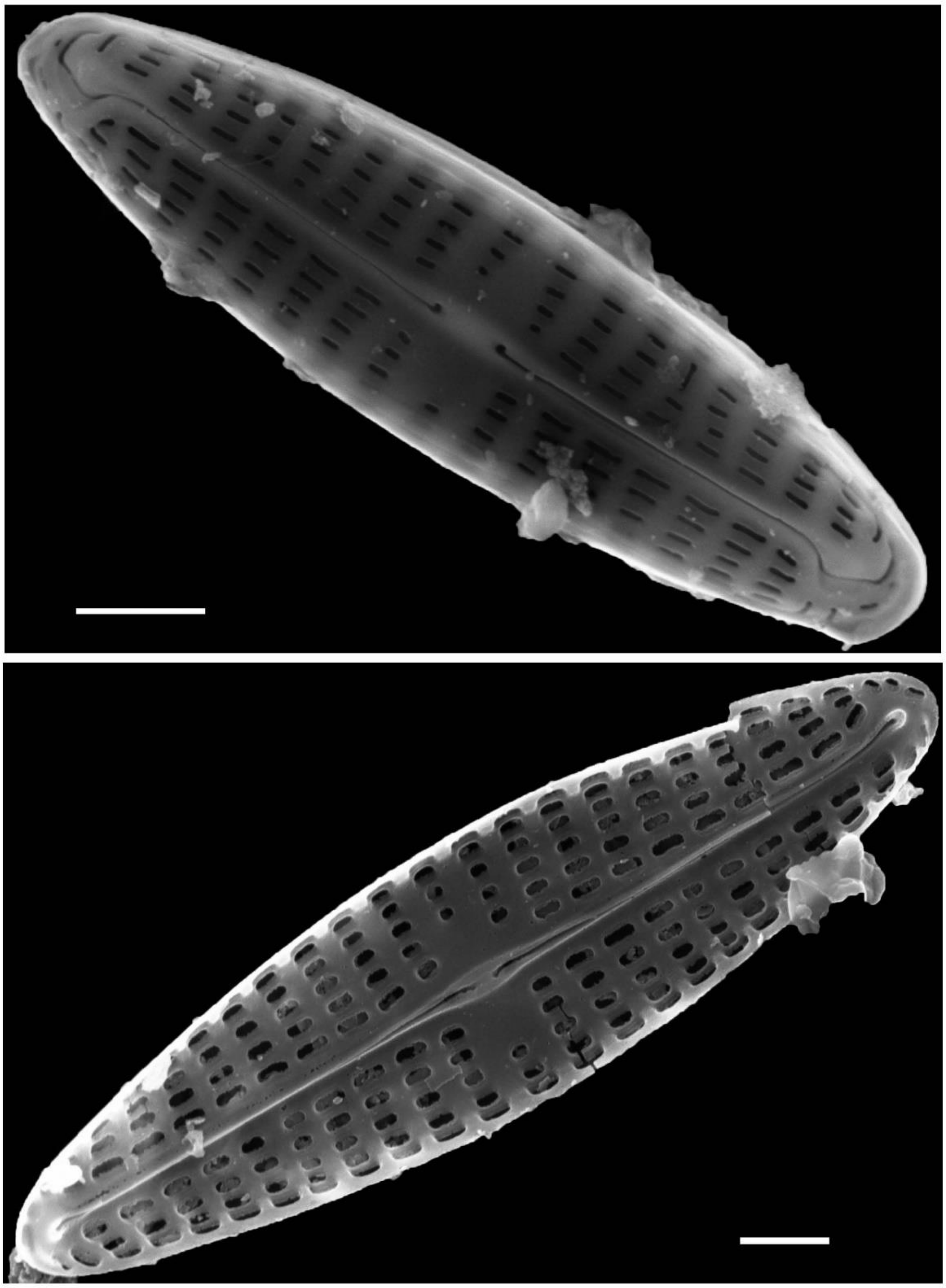
Lit.: Hustedt 1939, p. 638; fig. 61-69

Fig. 1-21: Sample RUTG0001, Cape May Courthouse, NJ.

Fig. 22: Sample BB0056, Barnegat Bay, NJ.



1 - 20

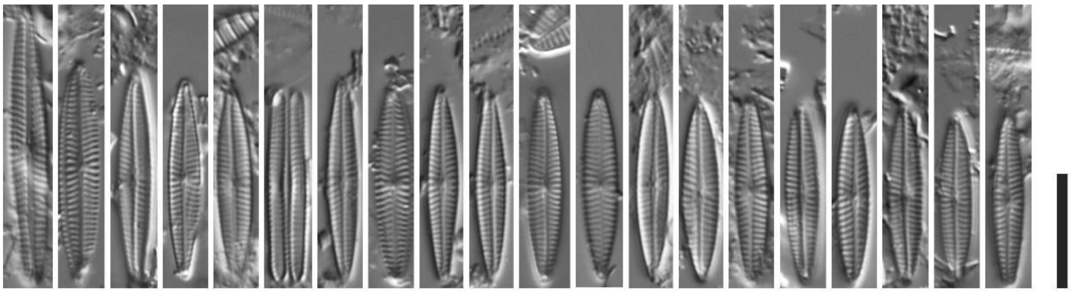


21 - 22

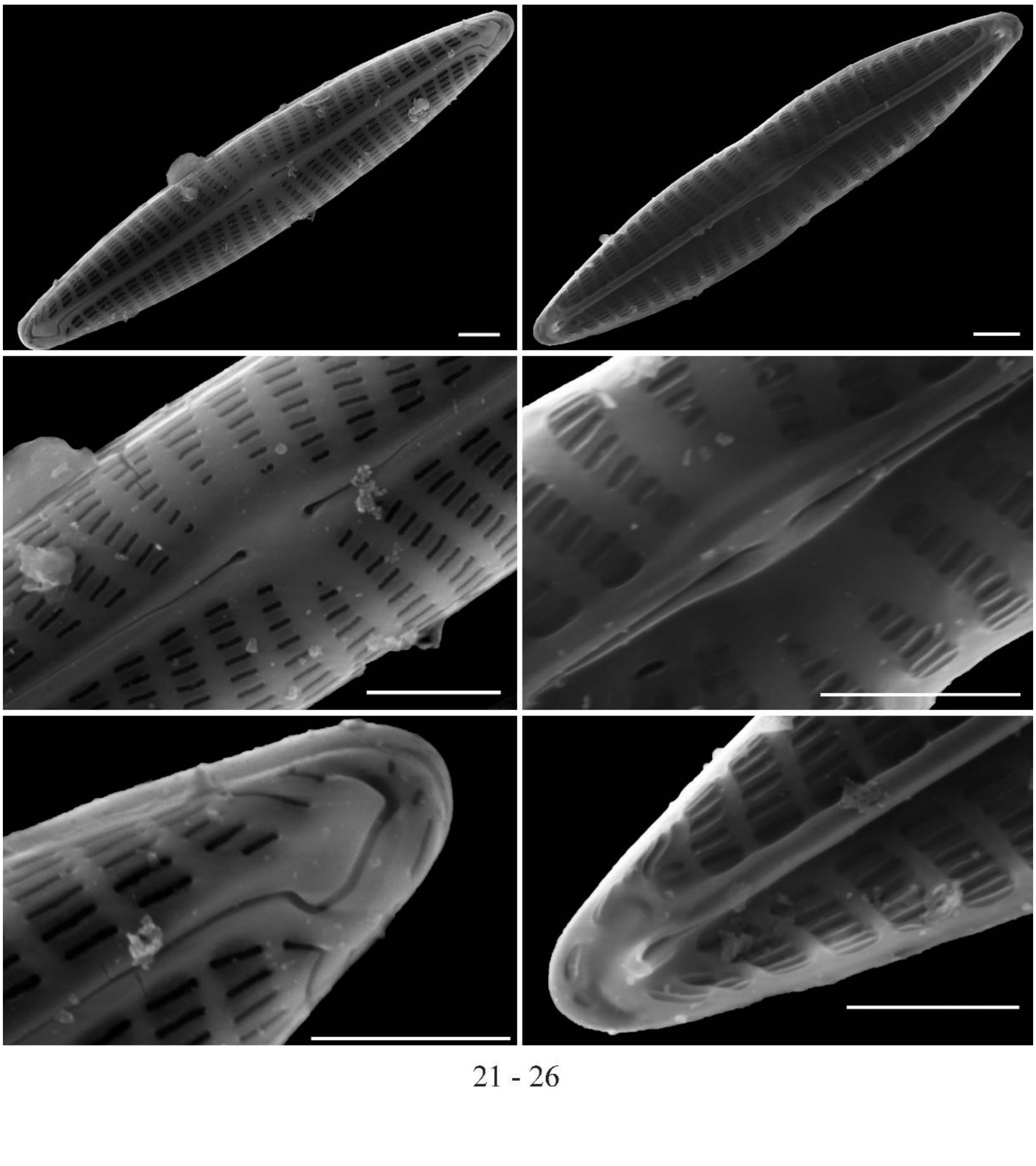
Plate 186 (Scale bars: Figs 1-20=10 µm; Figs 21-26=1 µm)

***Navicula* sp. 63**

Fig. 1-26: Sample RUTG0001, Cape May Courthouse, NJ.



1 - 20



21 - 26

Plate 187 (Scale bar: Figs 1-33=10 µm)

Figs 1-10: ***Navicula flanatica*** Grunow

Lit.: Grunow 1860, p. 527; pl. 1, fig. 9 (pl. 3, fig. 9)

Figs 1, 8: Sample BBDC0072, Barnegat Bay, NJ.
Fig. 2: Sample BBDC0006, Barnegat Bay, NJ.
Figs 3, 10: Sample BBDC0002, Barnegat Bay, NJ.
Figs 4,6-7,9: Sample BBDC0044, Barnegat Bay, NJ.
Fig. 5: Sample BBDC0009, Barnegat Bay, NJ.

Figs 11-14: ***Navicula spartinetensis*** Sullivan & Reimer

Lit.: Sullivan & Reimer 1975, v. 18: p. 119; pl. 1 & 2, fig. 3

Figs 11,14: Sample BBDC0072, Barnegat Bay, NJ.
Fig. 12: Sample BBDC0009, Barnegat Bay, NJ.
Fig. 13: Sample BBDC0088, Barnegat Bay, NJ.
Fig. 15: Sample BBDC0012, Barnegat Bay, NJ.

Figs 16-19: ***Navicula* cf. *spartinetensis***

Fig. 16: Sample GB055, Great Bay, NJ.
Fig. 17: Sample BBDC0065, Barnegat Bay, NJ.
Fig. 18: Sample COAST084, Atlantic City, NJ.
Fig. 19: Sample BBEDC048, Tuckerton Bay, NJ.

Fig. 20-21: ***Navicula flagellifera*** Hustedt

Lit: Hustedt 1939, p. 628; fig. 94, 95

Fig. 20: Sample COAST023, Great South Bay, NY.
Fig. 21: Sample BBDC0005, Barnegat Bay, NJ.

Fig. 22: ***Navicula* cf. *flagellifera***

Fig. 22: Sample BBDC0053, Barnegat Bay, NJ.

Figs 23-24: ***Navicula* cf. *longa* var. *irregularis***

Figs 23-24: Sample BBDC0021, Barnegat Bay, NJ.

Fig. 25: ***Navicula escambia*** (Patrick) Metzeltin & Lange-Bertalot

Lit: Metzeltin & Lange-Bertalot 2007, p. 162

Fig. 25: Sample BB0054, Barnegat Bay, NJ.

Figs 26: ***Navicula arenaria*** Donkin

Lit: Donkin 1861, p. 10; pl. 1, fig. 8, 9

Fig. 26: Sample BBDC0046, Barnegat Bay, NJ.

Fig. 27: ***Navicula* cf. *transistantioides***

Fig. 5: Sample BB0001, Barnegat Bay, NJ.

Figs 28-32: ***Navicula agatkae*** Witkowski, Metzeltin & Lange-Bertalot

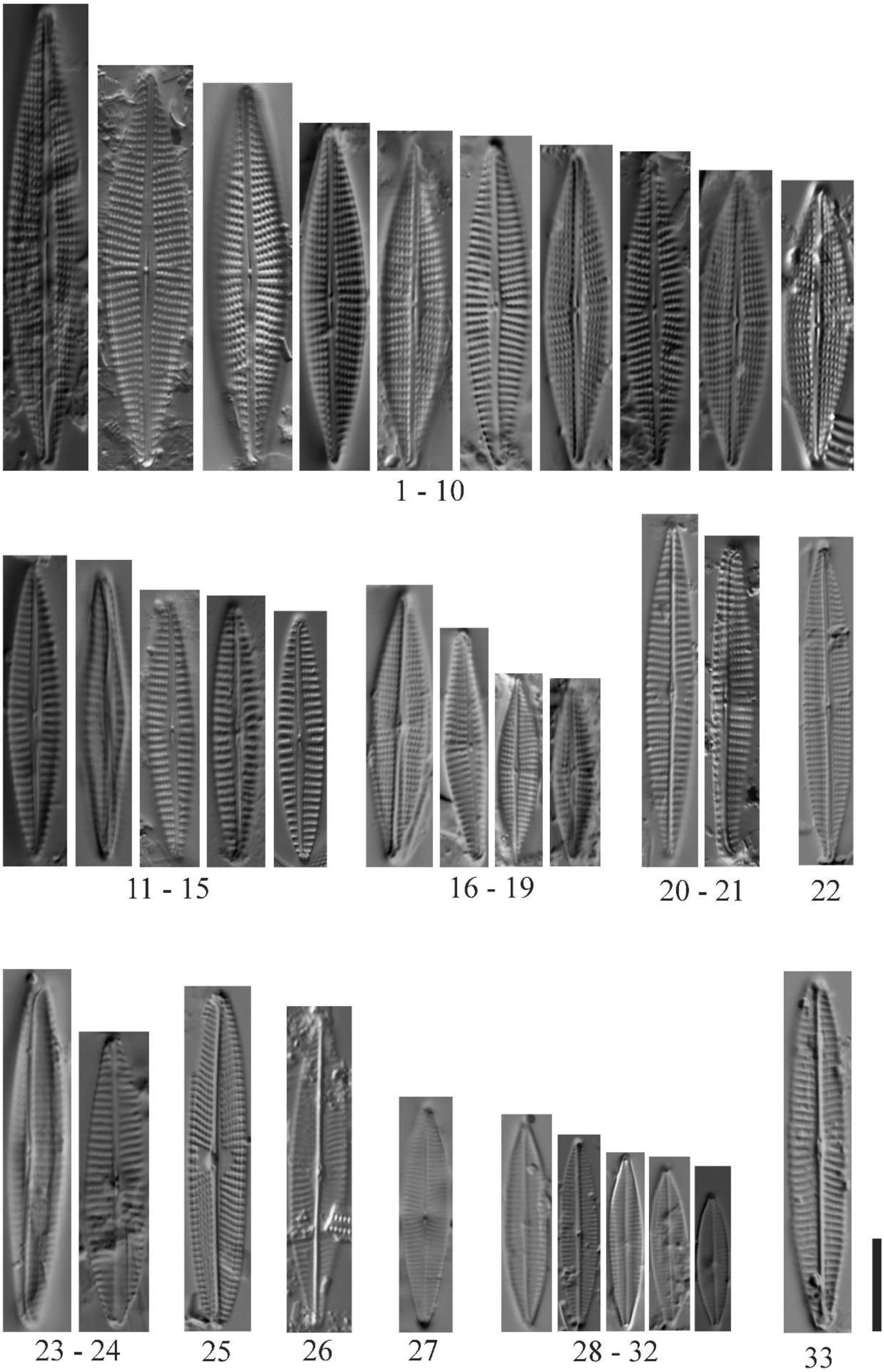
Lit: Witkowski, Metzeltin & Lange-Bertalot 2000, p. 265, 431; pl. 146, fig. 1-8

Fig. 28: Sample BBDC0001, Barnegat Bay, NJ.
Fig. 29: Sample BBDC0054, Barnegat Bay, NJ.
Fig. 30: Sample COAST021, Great South Bay, NY
Fig. 31: Sample BBDC0059, Barnegat Bay, NJ.
Fig. 32: Sample BBDC0044, Barnegat Bay, NJ.

Fig. 33: ***Navicula normaloides*** Cholnoky

Lit.: Cholnoky 1968, p. 55; fig. 76-86

Fig. 21: Sample BBDC0001, Barnegat Bay, NJ.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11 - 15
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23 - 24
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28 - 32
33

Plate 188 (Scale bars: Figs 1-13; 16-30 =10 μm; Figs 14-15 = 1 μm)

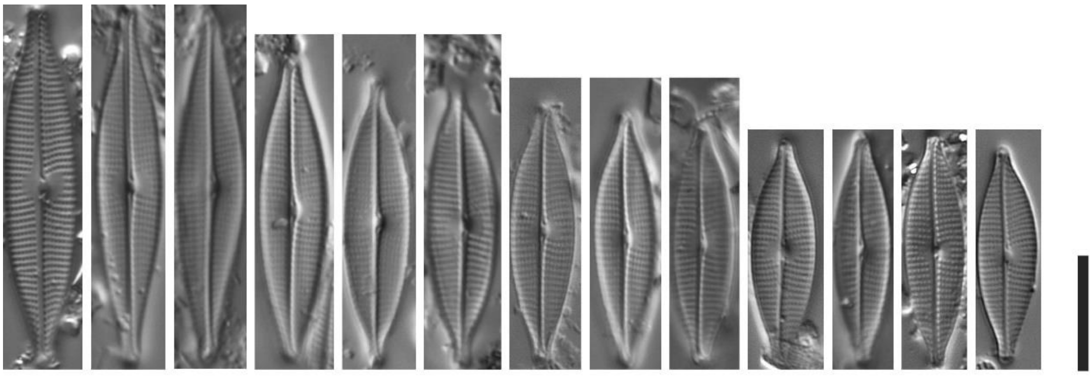
Figs 1-15: ***Navicula gregaria*** Donkin

Lit.: Donkin 1861, p. 10; pl. 1, fig. 10

Figs 1,4,8,15: Sample RUTG0001, Cape May Courthouse, NJ.
Fig. 2: Sample BBDC0029, Barnegat Bay, NJ.
Fig. 3: Sample RUTG0843, Leeds Point, NJ.
Fig. 5: Sample BBDC0009, Barnegat Bay, NJ.
Fig. 6: Sample BBEDC079, Cattus Island, NJ.
Fig. 7: Sample BBDC0007, Barnegat Bay, NJ.
Fig. 9: Sample BB0069, Barnegat Bay, NJ.
Figs 10,13: Sample BBDC0001, Barnegat Bay, NJ.
Fig. 11: Sample BB0059, Barnegat Bay, NJ.
Fig. 12: Sample BBDC0005, Barnegat Bay, NJ.
Fig. 14: Sample RUTG0811, Cape May Courthouse, NJ.

Figs 16-30: *Navicula* sp. 34 (? ***Navicula namibica*** **Lange-Bertalot & Rumrich)**

Fig. 16: Sample BBDC0007, Barnegat Bay, NJ.
Fig. 17: Sample BBEDC099, Cattus Island, NJ.
Fig. 18: Sample BBDC0028, Barnegat Bay, NJ.
Figs 19,22,24,26,28,30: Sample BBEDC079, Cattus Island, NJ.
Figs 20-21,23,29: Sample BB0001, Barnegat Bay, NJ.
Figs 25,27: Sample BBEDC099, Cattus Island, NJ.



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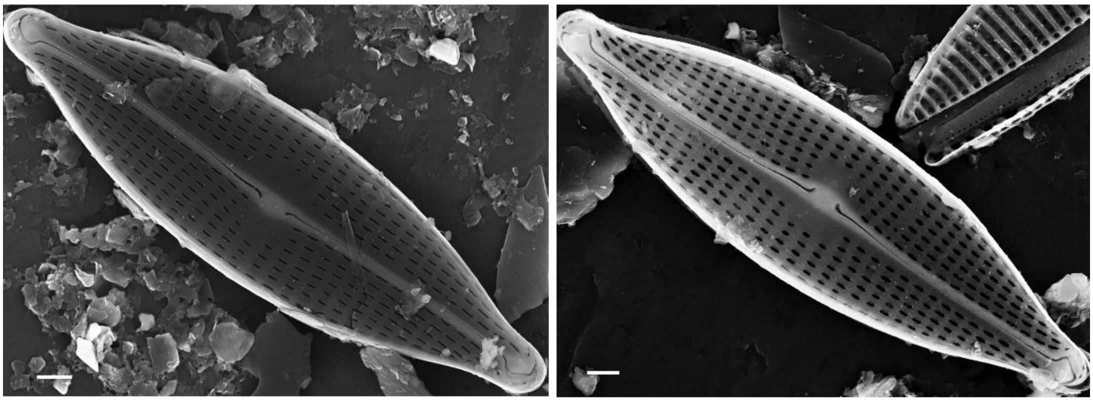
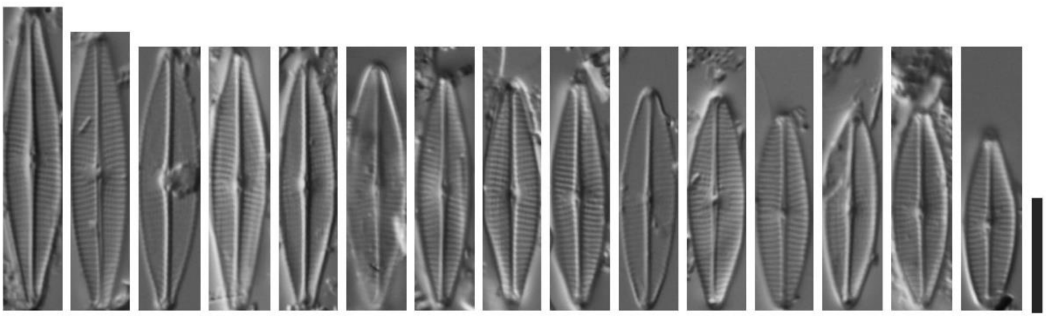


14 - 15



16 - 30

Plate 189 (Scale bar: Figs 1-33=10 µm)

Figs 1-11: ***Navicula ammophila*** Grunow

Lit.: Grunow 1882, p. 149; pl. 30, fig. 66-69

Figs 1,3,5: Sample BB0001, Barnegat Bay, NJ.
Fig. 2: Sample COAST004, Peconic Bay, NY.
Fig. 4: Sample BBDC0001, Barnegat Bay, NJ.
Fig. 6: Sample GB008, Great Bay, NJ.
Fig. 7: Sample BBEDC010, Tuckerton Bay, NJ.
Fig. 8: Sample BBDC0046, Barnegat Bay, NJ.
Fig. 9: Sample BBDC0065, Barnegat Bay, NJ.
Figs 10-11: Sample RUTG1019, Tuckerton Bay, NJ.

Figs 12-19: ***Navicula* sp. 111 (*Navicula* cf. *abscondita*)**

Fig. 12: Sample BBDC0018, Barnegat Bay, NJ.
Fig. 13: Sample RUTG0280, Rutgers Field Station, NJ.
Figs 14-15: Sample BBEDC010, Tuckerton Bay, NJ.
Fig. 16: Sample COAST003, Peconic Bay, NY.
Fig. 17: Sample BBEDC099, Cattus Island, NJ.
Fig. 18: Sample BBEDC058, Cattus Island, NJ.
Fig. 19: Sample BBDC0088, Barnegat Bay, NJ.

Figs 20-22: ***Navicula apta*** Hustedt

Lit: Hustedt 1955, p. 28; pl. 9, fig. 17-18

Fig. 20: Sample BBDC0045, Barnegat Bay, NJ.
Figs 21-22: Sample COAST033, Western Bay, NY.

Figs 23-27: ***Navicula hamiltonii*** Witkowski, Lange-Bertalot & Metzeltin

Lit: Witkowski, Metzeltin & Lange-Bertalot 2000, p. 282, 433; pl. 130, fig. 5-11

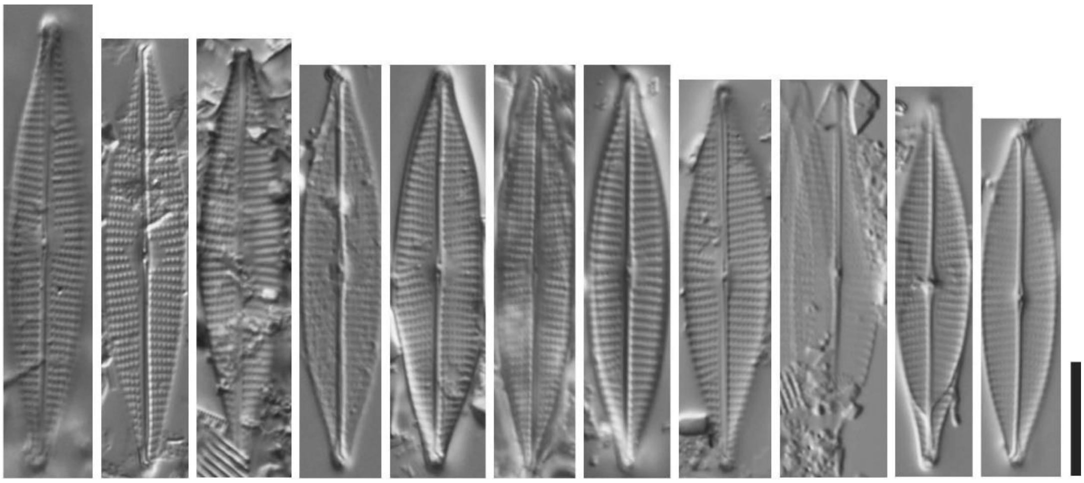
Fig. 23: Sample RUTG1019, Tuckerton Bay, NJ.
Figs 24-25: Sample BBEDC010, Tuckerton Bay, NJ.
Fig. 26: Sample GB055, Tuckerton Bay, NJ.
Fig. 27: Sample BBDC0008, Barnegat Bay, NJ.

Figs 28-31: ***Navicula* sp. 17**

Fig. 28: Sample GB009, Great Bay, NJ.
Fig. 29: Sample RUTG0001, Cape May Courthouse, NJ.
Fig. 30: Sample GB002, Great Bay, NJ.
Fig. 31: Sample BBEDC058, Cattus Island, NJ.

Figs 32-33: ***Navicula* sp. 112**

Fig. 32: Sample BBDC0016, Barnegat Bay, NJ.
Fig. 33: Sample BBDC0031, Barnegat Bay, NJ.



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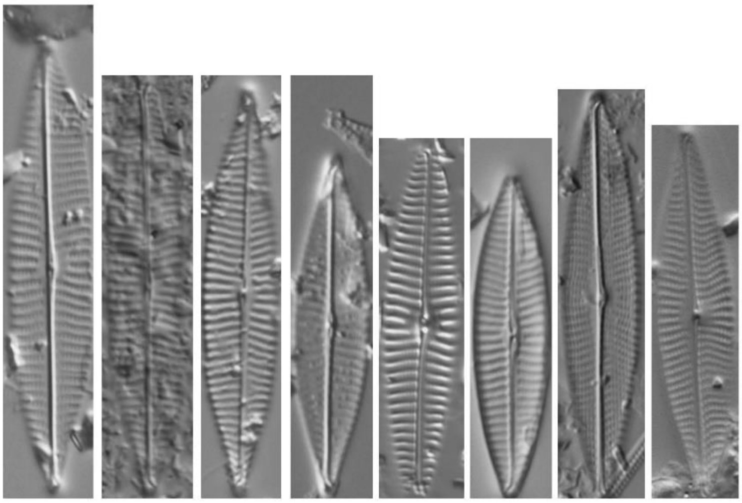

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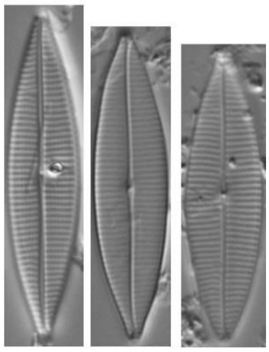

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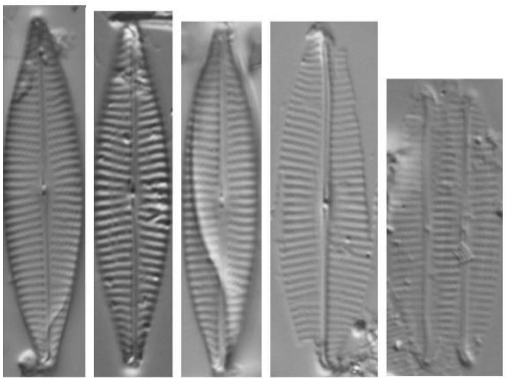
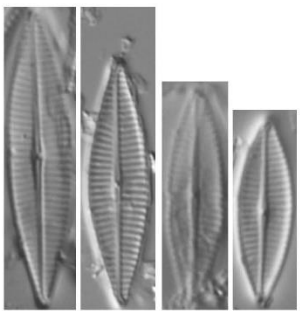
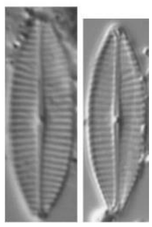


23 - 27



28 - 31



32 - 33

Plate 190 (Scale bar: Figs 1-43=10 µm)

Figs 1-12: ***Navicula* cf. *cryptocephala***

Lit: Schoeman & Archibald 1987, p. 482-483; fig. 1-14, 34-36

Fig. 1: Sample BB0079, Tuckerton Bay, NJ.
Figs 2-4,6-12: Sample BBEDC010, Tuckerton Bay, NJ.
Fig. 5: Sample RUTG1019, Tuckerton Bay, NJ.

Fig. 13: ***Navicula* cf. *phyllepta*** Lange-Bertalot

Lit.: Krammer & Lange-Bertalot 1985, v. 9: p. 91; pl. 29, fig. 5, 6

Fig. 25: Sample BBDC0016, Barnegat Bay, NJ.

Fig. 14: ***Navicula transitans* var. *derasa*** Grunow

Lit: Cleve 1883, p. 467; pl. 36, fig. 32

Fig. 13: Sample BBDC0044, Barnegat Bay, NJ.

Fig. 15: ***Navicula* sp. 114**

Fig. 15: Sample COAST004, Peconic Bay, NY.

Figs 16-20: ***Navicula* cf. *salinicola***

Fig. 16: Sample BBDC0051, Barnegat Bay, NJ.
Fig. 17: Sample BBDC0053, Barnegat Bay, NJ.
Figs 18-19: Sample BBDC0058, Barnegat Bay, NJ.
Fig. 20: Sample COAST011, Great South Bay, NY.

Figs 21-26: ***Navicula pseudosalinarioides*** Giffen

Lit: Giffen 1975, p. 87; fig. 94-96

Fig. 21: Sample COAST001, Peconic Bay, NY.
Fig. 22: Sample COAST019, Great South Bay, NY.
Fig. 23: Sample COAST004, Peconic Bay, NY.
Fig. 24: Sample BBDC0001, Barnegat Bay, NJ.
Fig. 25: Sample COAST003, Peconic Bay, NY.
Fig. 26: Sample COAST068, North East shore, NJ.

Figs 27-35: ***Navicula biskanterae*** Hustedt

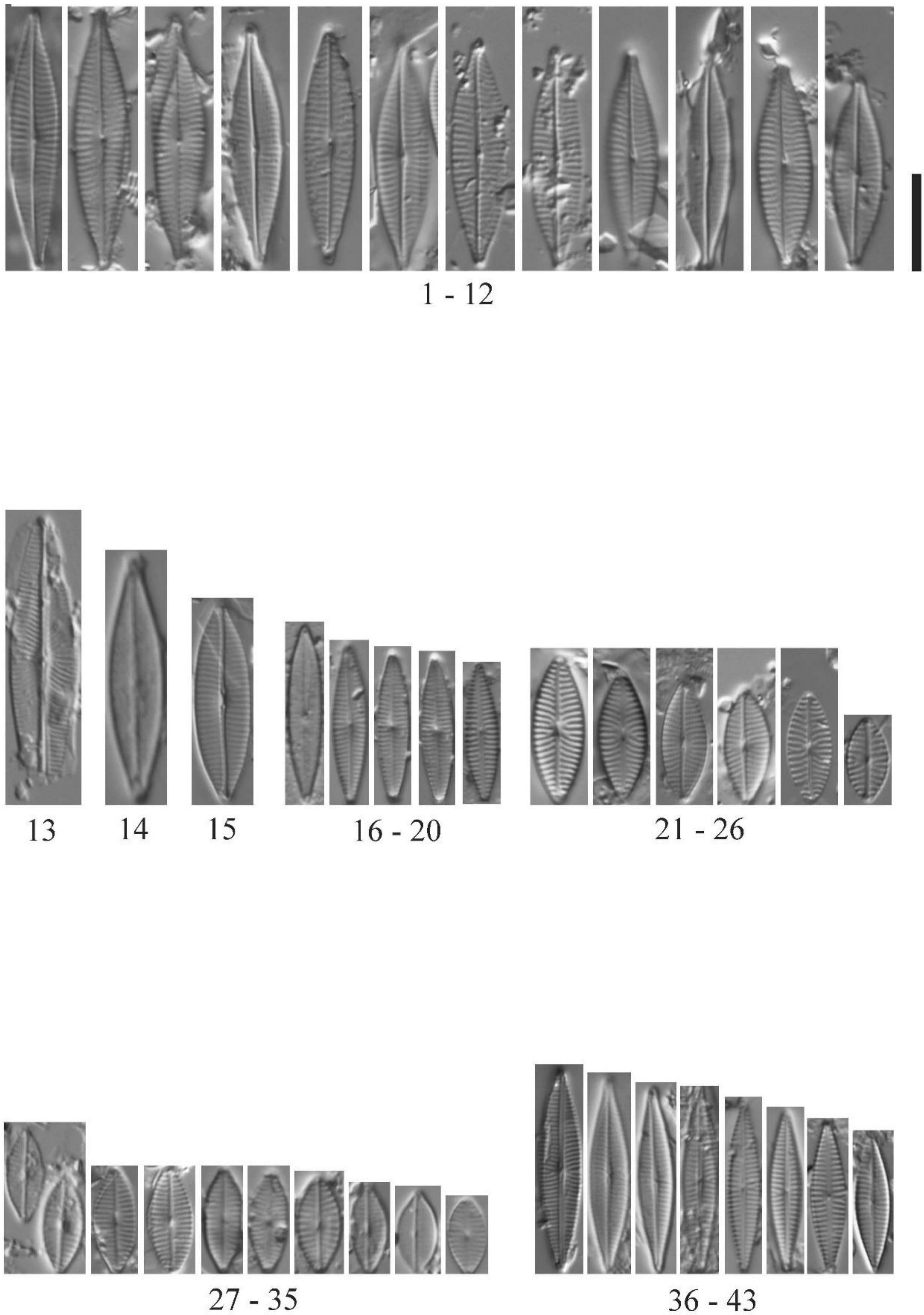
Lit: Hustedt 1939, p. 623; fig. 80-85

Fig. 27,32: Sample COAST053, Barnegat Bay, NJ.
Fig. 28: Sample BBDC0062, Barnegat Bay, NJ.
Fig. 29: Sample COAST002, Peconic Bay, NY.
Fig. 30: Sample BBDC0047, Barnegat Bay, NJ.
Fig. 31,33: Sample BBDC0036, Barnegat Bay, NJ.
Fig. 53: Sample BBDC0053, Barnegat Bay, NJ.
Fig. 54: Sample BBDC0003, Barnegat Bay, NJ.

Figs 36-43: ***Navicula dilucida*** Hustedt

Lit: Hustedt 1939, p. 627; fig. 104 (?), 105, 106, 107

Fig. 36: Sample BBDC0009, Barnegat Bay, NJ.
Fig. 37,39: Sample BBDC0059, Barnegat Bay, NJ.
Fig. 38: Sample BBDC0038, Barnegat Bay, NJ.
Fig. 40: Sample BBDC0072, Barnegat Bay, NJ.
Fig. 41: Sample BBDC0051, Barnegat Bay, NJ.
Fig. 42: Sample COAST008, Peconic Bay, NY.
Fig. 43: Sample COAST015, Peconic Bay, NY.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13
14
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16 - 20
21 - 26
27 - 35
36 - 43

Plate 191 (Scale bars: Figs 1-3; 5-22=10 μm; Figs 4; 23-25=1 μm)

Fig. 1: ***Navicula* cf. *gregaria***

Fig. 1: Sample BBDC0107, Great Bay, NJ.

Figs 2-4: ***Navicula vandamii* var. *mertensiae*** Lange-Bertalot

Lit: Schoeman & Archibald 1987, p. 482-483; fig. 1-14, 34-36

Fig. 2: Sample BBDC0008, Barnegat Bay, NJ.
Fig. 3: Sample BBDC0015, Barnegat Bay, NJ.
Fig. 4: Sample RUTG0811, Cape May Courthouse, NJ.

Fig. 5: ***Navicula* sp. 22**

Fig. 5: Sample BBDC0046, Barnegat Bay, NJ.

Fig. 6: ***Navicula* sp. 31**

Fig. 6: Sample COAST023, Great South Bay, NY.

Fig. 7: ***Navicula* sp. 5**

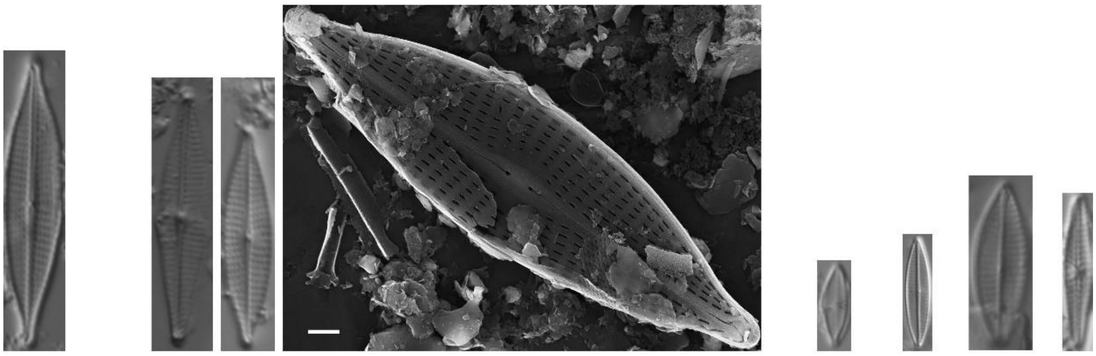
Fig. 7: Sample GB008, Great Bay, NJ.

Fig. 8: ***Navicula* sp. 14**

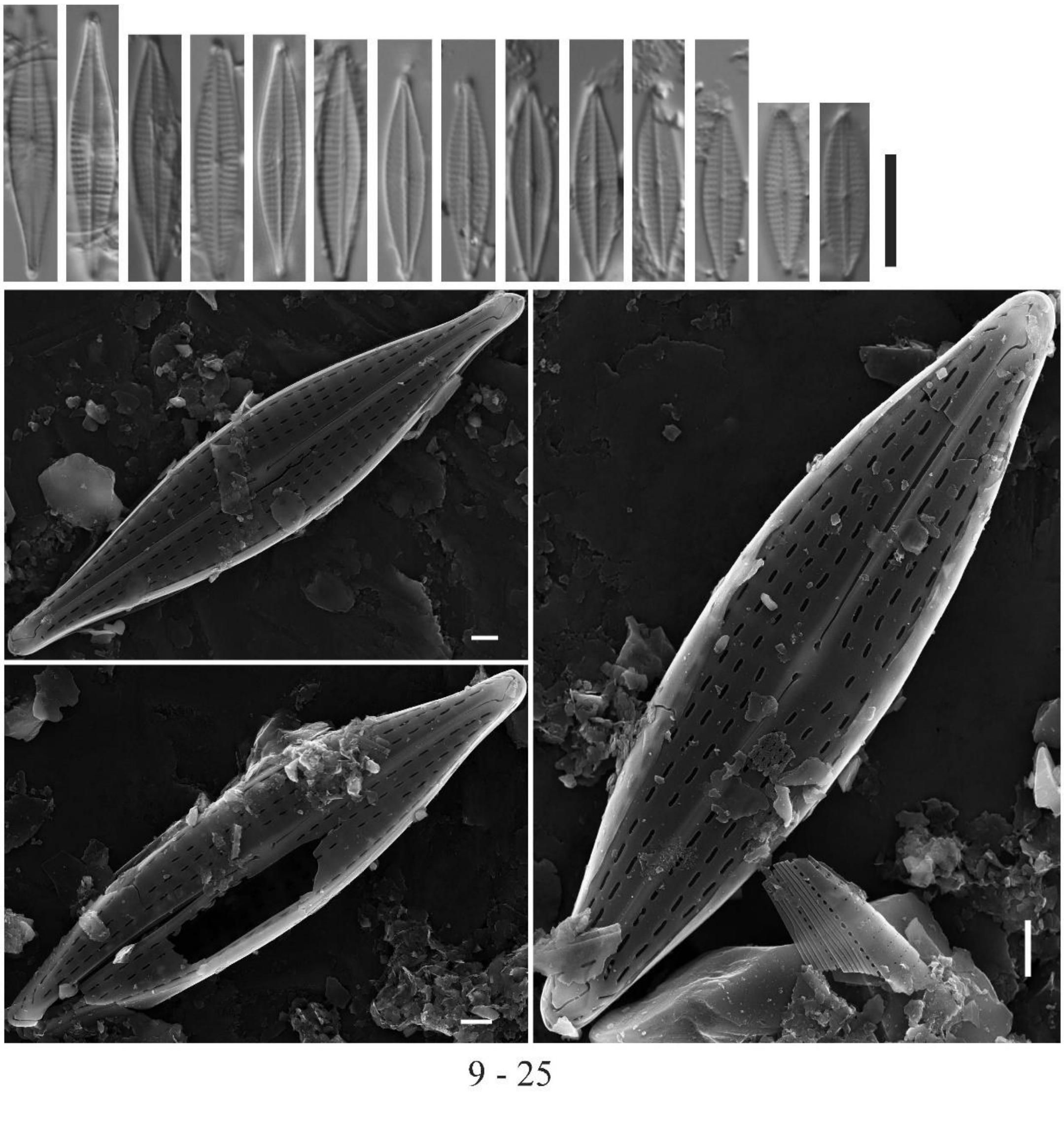
Fig. 8: Sample BB0008, Barnegat Bay, NJ.

Figs 9-25: ***Navicula* sp. 37**

Figs 9-10,14: Sample BBDC0044, Barnegat Bay, NJ.
Figs 11-12,15-16,20: Sample BBDC0063, Barnegat Bay, NJ.
Fig. 13: Sample BBDC0059, Barnegat Bay, NJ.
Fig. 17: Sample BBEDC058, Cattus Island, NJ.
Fig. 18: Sample BBDC0015, Barnegat Bay, NJ.
Fig. 19: Sample BB0079, Barnegat Bay, NJ.
Fig. 21: Sample BBEDC059, Cattus Island, NJ.
Fig. 22: Sample BBDC0017, Barnegat Bay, NJ.
Figs 23-25: Sample RUTG0811, Cape May Courthouse, NJ.



1 2 - 4 5 6 7 8



9 - 25

Plate 192 (Scale bars: Figs 1-33, 35-39=10 µm; Fig. 34=1 µm)

Figs 1-11: ***Navicula* sp. 101**

Fig. 1: Sample COAST004, Peconic Bay, NY.
Fig. 2: Sample BBDC0017, Barnegat Bay, NJ.
Fig. 3: Sample BBEDC011, Tuckerton Bay, NJ.
Fig. 4: Sample COAST007, Peconic Bay, NY.
Fig. 5: Sample BBDC0071, Barnegat Bay, NJ.
Figs 6,10: Sample BBEDC079, Cattus Island, NJ.
Fig. 7: Sample BB0069, Barnegat Bay, NJ.
Fig. 8: Sample BBEDC058, Cattus Island, NJ.
Fig. 9: Sample BBEDC018, Tuckerton Bay, NJ.
Fig. 11: Sample BBDC0044, Barnegat Bay, NJ.

Figs 12-13: ***Navicula* sp. 4**

Fig. 12: Sample BBDC0001, Barnegat Bay, NJ.
Fig. 13: Sample BBDC0052, Barnegat Bay, NJ.

Figs 14-15: ***Navicula* sp. 55**

Fig. 14: Sample BBEDC064, Cattus Island, NJ.
Fig. 15: Sample BBDC0058, Barnegat Bay, NJ.

Figs 16-21: ***Navicula diserta*** Hustedt

Lit: Hustedt 1939, p. 627; fig. 78-79

Fig. 16: Sample BBDC0001, Barnegat Bay, NJ.
Figs 17-18: Sample BBDC0052, Barnegat Bay, NJ.
Fig. 19: Sample COAST003, Peconic Bay, NY.
Fig. 20: Sample COAST002, Peconic Bay, NY.
Fig. 21: Sample COAST001, Peconic Bay, NY.

Figs 22-34: ***Navicula* sp. 51 (N. incertata?)**

Figs 22,29,32-33: Sample BBDC0084, Barnegat Bay, NJ.
Figs 23-25,34: Sample BBEDC043, Tuckerton Bay, NJ
Fig. 26: Sample BBDC0043, Barnegat Bay, NJ.
Fig. 27: Sample BBDC0027, Barnegat Bay, NJ.
Fig. 28: Sample BBDC0071, Barnegat Bay, NJ.
Figs 30: Sample BBDC0052, Barnegat Bay, NJ.
Fig. 31: Sample GB002, Great Bay, NJ.

Figs 35-37: ***Navicula* vekhovii** Lange-Bertalot & Genkal

Lit: Lange-Bertalot & Genkal 1999, p. 71; pl. 14, figs. 1-7

Fig. 35: Sample BBDC0006, Barnegat Bay, NJ.
Fig. 36: Sample BBDC0084, Barnegat Bay, NJ.
Fig. 37: Sample BBDC0001, Barnegat Bay, NJ.

Fig. 38: ***Navicula* sp. 9**

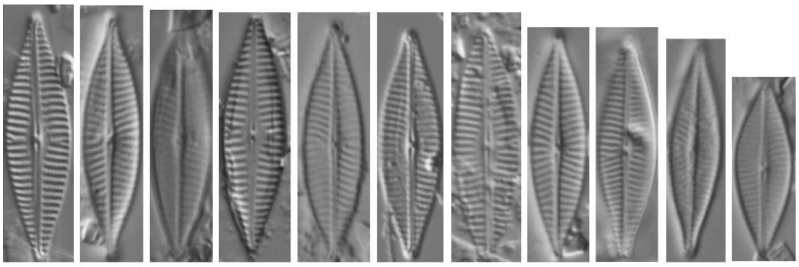
Fig. 38: Sample RUTG0811, Cape May Courthouse, NJ.

Fig. 39: ***Navicula* sp. 15**

Fig. 39: Sample BBDC0052, Barnegat Bay, NJ.

Fig. 40: ***Navicula* sp. 33**

Fig. 40: Sample BBDC0055, Barnegat Bay, NJ.



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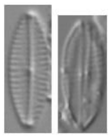
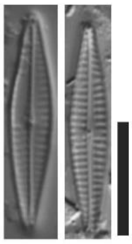
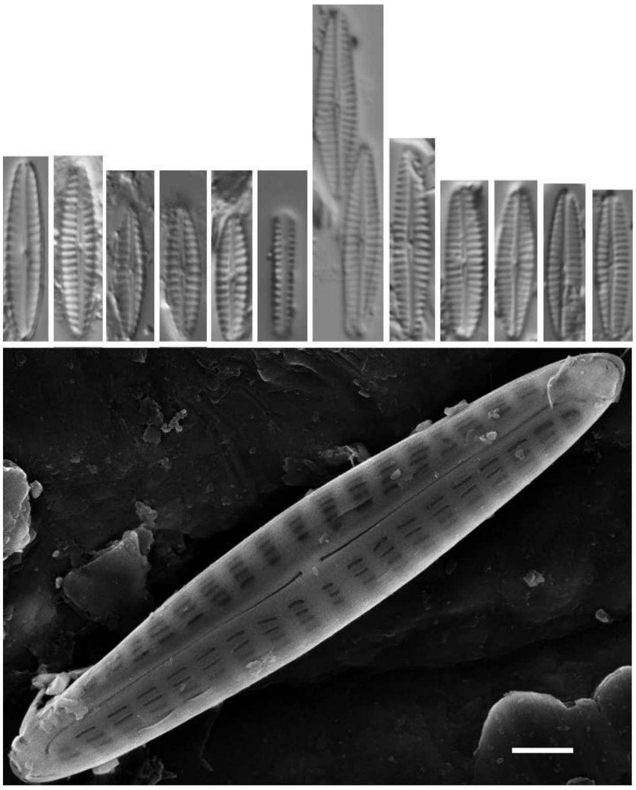


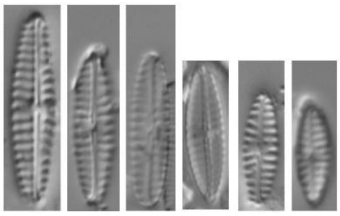
12 - 13



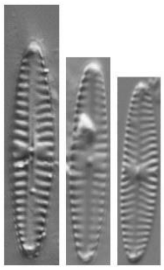
14 - 15



22 - 34



16 - 21



35 - 37

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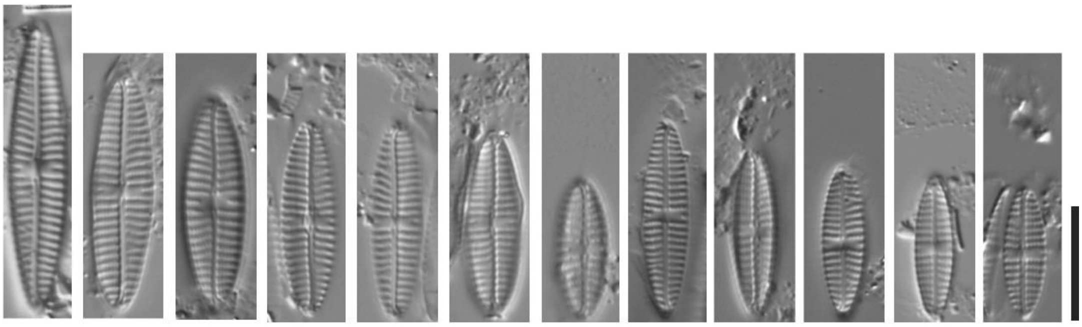
40

Plate 193 (Scale bars: Figs 1-12=10 µm; Figs 13-17=1 µm)

***Navicula* sp. 1**

Fig. 1: Sample BBEDC079, Cattus Island, NJ.

Figs 2-17: Sample BBDC0001, Barnegat Bay, NJ.



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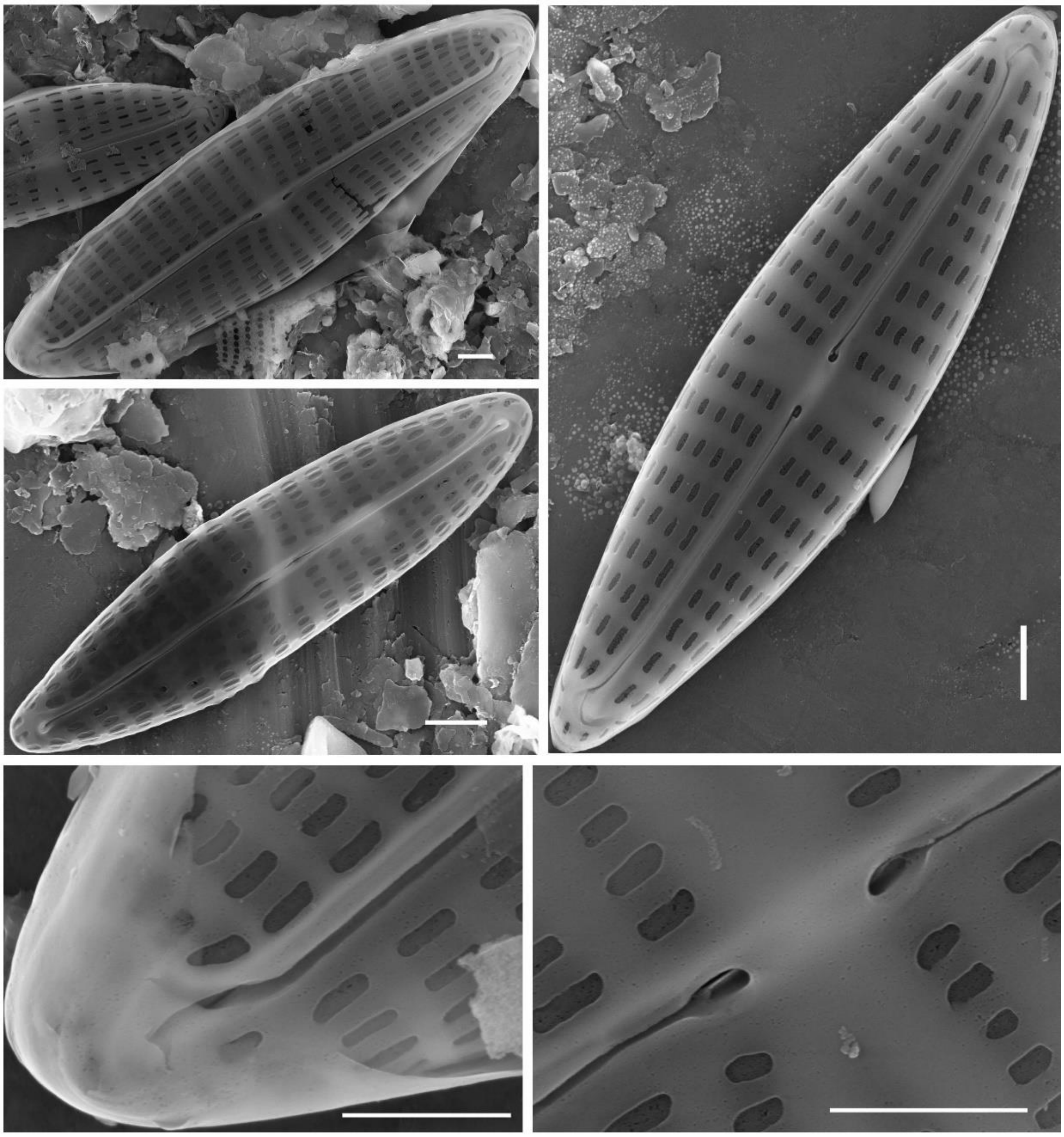


13 - 17

Plate 194 (Scale bars: Figs 1-20; 25-28=10 µm; Figs 21-24; 29-31=1 µm)

Figs 1-24: ***Navicula perminuta*** Østrup

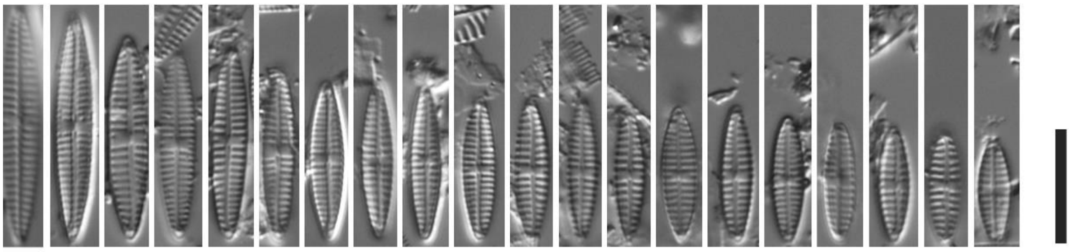
Lit.: Østrup 1913, p. 5; pl. 1, fig. 2

Fig. 1: Sample BBDC0064, Barnegat Bay, NJ.

Figs 2-24: Sample RUTG0001, Cape May Courthouse, NJ.

Figs 25-31: ***Navicula* sp. 23**

Figs 25-31: Sample RUTG0001, Cape May Courthouse, NJ.



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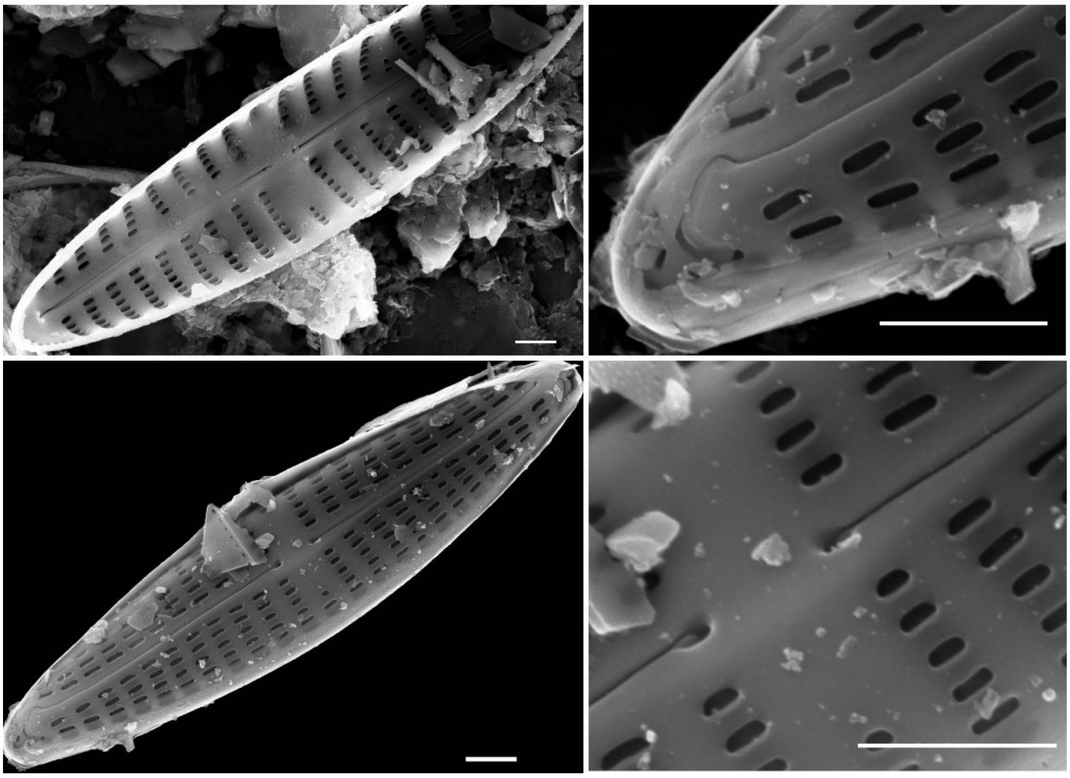
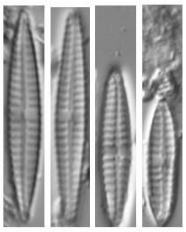
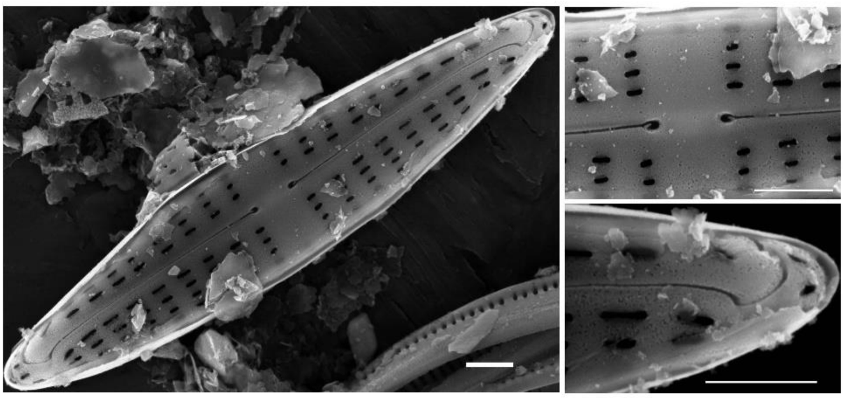


21 - 24



25 - 28



29 - 31

Plate 195 (Scale bar: Figs 1-16, 6-22=10 µm; Fig. 17=1 µm)

Figs 1-17: ***Navicula microcari*** Lange-Bertalot

Lit.: Lange-Bertalot 1993, v. 27: p. 121-122; pl. 58, fig. 1-5, Bacill. 2/4, fig. 59: 4-7

Figs 1-8,11-17: Sample RUTG0001, Cape May Courthouse, NJ.

Fig. 9: Sample BBDC0001, Barnegat Bay, NJ.

Fig. 10: Sample BBDC0052, Barnegat Bay, NJ.

Figs 18-20: **Navicula sp. 53**

Lit.: Krammer & Lange-Bertalot 1985, v. 9: p. 91; pl. 29, fig. 5, 6

Figs 18,20: Sample RUTG0785, Rutgers Field Station, NJ.

Fig. 19: Sample BBDC0028, Barnegat Bay, NJ.

Figs 21-24: ***Navicula* cf. *libonensis***

Figs 21,23: Sample BBDC0001, Barnegat Bay, NJ.

Fig. 22: Sample BBDC0006, Barnegat Bay, NJ.

Fig. 24: Sample BBEDC058, Cattus Island, NJ.

Figs 25-31: ***Navicula* cf. *microcari***

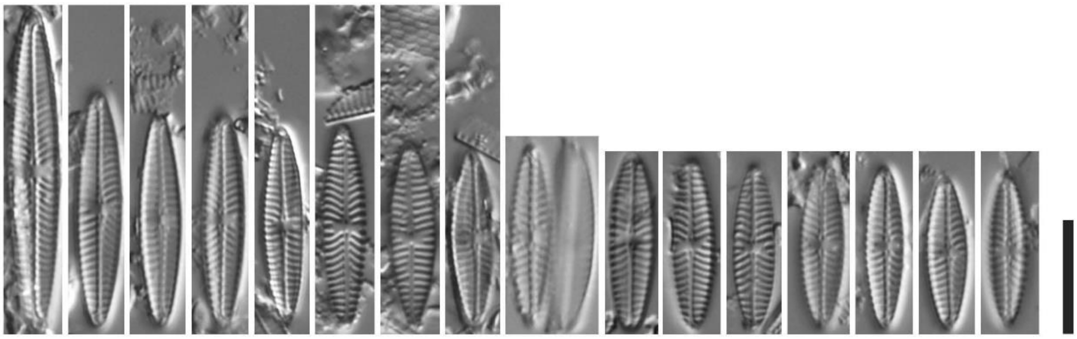
Figs 25-27: Sample RUTG0852, Bass River, NJ.

Fig. 28: Sample BBDC0007, Barnegat Bay, NJ.

Fig. 29: Sample BBEDC058, Cattus Island, NJ.

Fig. 30: Sample BBDC0043, Barnegat Bay, NJ.

Fig. 31: Sample BBDC0001, Barnegat Bay, NJ.



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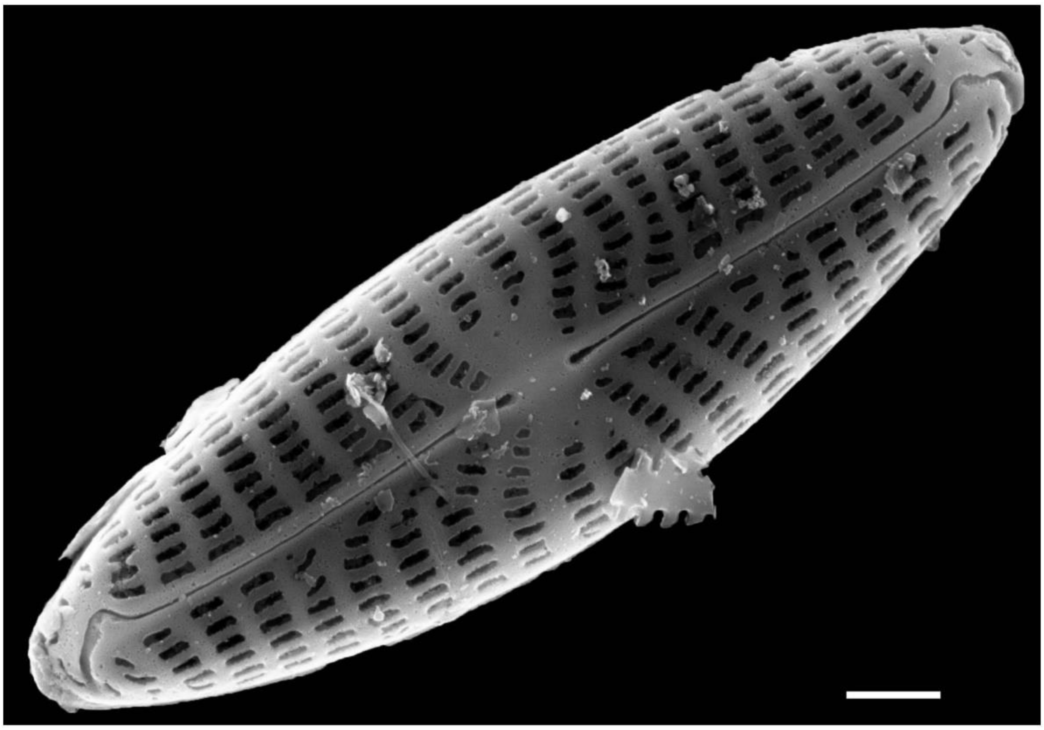

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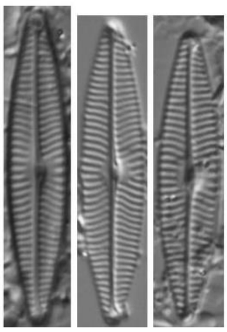
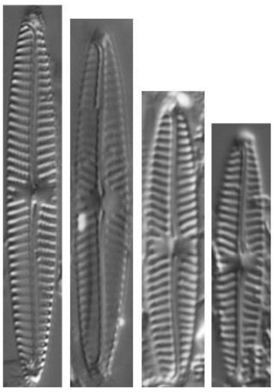
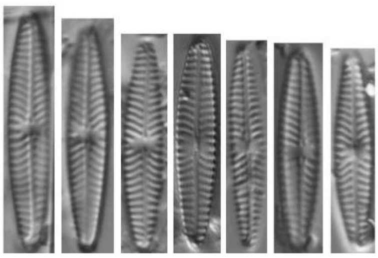


18 - 20



21 - 24



25 - 31

Plate 196 (Scale bars: Figs 1-10; 13-25=10 µm; Fig 11-12; 26-28=1 µm)

Figs 1-12: ***Navicula platyventris*** Meister

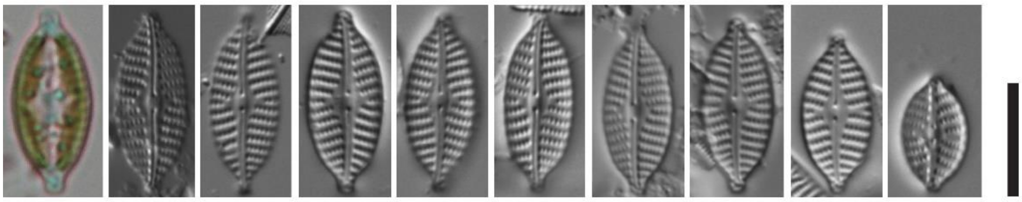
Lit.: Meister 1935, p. 95; fig. 33

Fig. 1: Barnegat Bay, NJ.
Fig. 2: Sample BBDC0008, Barnegat Bay, NJ.
Figs 3-6,9-10,11-12: Sample LR14-3, Lewes-Rehoboth canal, DE.
Fig 7-8: Sample BBDC0046, Barnegat Bay, NJ.

Figs 13-24: ***Navicula viminoides*** Giffen

Lit.: Giffen 1975, p. 88; fig. 99-101

Fig. 13,21: Sample COAST001, Peconic Bay, NY.
Figs 14,19,22-23: Sample BBDC0044, Barnegat Bay, NJ.
Fig. 15: Sample COAST004, Peconic Bay, NY.
Fig. 16: Sample COAST002, Peconic Bay, NY.
Fig. 17: Sample RUTG0861, Pilot Drive, NJ.
Fig. 18: Sample BBEDC059, Cattus Island, NJ.
Fig. 20: Sample BBDC0032, Barnegat Bay, NJ.
Figs 24-25: Sample BBDC0052, Barnegat Bay, NJ.
Figs 26-28: Sample BBDC0047, Barnegat Bay, NJ.



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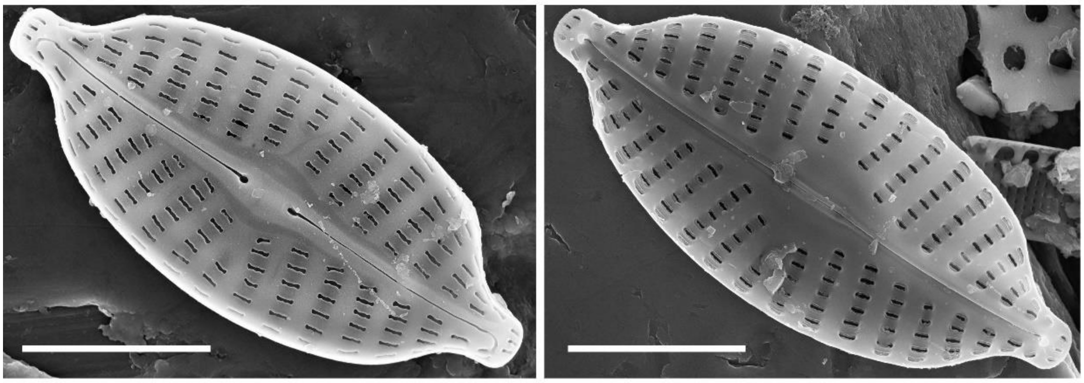

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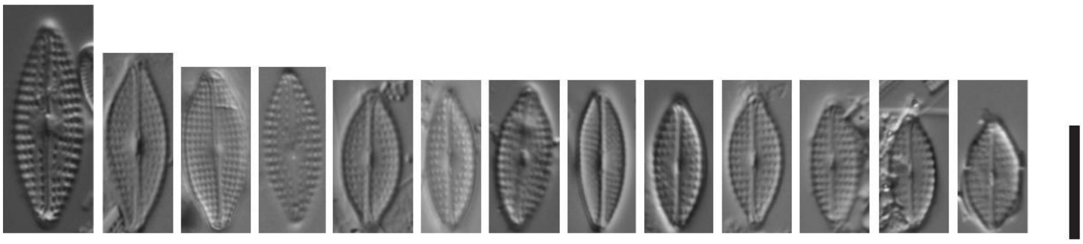


13 - 25

26 - 28

Plate 197 (Scale bars: Figs 1-6; 11-14; 16-21=10 µm; Fig 7-10; 15=1 µm)

Figs 1-10: ***Navicula binodulosa*** Sullivan & Reimer

Lit.: Sullivan & Reimer 1975, p. 119; pl. 1, 2, fig. 4

Figs 1-10: Sample BB0072, Barnegat Bay, NJ.

Figs 11-15: ***Navicula pargemina*** Underwood & Yallop

Lit.: Underwood & Yallop 1994, p. 477; fig. 1-14

Fig. 11: Sample BBDC0051, Barnegat Bay, NJ.

Fig. 12: Sample COAST003, Peconic Bay, NY.

Fig. 13: Sample BBDC0064, Barnegat Bay, NJ.

Fig. 14: Sample BBEDC048, Tuckerton Bay, NJ.

Fig. 15: Sample BBDC0080, Barnegat Bay, NJ.

Figs 16-17: ***Navicula* cf. *arenaria***

Fig. 16: Sample BBDC0030, Barnegat Bay, NJ.

Fig. 17: Sample BBDC0069, Barnegat Bay, NJ.

Fig. 18: ***Navicula* sp. 24**

Fig. 33: Sample COAST080, Great Bay, NJ.

Fig. 19: ***Navicula* sp. 60**

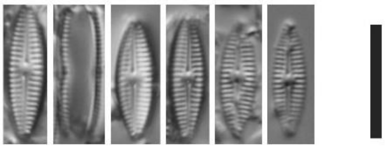
Fig. 19: Sample BB0053, Barnegat Bay, NJ.

Fig. 20: ***Navicula* sp. 12**

Fig. 20: Sample BBDC0052, Barnegat Bay, NJ.

Fig. 21: ***Navicula* sp. 57**

Fig. 21: Sample BBDC0069, Barnegat Bay, NJ.



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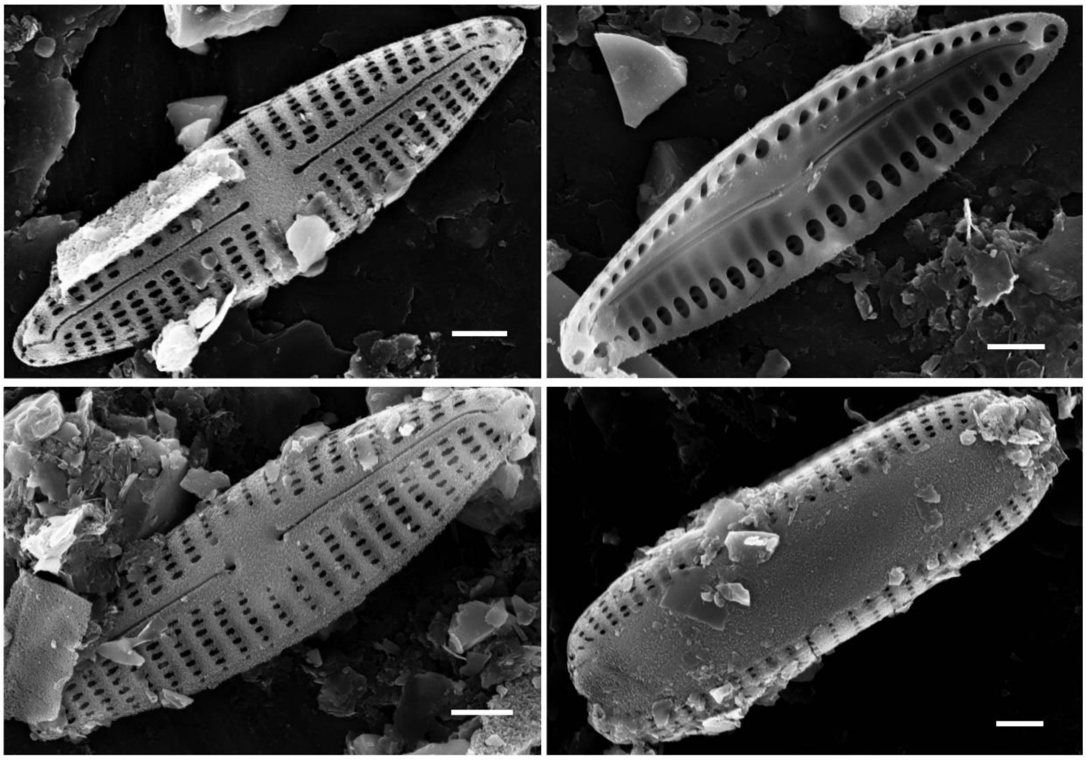
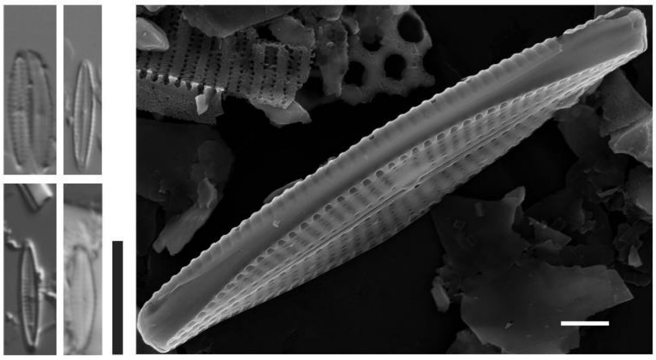
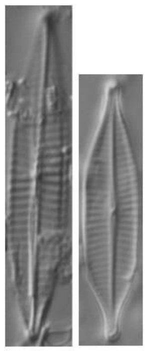


7 - 10



11 - 15



16 - 17

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Plate 198 (Scale bars: Figs 1-8, 10-28=10 µm; Fig. 9=1 µm)

Figs 1-3: ***Navicula bipustulata*** Mann

Lit.: Mann 1925, p. 18 F; pl. 1, fig. 6

Fig. 1: Sample BBDC0037, Barnegat Bay, NJ.
Fig. 2: Sample BBDC0012, Barnegat Bay, NJ.
Fig. 3: Sample BBDC0024, Cattus Island, NJ.

Fig. 4: ***Navicula* sp. 69**

Fig. 4: Sample BBDC0012, Barnegat Bay, NJ.

Figs 5-8: ***Navicula cancellata*** Donkin

Lit.: Donkin 1872, p. 55; pl. 8, fig. 4

Fig. 5,7: Sample BBDC0003, Barnegat Bay, NJ.
Fig. 6: Sample BBDC0045, Barnegat Bay, NJ.
Fig. 8: Sample BBDC0100, Great Bay, NJ.

Figs 9-14: ***Navicula* sp. 47**

Fig. 9: Sample BBDC0080, Barnegat Bay, NJ.
Fig. 10: Sample BBDC0048, Barnegat Bay, NJ.
Fig. 11: Sample COAST001, Peconic Bay, NY.
Fig. 12: Sample BBDC0091, Barnegat Bay, NJ.
Fig. 13: Sample BBDC0045, Barnegat Bay, NJ.
Fig. 14: Sample BBDC0064, Barnegat Bay, NJ.

Figs 15-18: ***Navicula* sp. 7**

Fig. 15: Sample BBDC0054, Barnegat Bay, NJ.
Fig. 16: Sample BBDC0091, Barnegat Bay, NJ.
Fig. 17: Sample BBDC0088, Barnegat Bay, NJ.
Fig. 18: Sample BBDC0051, Barnegat Bay, NJ.

Fig. 19: ***Navicula* sp. 25**

Fig. 15: Sample BBDC0059, Barnegat Bay, NJ.

Figs 20-24: ***Navicula* cf. *duerrenbergiana***

Fig. 20: Sample BBDC0056, Barnegat Bay, NJ.
Fig. 21: Sample BBEDC047, Tuckerton Bay, NJ.
Fig. 22: Sample BBDC0063, Barnegat Bay, NJ.
Fig. 23: Sample BB0038, Barnegat Bay, NJ.
Fig. 24: Sample BBDEC063, Cattus Island, NJ.

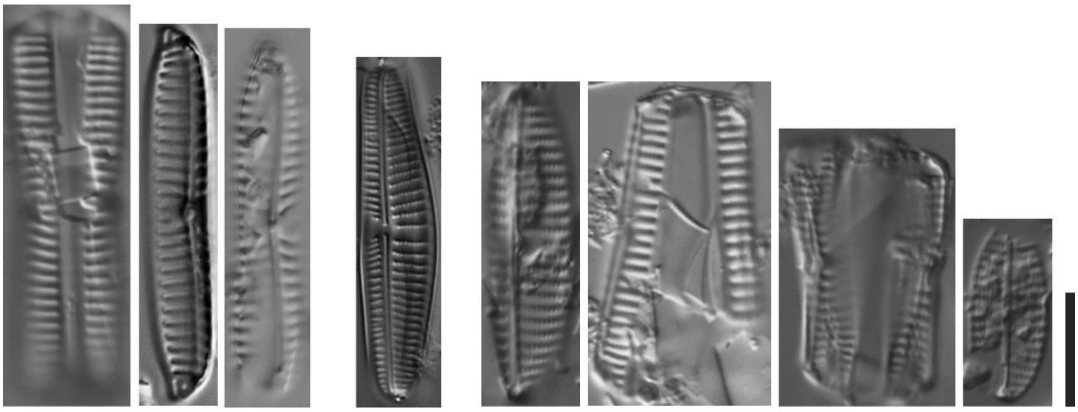
Figs 25-26: ***Navicula* cf. *formenterae***

Fig. 25: Sample BBDC0044, Barnegat Bay, NJ.
Fig. 26: Sample BBEDC002, Barnegat Bay, NJ.

Figs 27-28: ***Navicula pavillardi*** Hustedt

Lit.: Hustedt 1939, p. 635; fig. 86-90

Fig. 27: Sample BBDC0062, Barnegat Bay, NJ.
Fig. 28: Sample BBDC0056, Barnegat Bay, NJ.



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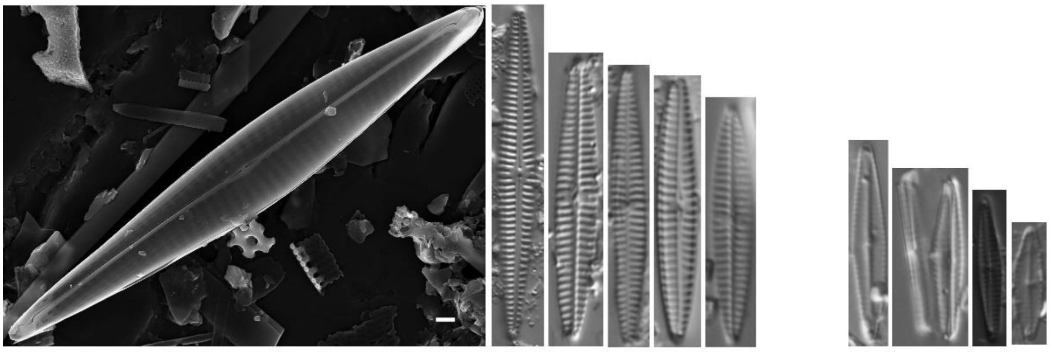
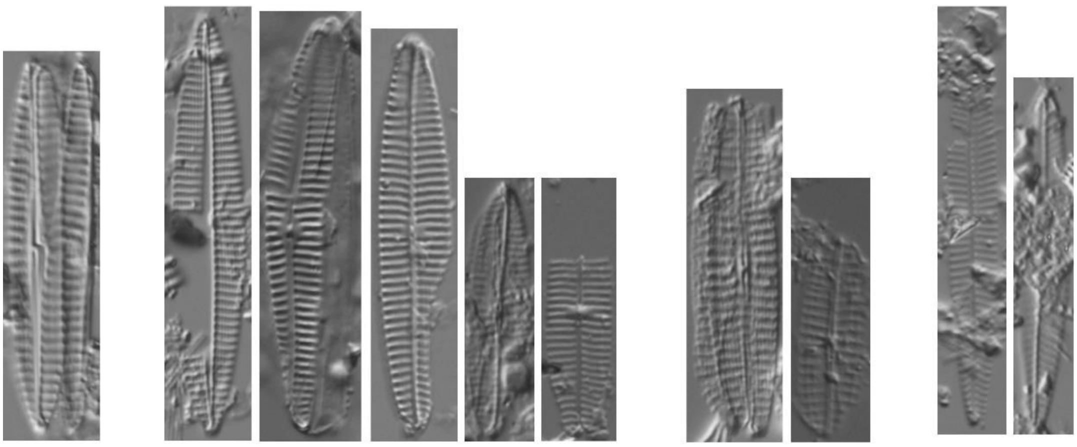


9 - 14 15 - 18



19 20 - 24 25 - 26 27 - 28

Plate 199 (Scale bar: Figs 1-38=10 µm)

Figs 1-6: ***Navicula* sp. 13**

Fig. 1: Sample BBDC0071, Barnegat Bay, NJ.
Fig. 2,4-5: Sample BBDC0052, Barnegat Bay, NJ.
Fig. 3: Sample BBDC0009, Barnegat Bay, NJ.
Fig. 6: Sample BBDC0018, Barnegat Bay, NJ.

Figs 7-14: ***Navicula* sp. 45**

Fig. 7: Sample BB0063, Barnegat Bay, NJ.
Fig. 8-14: Sample BBDC0052, Barnegat Bay, NJ.

Figs 15-17: ***Navicula* sp. 120**

Figs 15-17: Sample BBDC0052, Barnegat Bay, NJ.

Figs 18-19: ***Navicula* sp. 8**

Figs 18-19: Sample BBDC0052, Barnegat Bay, NJ.

Fig. 20: ***Navicula* sp. 19**

Fig. 21: Sample RUTG0844, Leeds Point, NJ.

Figs 21-26: ***Navicula* sp. 50**

Fig. 21: Sample BBDC0063, Barnegat Bay, NJ.
Fig. 22: Sample BBDC0051, Barnegat Bay, NJ.
Fig. 23: Sample BBDC0062, Barnegat Bay, NJ.
Fig. 24: Sample COAST004, Peconic Bay, NY.
Fig. 25: Sample BB0083, Tuckerton Bay, NJ.
Fig. 26: Sample BBDC0002, Barnegat Bay, NJ.

Fig. 27: ***Navicula* sp. 20**

Fig. 27: Sample BBDC0049, Barnegat Bay, NJ.

Fig. 28: ***Navicula lineola* var. *perlepida*** (Grunow) Cleve

Lit.: Cleve 1894, p. 107

Fig. 28: Sample BBDC0034, Barnegat Bay, NJ.

Figs 29-30: ***Navicula* sp. 80**

Fig. 29: Sample BBDC0068, Barnegat Bay, NJ.
Fig. 30: Sample BBDC0051, Barnegat Bay, NJ.

Figs 31-33: ***Navicula* sp. 48**

Fig. 31,33: Sample BBDC0051, Barnegat Bay, NJ.
Fig. 32: Sample BBDC0059, Barnegat Bay, NJ.

Fig. 34: ***Navicula* sp. 28**

Fig. 34: Sample BB0059, Barnegat Bay, NJ.

Figs 35-38: ***Navicula* sp. 39**

Fig. 35: Sample COAST023, Great South Bay, NY.
Fig. 36: Sample BBDC0036, Barnegat Bay, NJ.
Fig. 37: Sample BBDC0008, Barnegat Bay, NJ.
Fig. 38: Sample BBDC0051, Barnegat Bay, NJ.

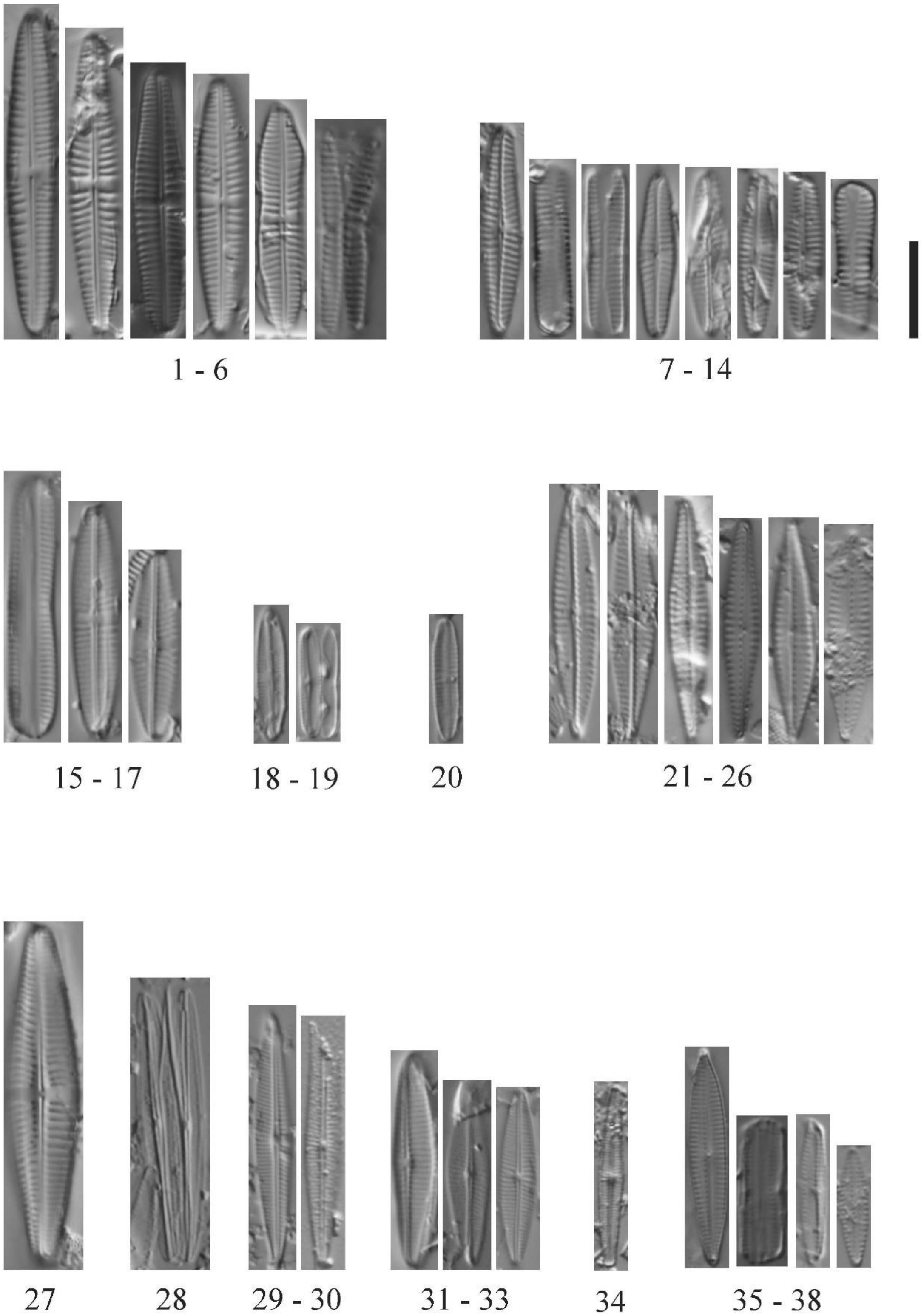

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Plate 200 (Scale bars: Figs 1-3, 6, 8, 11-19; 21-27=10 µm; Figs 4, 7, 9, 10, 20=1 µm)

Figs 1-4: ***Navicula* sp. 32**

Figs 1-2: Sample BBDC0064, Barnegat Bay, NJ.
Fig. 3: Sample BBDC0018, Barnegat Bay, NJ.
Fig. 4: Sample BBDC0050, Barnegat Bay, NJ.

Figs 5-7: ***Navicula* sp. 11**

Fig. 5: Sample BBDC0001, Barnegat Bay, NJ.
Fig. 6: Sample BBDC0052, Barnegat Bay, NJ.
Fig. 7: Sample BBDC0071, Barnegat Bay, NJ.

Figs 8-9: ***Navicula* sp. 21**

Fig. 8: Sample BBDC0071, Barnegat Bay, NJ.
Fig. 9: Sample BBDC0081, Barnegat Bay, NJ.

Figs 10-14: ***Navicula* sp. 2**

Fig. 10: Sample BBDC0080, Barnegat Bay, NJ.
Fig. 11: Sample BBEDC043, Tuckerton Bay, NJ.
Fig. 12: Sample COAST003, Peconic Bay, NY.
Fig. 13: Sample BBDC0052, Barnegat Bay, NJ.
Fig. 14: Sample BBDC0001, Barnegat Bay, NJ.

Fig. 15: ***Navicula* sp. 16**

Fig. 15: Sample COAST023, Great South Bay, NY.

Fig. 16: ***Navicula* sp. 116**

Fig. 15: Sample COAST053, Barnegat Bay, NY.

Fig. 17: ***Navicula* sp. 36**

Fig. 17: Sample BBDC0046, Barnegat Bay, NJ.

Fig. 18: ***Navicula* sp. 40**

Fig. 18: Sample BBDC0063, Barnegat Bay, NJ.

Figs 19-20: ***Navicula* sp. 44**

Fig. 19: Sample BBDC0003, Barnegat Bay, NJ.
Fig. 20: Sample BBDC0050, Barnegat Bay, NJ.

Figs 21-23: ***Navicula* sp. 43**

Figs 21-23: Sample BBDC0058, Barnegat Bay, NJ.

Figs 24-27: ***Navicula* sp. 106**

Fig. 24: Sample COAST003, Peconic Bay, NY.
Figs 25-26: Sample BBDC0053, Barnegat Bay, NY.
Fig. 27: Sample BBDC0058, Barnegat Bay, NY.

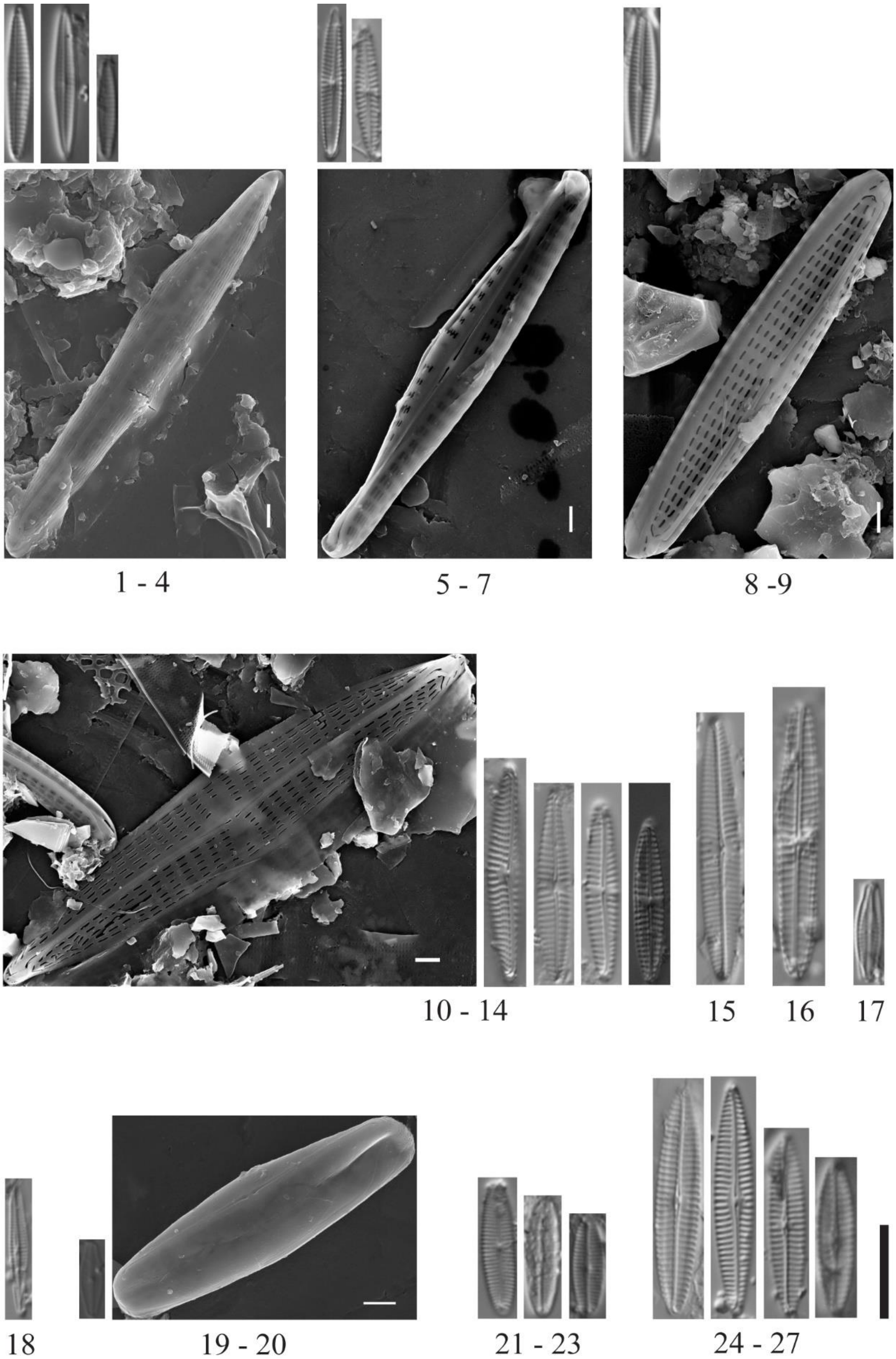
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Plate 201 (Scale bar: Figs 1-39=10 µm)

Figs 1-8: ***Navicula* cf. *veneta***

Fig. 1: Sample BBDC0052, Barnegat Bay, NJ.
Fig. 2: Sample BB0049, Barnegat Bay, NJ.
Figs 3-5,7-8: Sample RUTG0981, Marvel Saltmarsh Preserve, DE.
Fig. 6: Sample BB0050, Barnegat Bay, NJ.

Figs 9-10: ***Navicula* sp. 10**

Figs 9-10: Sample BBDC0052, Barnegat Bay, NJ.

Fig. 11: ***Navicula* sp. 49**

Fig. 8: Sample BBDC0095, Barnegat Bay, NJ.

Fig. 12: ***Navicula* sp. 46**

Fig. 12: Sample BB0010, Barnegat Bay, NJ.

Fig. 13: ***Navicula* sp. 56**

Fig. 13: Sample BBDC0088, Barnegat Bay, NJ.

Figs 14-20: ***Navicula abunda*** Hustedt

Lit: Hustedt 1955, p. 27; pl. 9, fig. 10-12

Fig. 14: Sample BBDC0027, Barnegat Bay, NJ.
Fig. 15: Sample COAST062, Great Bay, NJ.
Fig. 16: Sample BBEDC079, Cattus Island, NJ.
Fig. 17: Sample BBDC0088, Barnegat Bay, NJ.
Fig. 18: Sample COAST023, Great South Bay, NY.
Fig. 19: Sample BBDC0003, Barnegat Bay, NJ.
Fig. 20: Sample BB0067, Barnegat Bay, NJ.

Fig. 21: ***Navicula* sp. 59**

Fig. 31: Sample BBDC0058, Barnegat Bay, NY.

Fig. 22: ***Navicula* sp. 109**

Fig. 22: Sample COAST025, Great South Bay, NY.

Figs 23-25: ***Navicula* sp. 103**

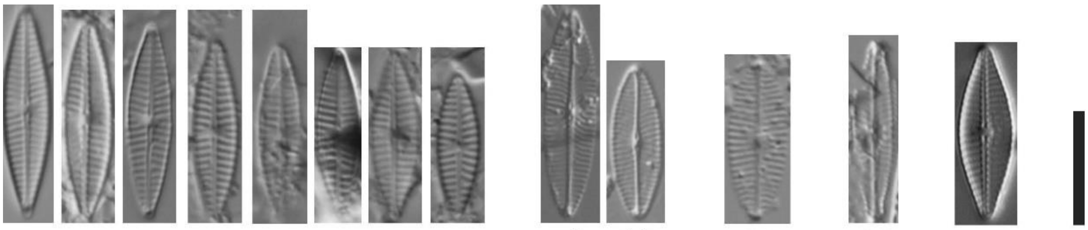
Fig. 23: Sample COAST004, Peconic Bay, NY.
Fig. 24: Sample COAST016, Great South Bay, NY.
Fig. 25: Sample COAST011, Great South Bay, NY.

Figs 26-34: ***Navicula* sp. 57**

Fig. 26: Sample BBDC0015, Barnegat Bay, NJ.
Fig. 27,31-32,34: Sample BBEDC058, Cattus Island, NJ.
Fig. 28: Sample BBDC0013, Barnegat Bay, NJ.
Fig. 29: Sample BBDC0027, Barnegat Bay, NJ.
Fig. 30: Sample BBDC0061, Barnegat Bay, NJ.
Fig. 33: Sample BBDC0056, Barnegat Bay, NJ.

Figs 35-39: ***Navicula* sp. 41**

Fig. 35: Sample BBDC0018, Barnegat Bay, NY.
Figs 36-37: Sample BBDC0001, Barnegat Bay, NY.
Fig. 38: Sample BBDC0058, Barnegat Bay, NY.
Fig. 39: Sample BBDC0003, Barnegat Bay, NY.



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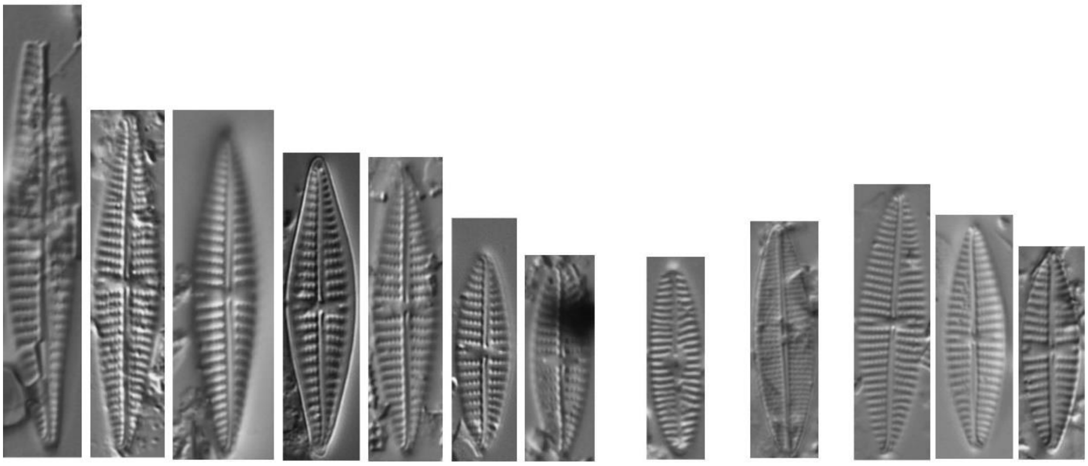
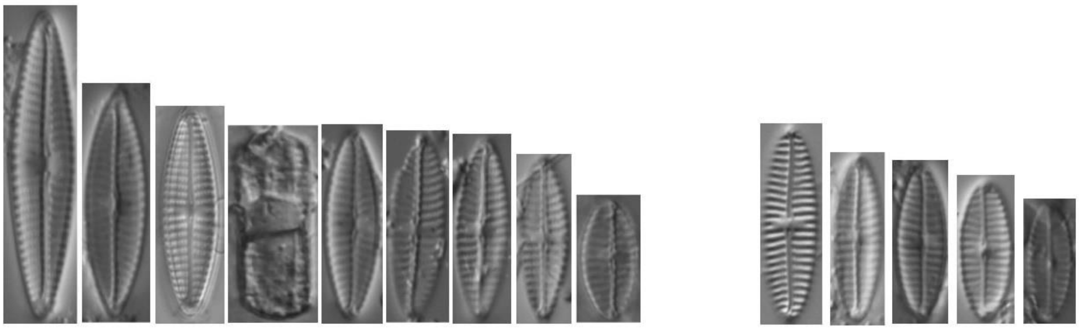


14 - 20 21 22 23 - 25



26 - 34 35 - 39

Plate 202 (Scale bar: Figs 1-44=10 µm)

Figs 1-15: ***Navicula* sp. 54**

Figs 1-3,7,9-12: Sample RUTG0010, Cape May Courthouse, NJ.
Figs 4,13,15: Sample RUTG0001, Cape May Courthouse, NJ.
Fig. 5: Sample RUTG0004, Cape May Courthouse, NJ.
Fig. 6: Sample BB0022, Barnegat Bay, NJ.
Fig. 8: Sample BB0049, Barnegat Bay, NJ.
Fig. 14: Sample BBDC0103, Great Bay, NJ.

Figs 16-27: ***Navicula diversistriata*** Hustedt

Lit: Hustedt 1955, p. 28; pl. 9, fig. 6-9

Figs 16-19,21-24: Sample BBDC0108, Great Bay, NJ.
Fig. 20: Sample BBDC0080, Barnegat Bay, NJ.
Fig. 25: Sample BBDC0095, Barnegat Bay, NJ.
Fig. 26: Sample COAST025, Great South Bay, NY.
Fig. 27: Sample BBDC0045, Barnegat Bay, NJ.

Figs 28-30: ***Navicula* sp. 35**

Figs 28-29: Sample BBDC0001, Barnegat Bay, NJ.
Fig. 30: Sample BBDC0061, Barnegat Bay, NJ.

Figs 31-36: ***Navicula* sp. 30**

Fig. 31: Sample BB0011, Barnegat Bay, NJ.
Fig. 32,34-35: Sample BBDC0001, Barnegat Bay, NJ.
Fig. 33: Sample BBDC0084, Barnegat Bay, NJ.
Fig. 36: Sample BBDC0002, Barnegat Bay, NJ.

Fig. 37: ***Fogedia finmarchica*** (Cleve & Grunow) Witkowski, Metzeltin & Lange-Bertalot

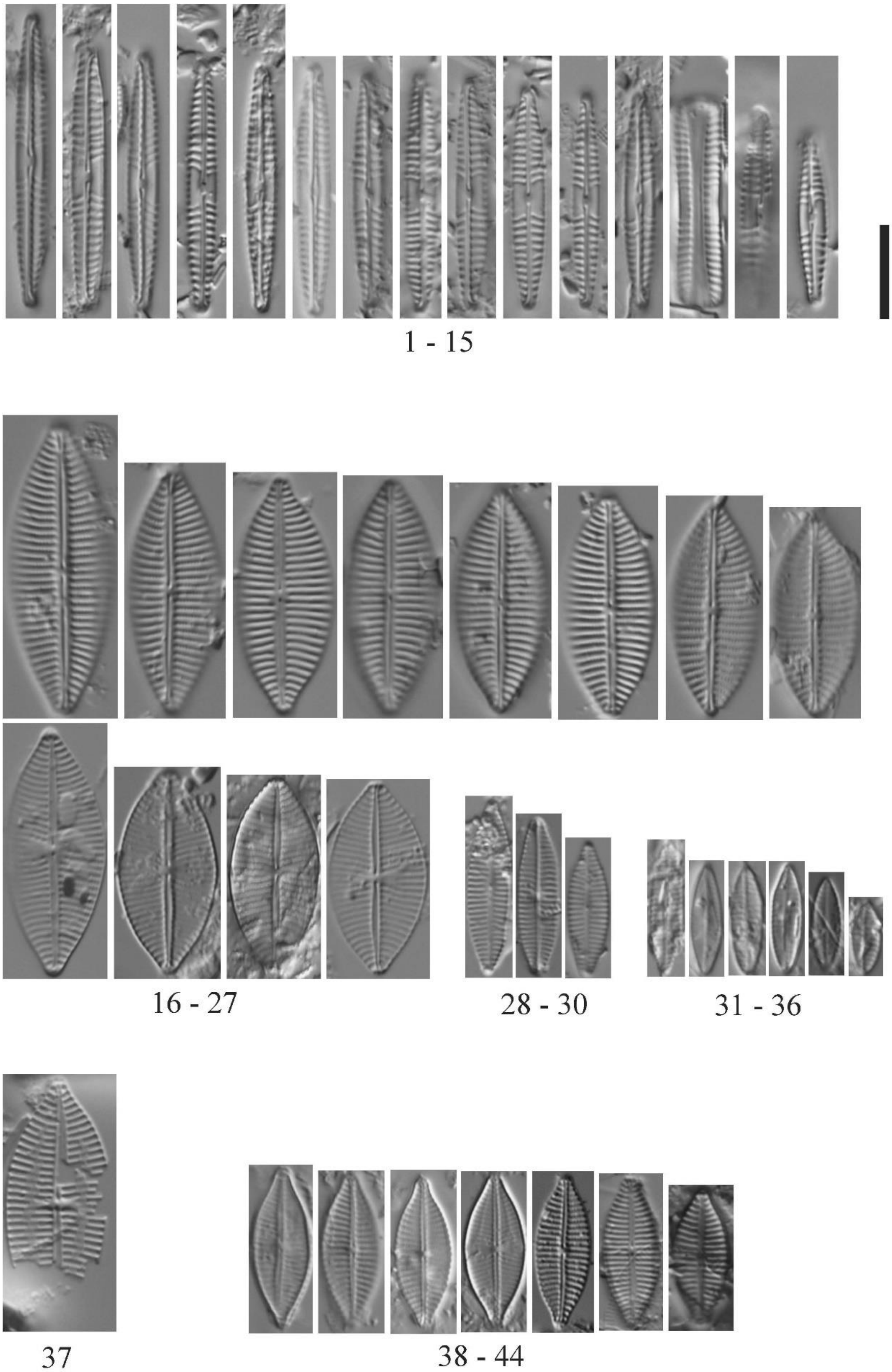
Lit: Witkowski, et al 1997, v. 65(1-4): p. 87; fig. 46-63
Basionym: *Stauroneis finmarchica* Cleve & Grunow 1880
Synonym: *Navicula finmarchica (finnmarchica)* (Cleve & Grunow) Cleve 1895
Schizonema finmarchicum (Cleve & Grunow) Kuntze 1898

Fig. 37: Sample BBDC0003, Barnegat Bay, NJ.

Figs 38 - 44: ***Fogedia heterovalvata*** (Simonsen) Witkowski, Lange-Bertalot & Metzeltin

Lit: Witkowski, Lange-Bertalot & Metzeltin 2000, p. 219
Basionym: *Navicula heterovalvata* Simonsen 1959

Figs 38-39: Sample BBDC0107, Great Bay, NJ.
Fig. 40: Sample COAST003, Peconic Bay, NY.
Fig. 41: Sample COAST003, Peconic Bay, NY.
Fig. 42: Sample BBDC0002, Barnegat Bay, NJ.
Fig. 43: Sample COAST021, Great South Bay, NY.
Fig. 44: Sample GB005, Great Bay, NJ.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38 - 44

Plate 203 (Scale bar: Figs 1-6=10 µm)

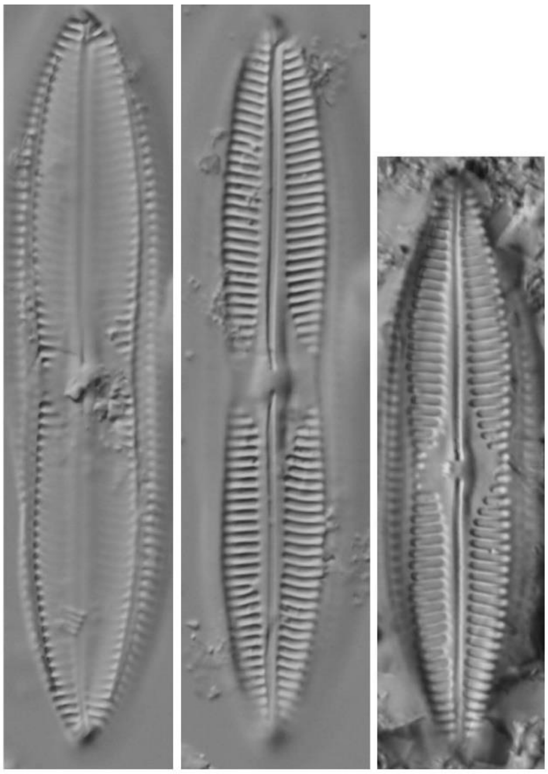
Figs 1-3: ***Navicula* sp. 3**

Figs 1-2: Sample BBDC0001, Barnegat Bay, NJ.
Fig. 3: Sample BB0052, Barnegat Bay, NJ.

Figs 4-6: ***Trachyneis aspera*** (Ehrenberg) Cleve

Lit: Cleve 1894, p. 191
Basionym: *Navicula aspera* Ehrenberg 1840
Synonym: *Schizonema asperum* (Ehrenberg) Kuntze 1898

Fig. 4: Sample BBDC0066, Barnegat Bay, NJ.
Fig. 5: Sample BBDC0004, Barnegat Bay, NJ.
Fig. 6: Sample BBDC0041, Barnegat Bay, NJ.



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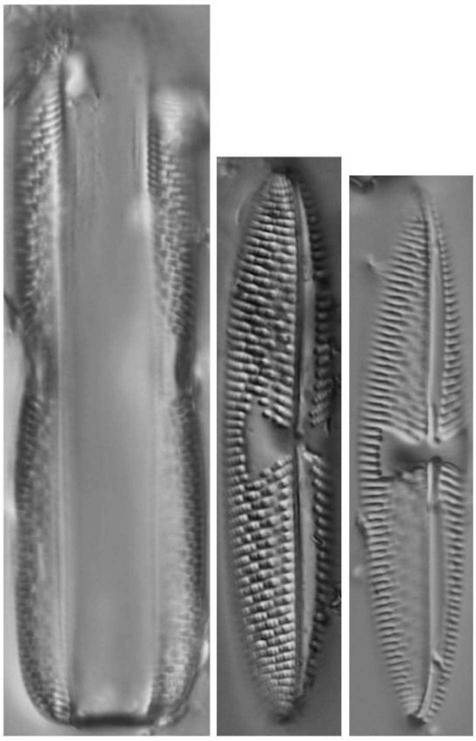
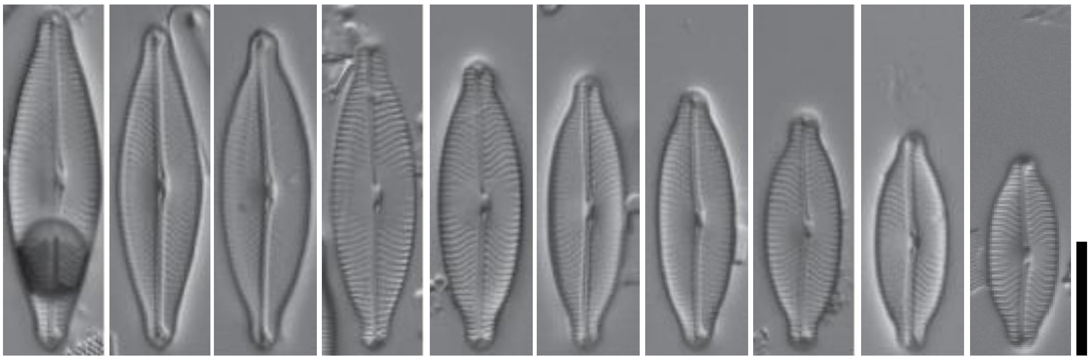


4 - 6

Plate 204 (Scale bar: Figs 1-10=10 µm)

Pinnuavis genustriata (Hustedt) Lange-Bertalot & Krammer
in Lange-Bertalot & Genkal 1999, p. 81

Basionym: *Navicula genustriata* Hustedt 1942



1 - 10

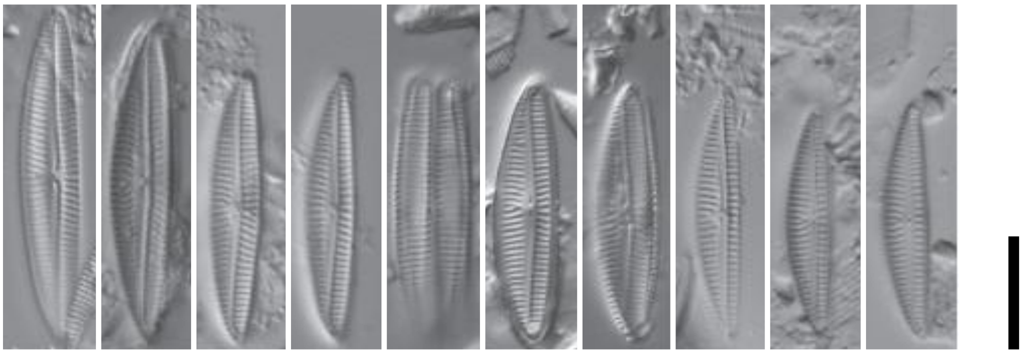
Plate 205 (Scale bars: Figs 1-10=10 µm; Figs 11-14=1 µm)

Seminavis pusilla (Grunow) Cox & Re

Lit.: Cox & G. Re 2004, p. 60

Basionym: *Cymbella pusilla* Grunow in Schmidt et al. 1875
Synonyms: *Cocconema pusilla* (Grunow in Schmidt et al.) W. & G.S. West 1911
Navicella pusilla (Grunow) Krammer 1997

Figs 1,3-5: Sample BB0002, Barnegat Bay, NJ.
Fig. 2: Sample BB0072, Barnegat Bay, NJ.
Fig. 6: Sample BB0001, Barnegat Bay, NJ.
Fig. 7: Sample BBDC0064, Barnegat Bay, NJ.
Figs 8-11,13-14: Sample BBDC0071, Barnegat Bay, NJ.
Fig. 12: Sample BB0003, Barnegat Bay, NJ.



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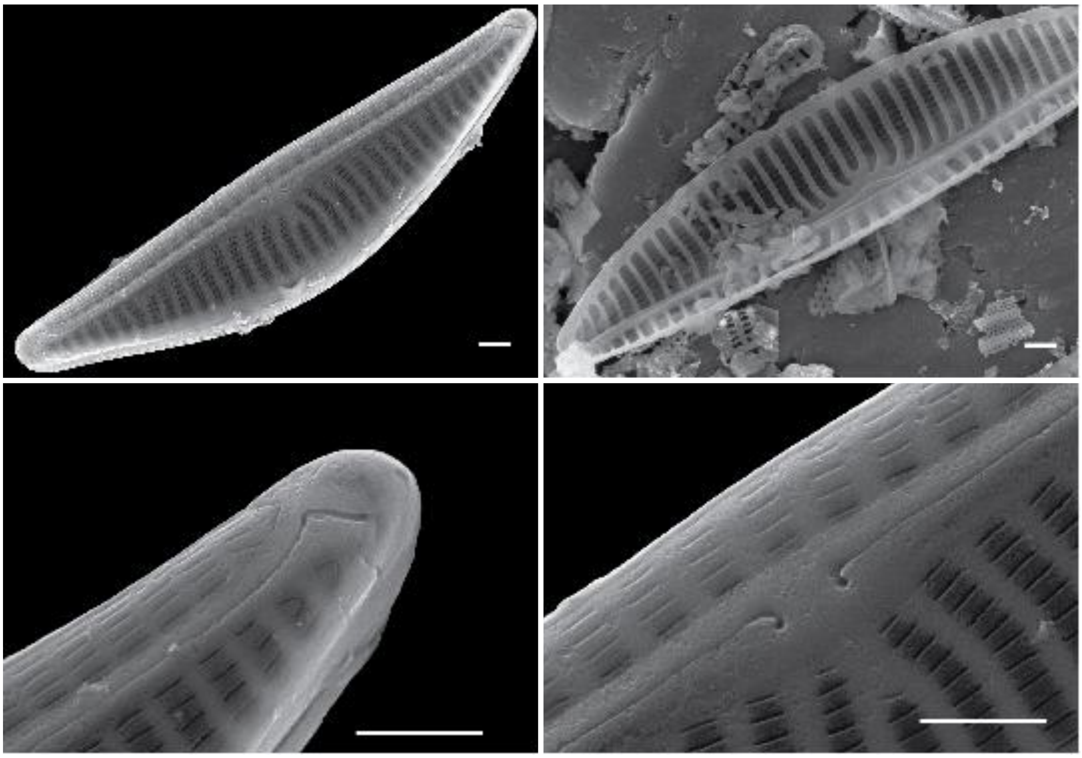
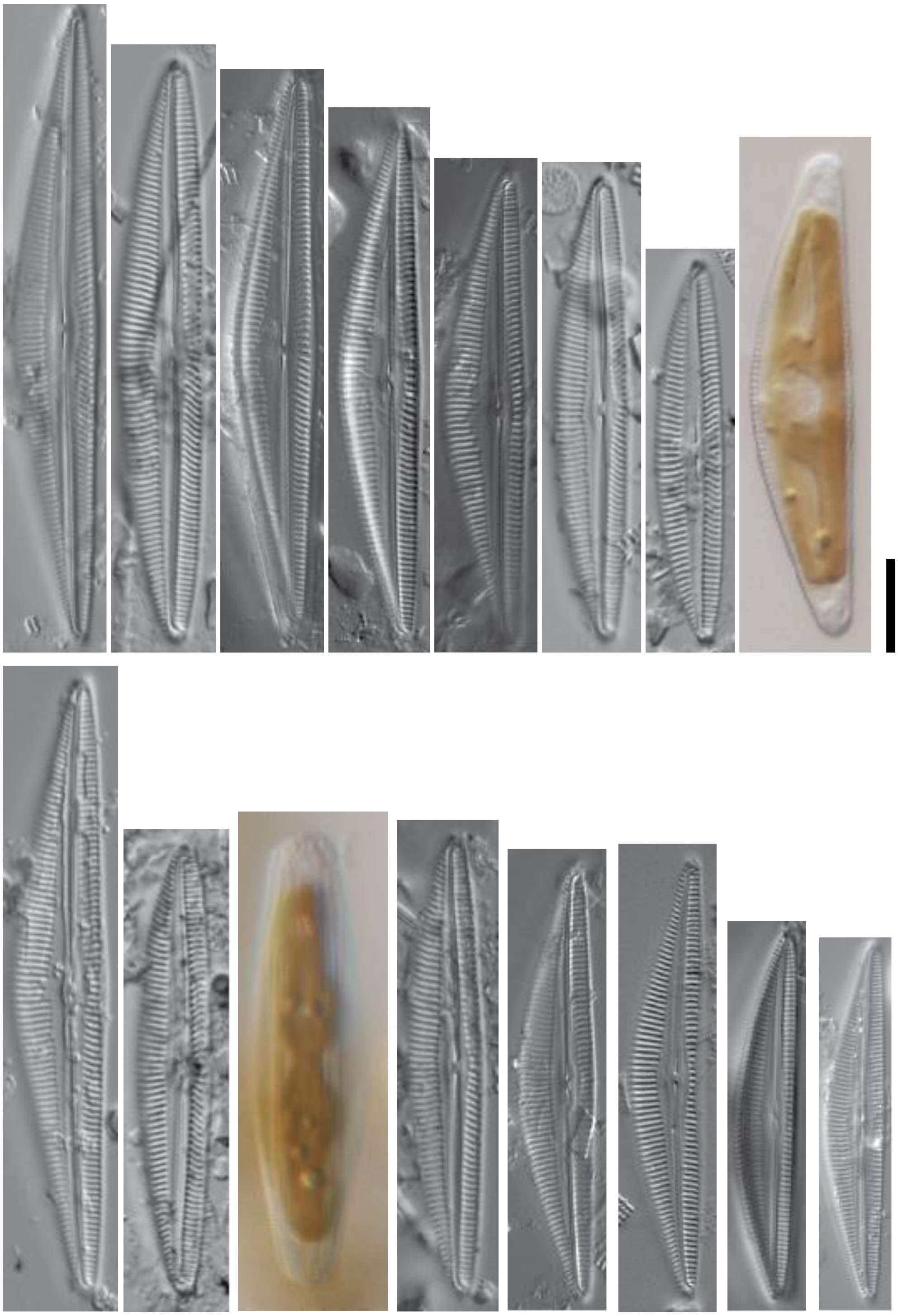


11 - 14

Plate 206 (Scale bar: Figs 1-16=10 µm)

Seminavis robusta Danielis & Mann

Lit.: Danielis & Mann 2002: 440, figs 39-53



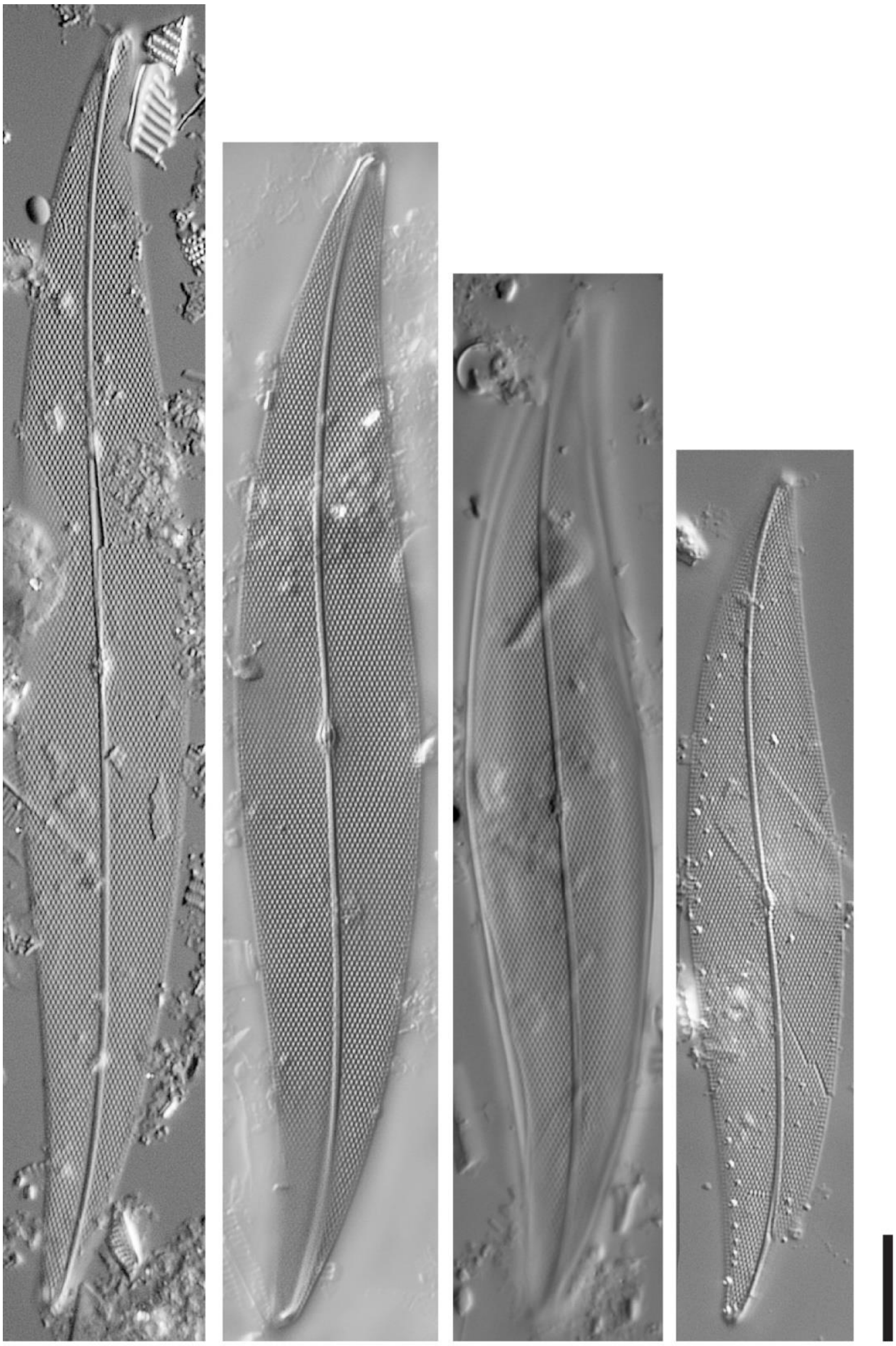
1 - 16

Plate 207 (Scale bar: Figs 1-4=10 µm)

Pleurosigma gracile Hustedt

Lit.: Hustedt 1955, p. 35; pl. 10, fig. 11

Fig. 1: Sample BBDC0004, Barnegat Bay, NJ.
Fig. 2: Sample BBDC0012, Barnegat Bay, NJ.
Fig. 3: Sample BBDC0008, Barnegat Bay, NJ.
Fig. 4: Sample BBDC0001, Barnegat Bay, NJ.



1 - 4

Plate 208 (Scale bar: Figs 1-6=10 µm)

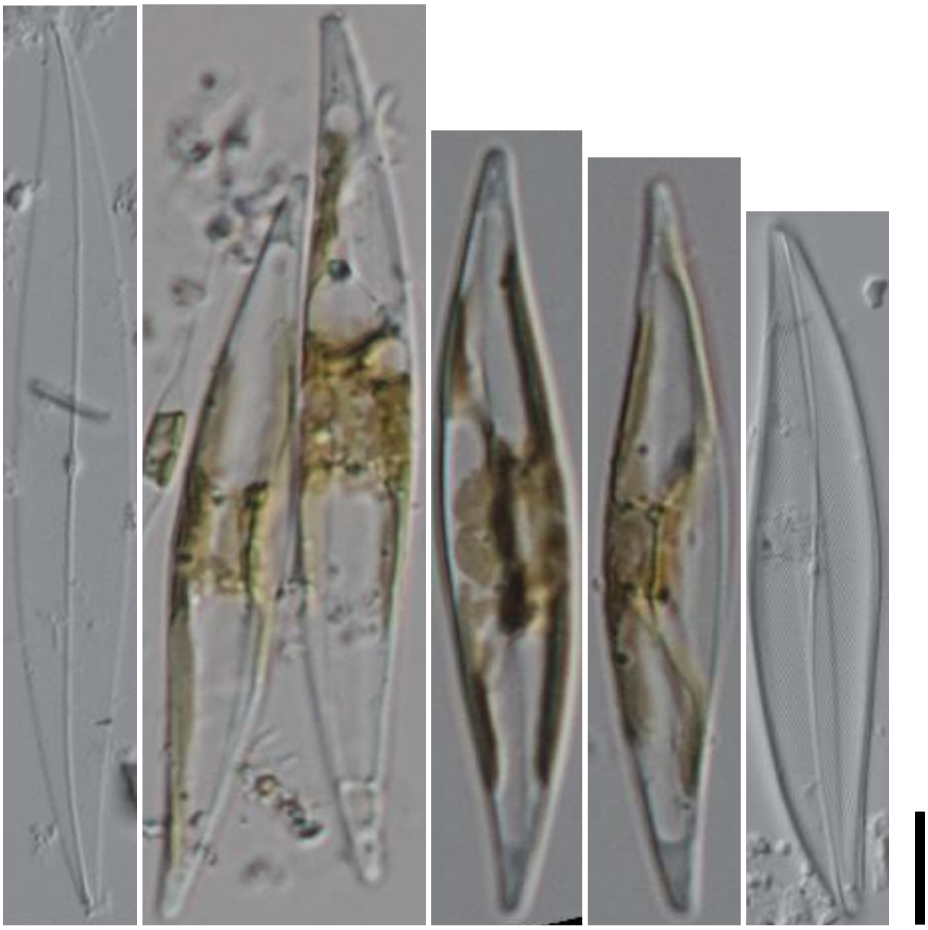
Figs 1-5: *Pleurosigma salinarum* (Grunow) Grunow in Cleve & Grunow

Lit.: Cleve & Grunow 1880, p. 54

Basionym: *Pleurosigma delicatulum* var. *salinarum* Grunow 1878
Synonyms: *Pleurosigma angulatum* f. *salinarum* (Grunow) De Toni 1891
Pleurosigma pusillum var. *salinarum* (Grunow) H. Peragallo 1891
Scalprum (Scalptrum) salinarum (Grunow) Kuntze 1891

Fig. 6: *Pleurosigma distinguendum* Hustedt

Lit.: Hustedt 1955, p. 36; pl. 11, fig. 3-5



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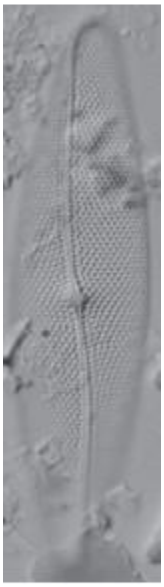

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Plate 209 (Scale bar: Figs 1-3=10 µm)

Fig. 1: *Pleurosigma indicum* Simonsen

Lit.: Simonsen 1974, p. 46; pl. 29, fig. 3

Fig. 2: *Gyrosigma parvulum* Hustedt

Lit.: Hustedt 1955, p. 34; pl. 10, fig. 6

Fig. 3: *Gyrosigma prolongatum* (W. Smith) Griffith & Henfrey

Lit.: Griffith & Henfrey 1856, p. 303; pl. 11, fig. 23

Basionym: *Pleurosigma prolongatum* Smith 1852

Synonyms: *Gyrosigma fasciola (fasciolum) var. prolongatum* (Smith) Proschkina-Lavrenko 1950
Pleurosigma fasciolum (fasciola) var. prolongatum (Smith) H. Peragallo 1891
Scalprum (Scalptrum) prolongatum (Smith) Kuntze 1891
Gyrosigma prolongatum (Smith) Cleve 1894

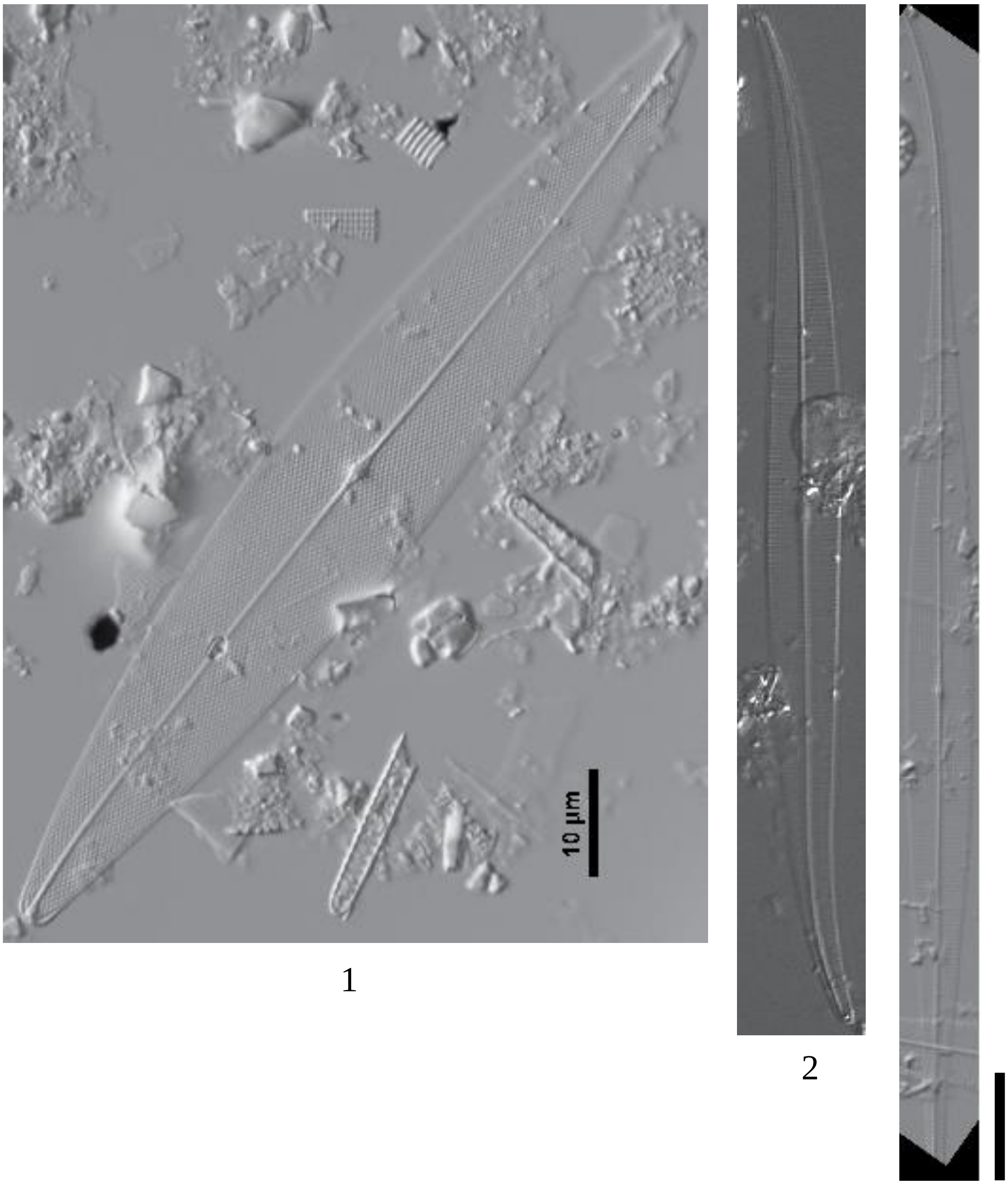

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Plate 210 (Scale bar: Figs 1-4=10 µm)

Gyrosigma fasciola (Ehrenberg) Griffith & Henfrey

Lit.: Griffith & Henfrey 1856, p. 303; pl. 11, fig. 21

Basionym: *Ceratoneis fasciola* Ehrenberg 1839
Synonyms: *Pleurosigma fasciolum (fasciola)* (Ehrenberg) Smith 1852
Scalprum (Scalptrum) fasciolum (Ehrenberg) Kuntze 1891
Gyrosigma fasciola (Ehrenberg) Cleve 1894

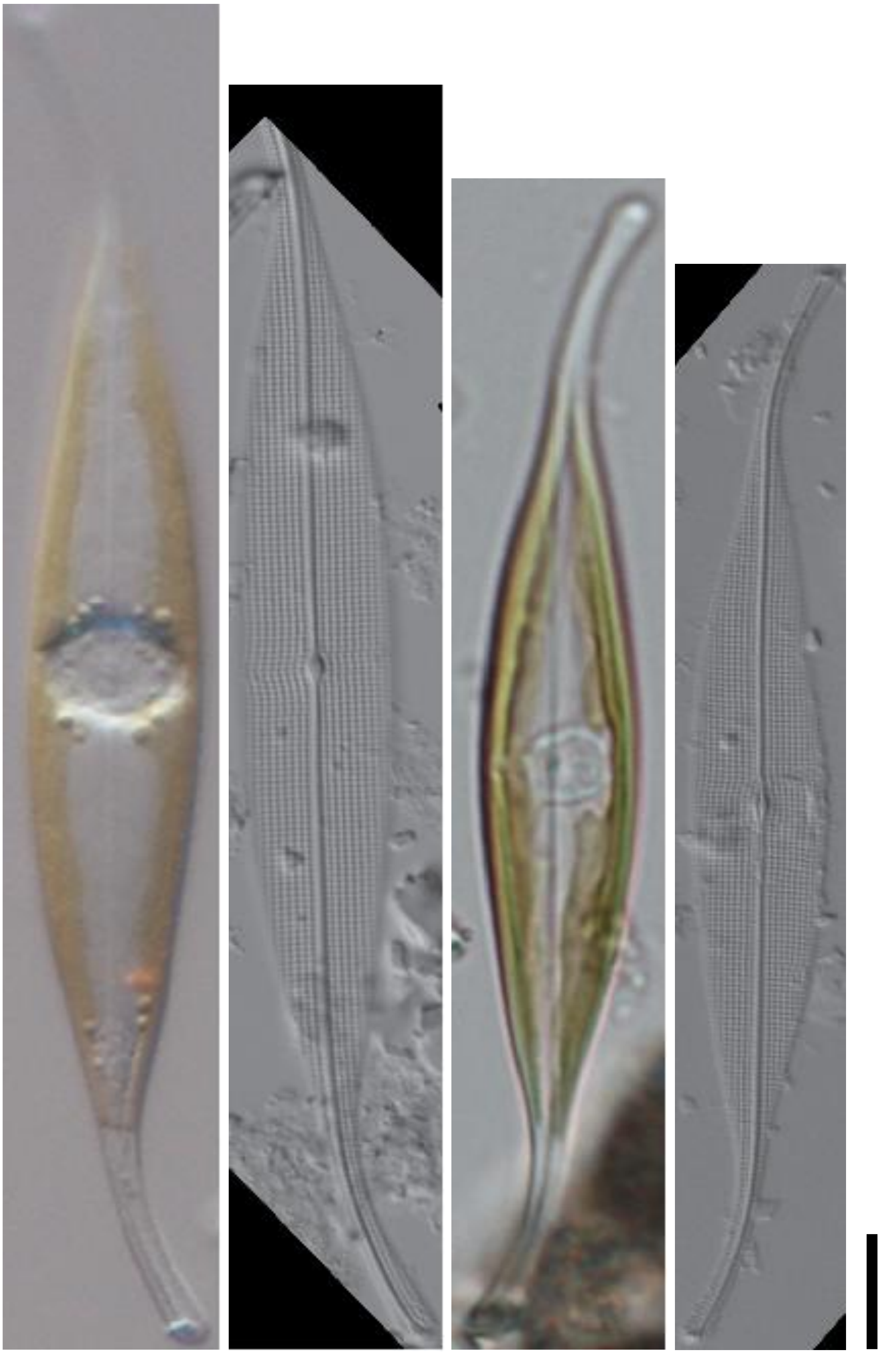

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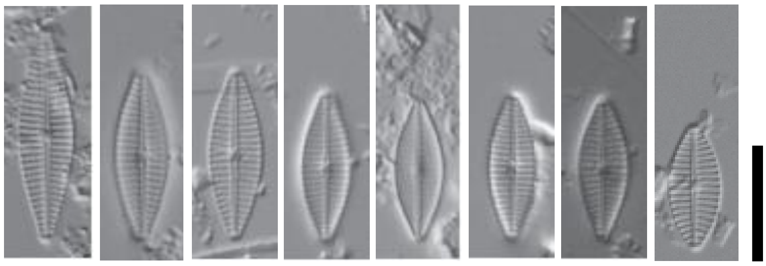
Plate 211 (Scale bars: Figs 1-8=10 µm; Fig 9-12=1 µm)

Craticula Sp. 1

Figs 1-2,8: Sample BBDC0091, Great Bay, NJ.
Fig. 3: Sample BBDC0053, Barnegat Bay, NJ.
Figs 4,6: Sample BBDC0018, Barnegat Bay, NJ.
Fig. 5: Sample BBDC0068, Barnegat Bay, NJ.
Fig. 7: Sample BBEDC058, Cattus Island, NJ.
Figs 9-12: Sample BBDC0054, Barnegat Bay, NJ.



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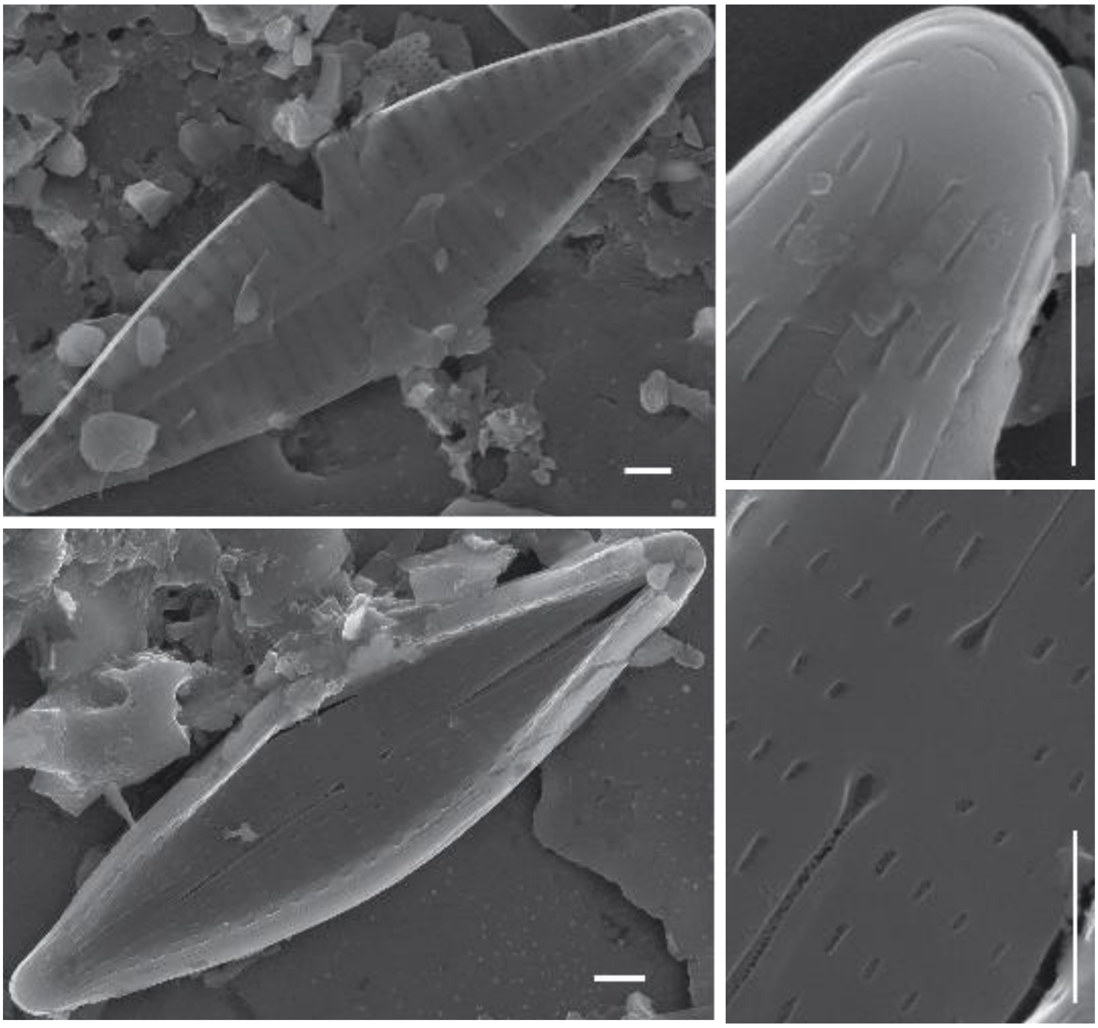


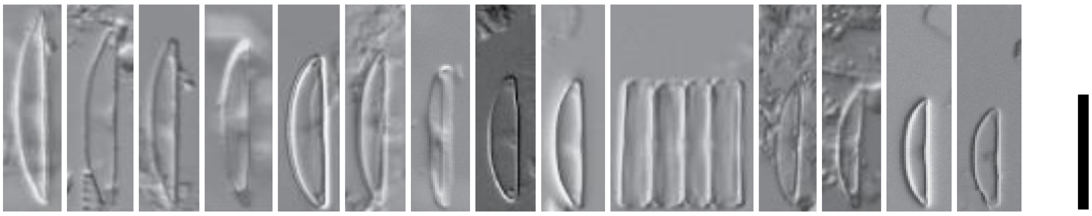
9 - 12

Plate 212 (Scale bars: Figs 1-14=10 µm; Fig. 15=1 µm)

Catenula adhaerens Mereschkowsky

Lit.: Mereschkowsky 1902, p. 103, 114; pl. 3, fig. 9-15

Figs 1,10: Sample COAST052, Barnegat Bay, NY.
Fig. 2: Sample BBDC0044, Barnegat Bay, NJ.
Fig. 3: Sample BB0052, Barnegat Bay, NJ.
Fig. 4: Sample BBDC0062, Barnegat Bay, NJ.
Fig. 5: Sample COAST001, Peconic Bay, NY.
Fig. 6: Sample BBDC0066, Barnegat Bay, NJ.
Fig. 7: Sample COAST051, Barnegat Bay, NY.
Figs 8-9: Sample BBDC0012, Barnegat Bay, NJ.
Fig. 11: Sample BB0069, Barnegat Bay, NJ.
Fig. 12: Sample BBEDC058, Cattus Island, NJ.
Figs 13-14: Sample BBDC0041, Barnegat Bay, NJ.
Fig. 15: Sample COAST054, Barnegat Bay, NY.



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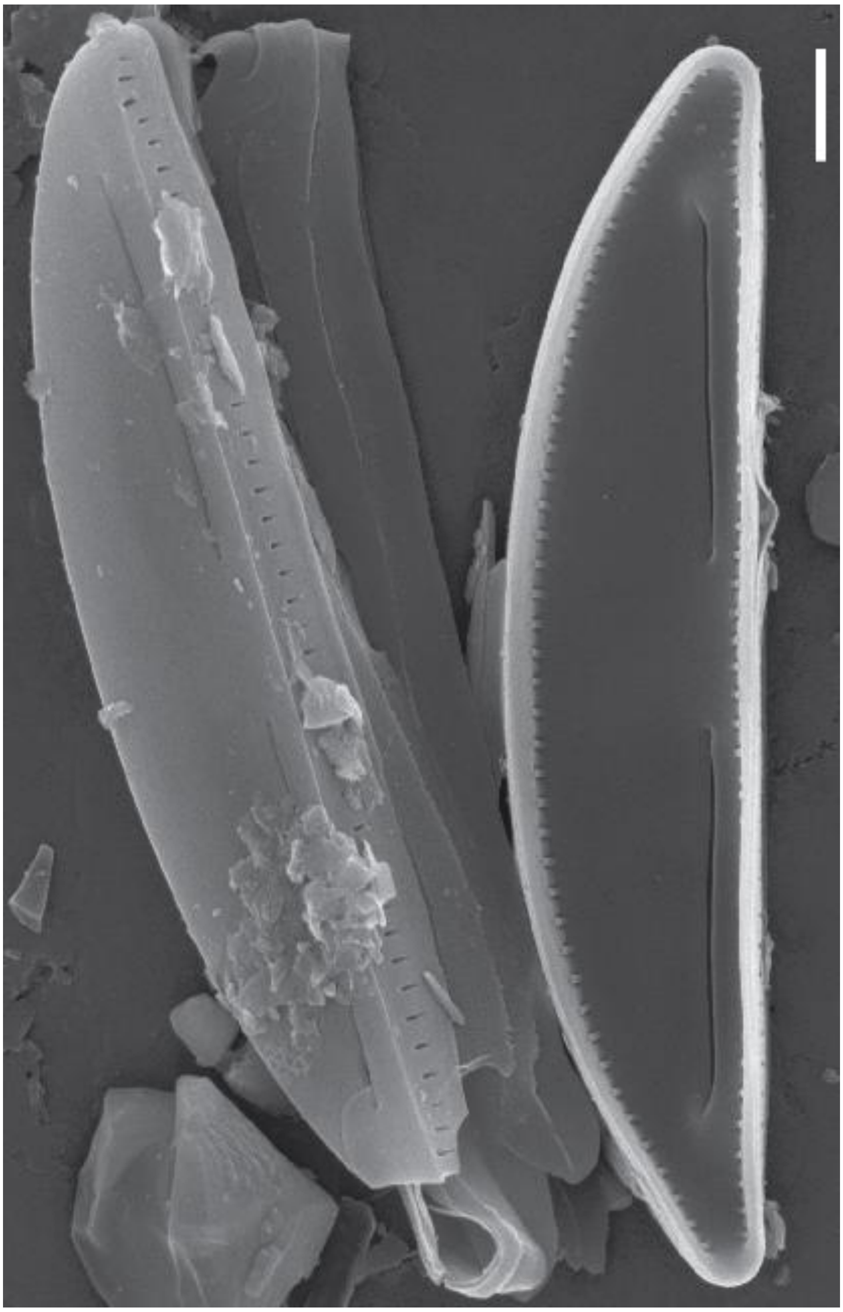

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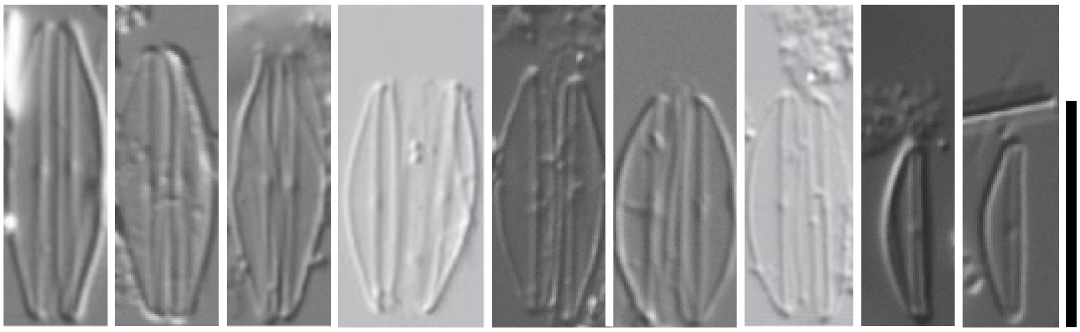
Plate 213 (Scale bars: Figs 1-9=10 µm; Figs 10-15=1 µm)

Amphora micrometra Giffen emend. Ács, Kiss & Levkov

Lit.: Ács, Kiss & Levkov 2011, p.199-212, figs 1-39

Figs 1-3,5-7,11: Sample BBDC0016, Barnegat Bay, NJ.
Figs 4: Sample BBDC0031, Barnegat Bay, NJ.
Figs 8-9: Sample GB001, Great Bay, NJ.
Figs 10,12-13: Sample BBDC0080, Barnegat Bay, NJ.
Figs 14-15: Sample BBDC0071, Barnegat Bay, NJ.



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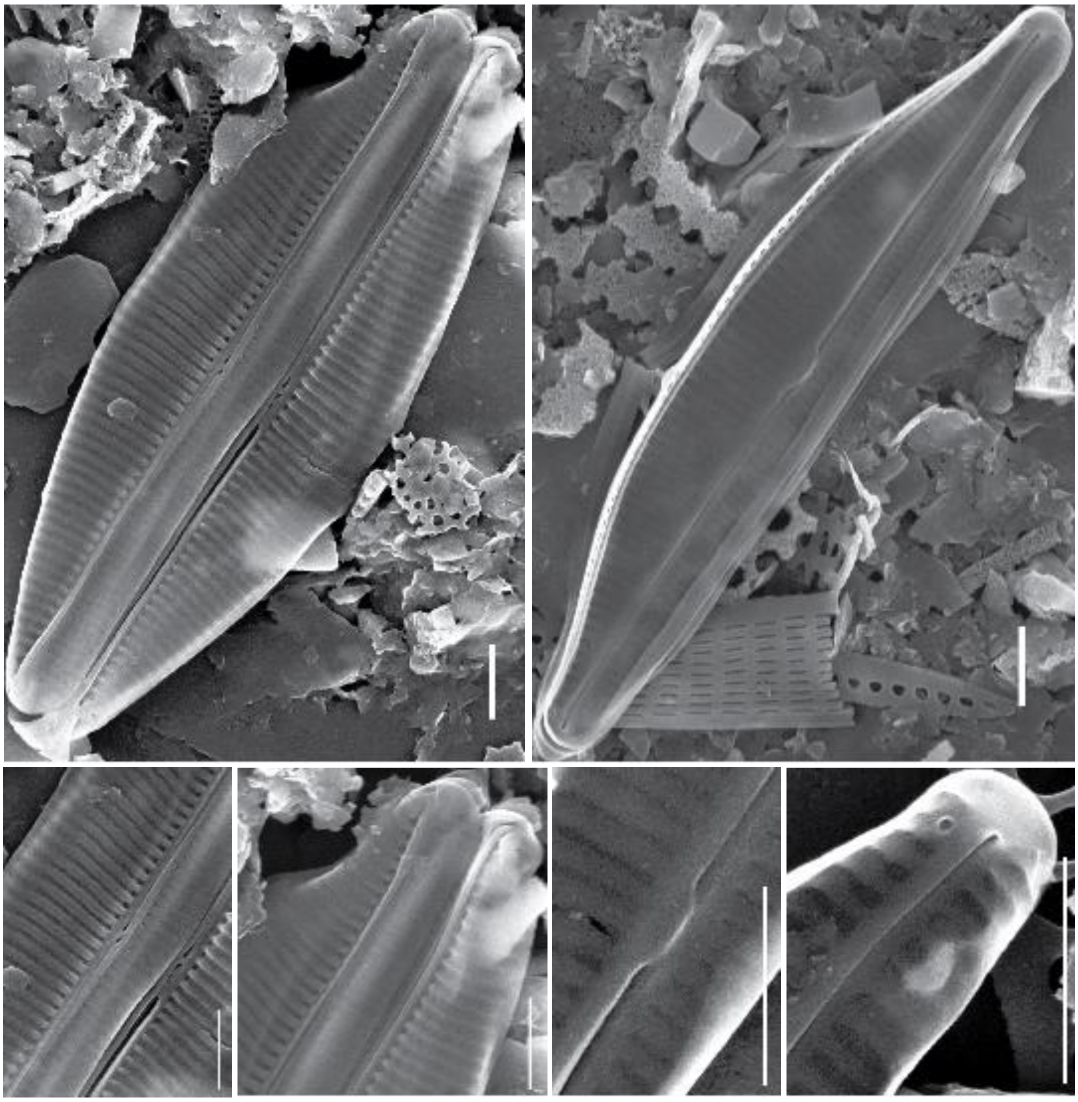


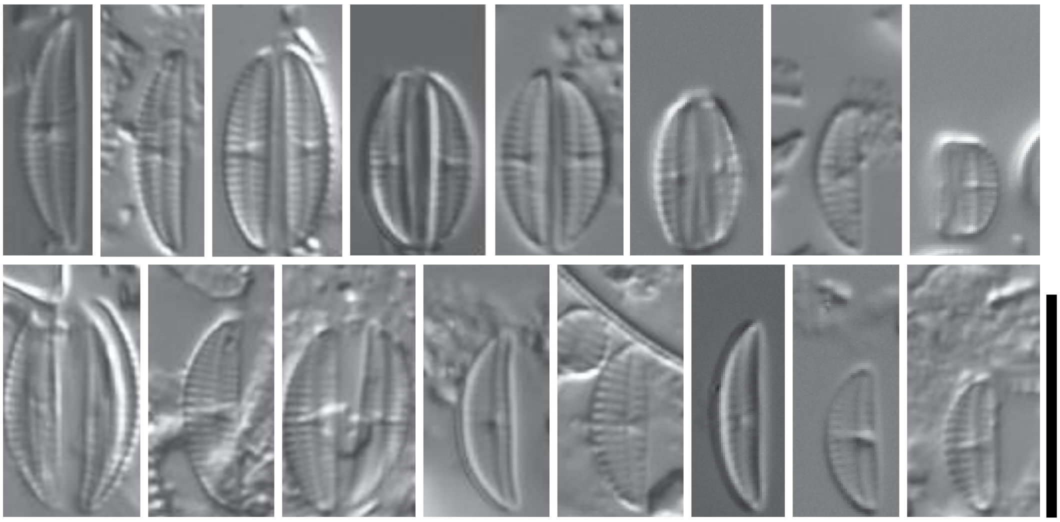
10- 15

Plate 214 (Scale bars: Figs 1-16=10 µm; Figs 17-19=1 µm)

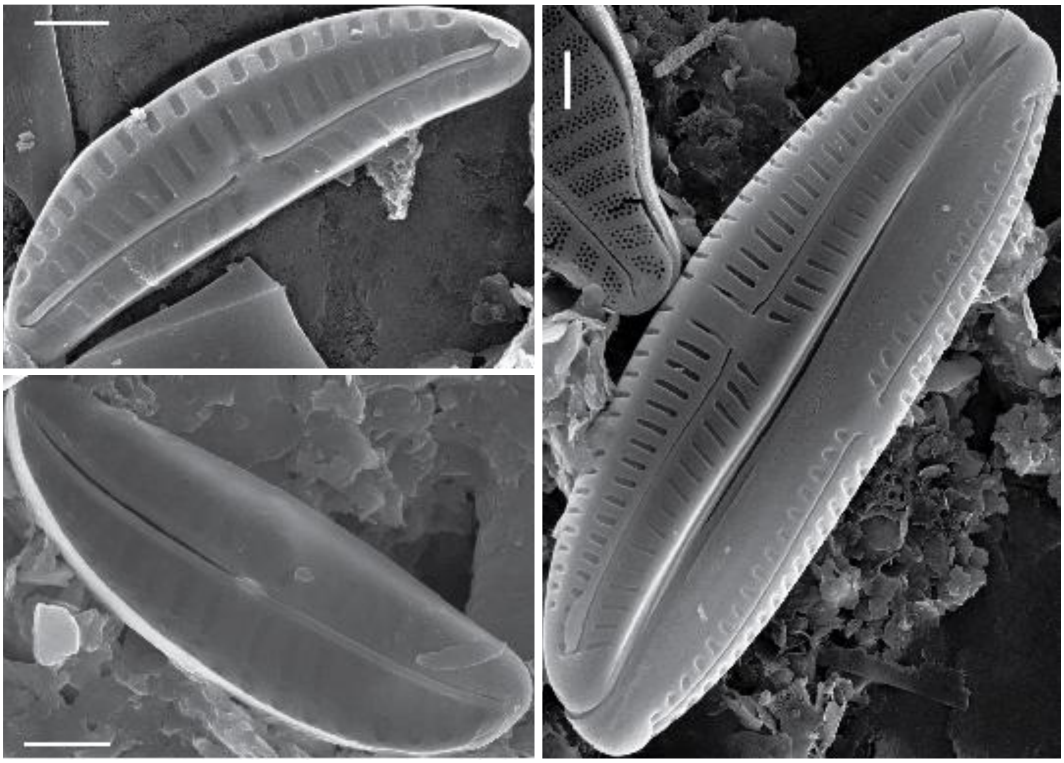
Amphora indistincta Levkov

Lit.: Levkov 2009, p. 69-70, 287; pl. 56, fig. 20-21; pl. 78, fig. 29-39; pl. 152, fig. 3; pl. 193, fig. 1-6; pl. 196, fig. 3

Figs 1,5,7,12,15-16: Sample BBDC0047, Barnegat Bay, NJ.
Figs 2-3,9-11,13: Sample COAST025, Great South Bay, NY.
Figs 4,6,8,14: Sample COAST001, Peconic Bay, NY.



1 - 16

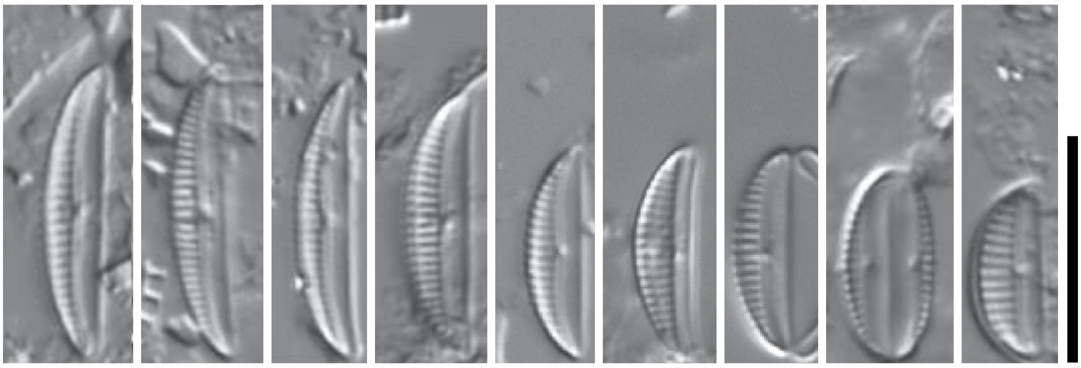


17 - 19

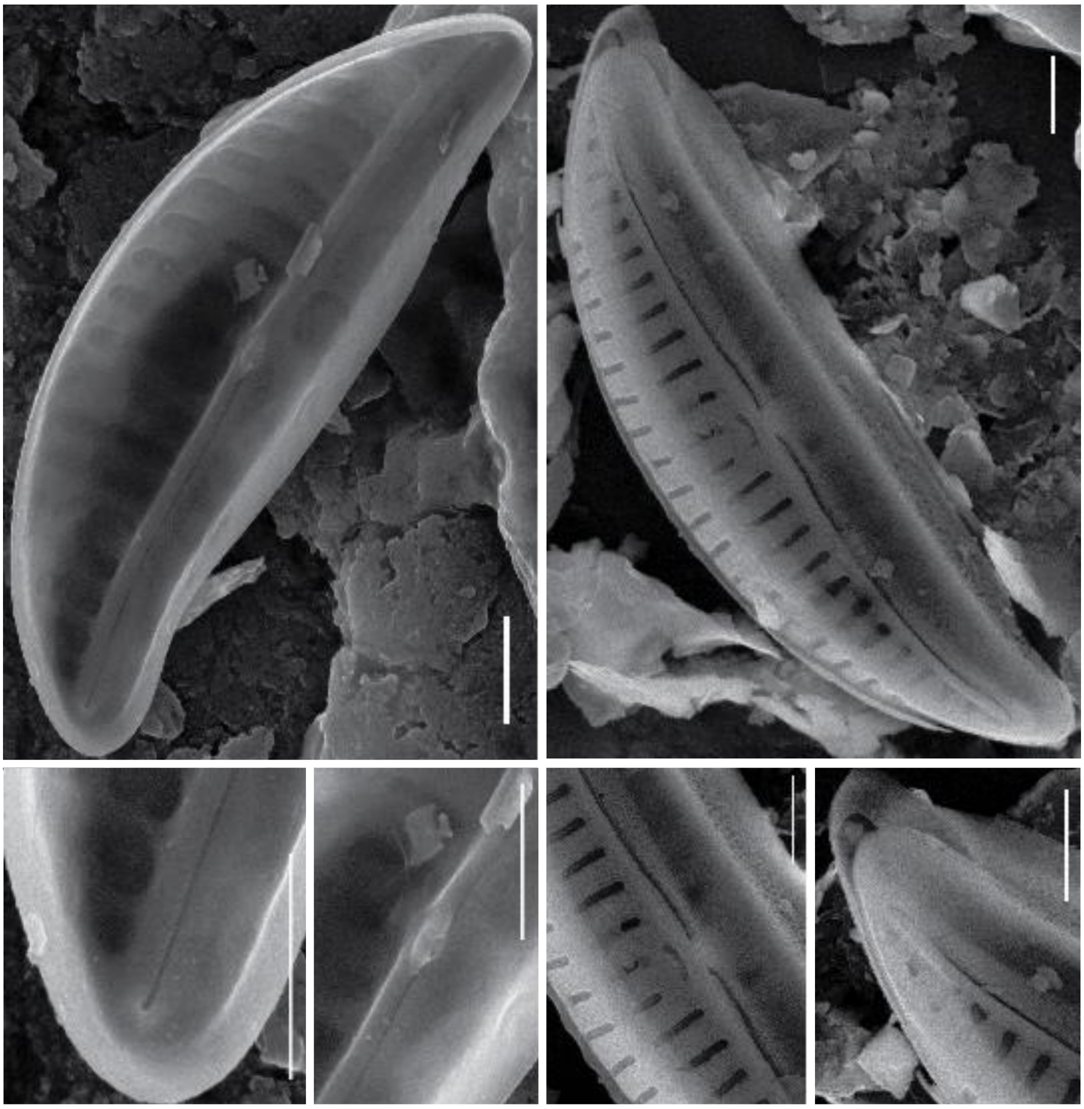
Plate 215 (Scale bars: Figs 1-9=10 µm; Figs 10-15=1 µm)

Amphora sp. 2

Figs 1-9: Sample COAST025, Great South Bay, NY.
Figs 10,12-13: Sample BBDC0003, Barnegat Bay, NJ.
Figs 11,14-15: Sample BBDC0054, Barnegat Bay, NJ.



1 - 9



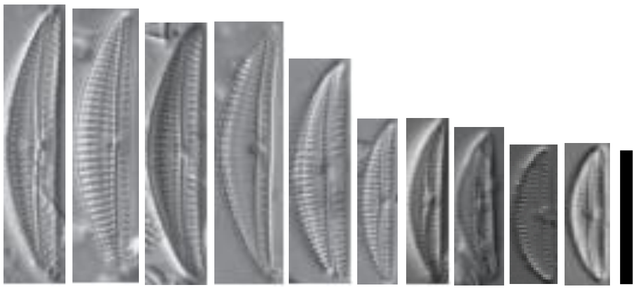
10 - 15

Plate 216 (Scale bar: Figs 1-10=10 µm)

Amphora pusio Cleve

Lit.: Cleve 1895, p. 102; pl. 3, fig. 40

Fig. 1: Sample COAST031, Western Bay, NY.
Figs 2-4: Sample COAST011, Great South Bay, NY.
Figs 5: Sample COAST010, Great South Bay, NY.
Figs 6: Sample COAST012, Great South Bay, NY.
Figs 7-8,10: Sample COAST001, Peconic Bay, NY.
Fig. 9: Sample BBDC0002, Barnegat Bay, NJ.



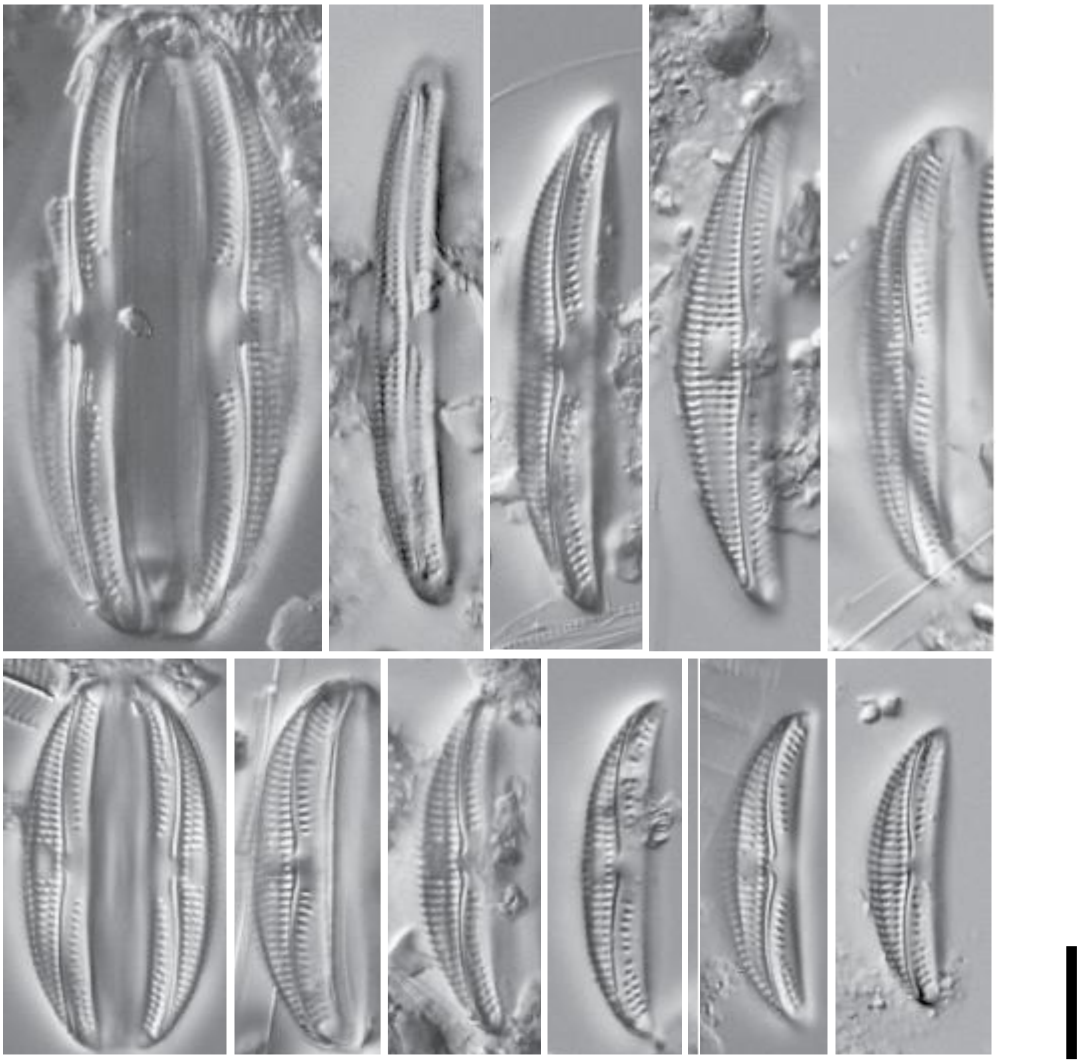
1 - 10

Plate 217 (Scale bars: Figs 1-11=10 µm; Fig 12-13=1 µm)

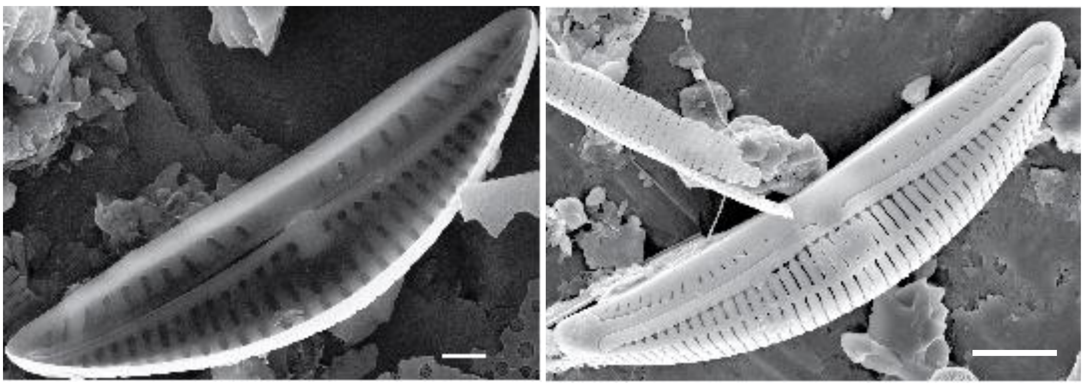
Amphora allanta Hohn & Hellerman

Lit.: Hohn & Hellerman 1966, p. 119; pl. 1, fig. 24

Figs 1,3-11: Sample GC44890, Middle River, MD.
Fig.2: Sample GC44890, Middle River, MD. Holotype specimen.
Fig. 12: Sample BBDC0051, Barnegat Bay, NJ.



1 - 11



12 - 13

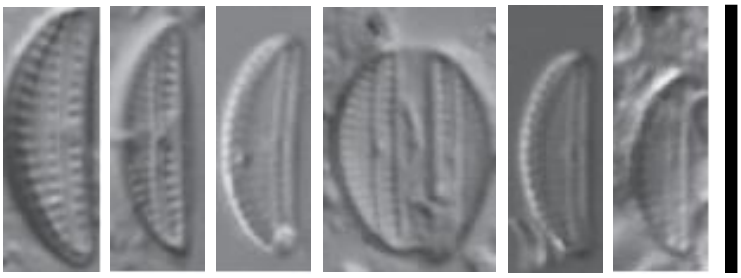
Plate 218 (Scale bars: Figs 1-6=10 μm; Fig 7-8=1 μm)

Amphora pediculus (Kützing) Grunow

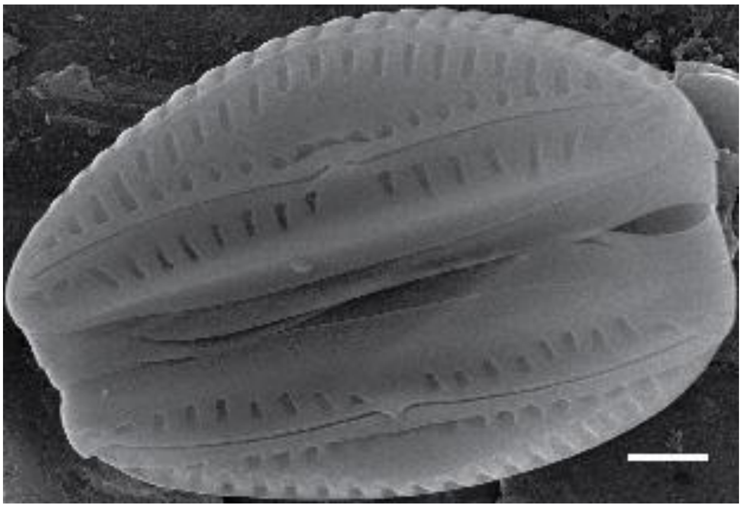
Lit.: Schmt et al. 1875, pl. 26, fig. 99

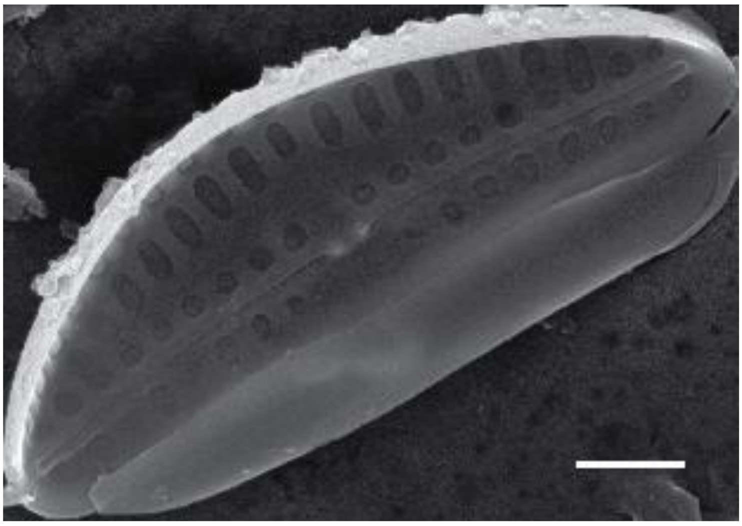
Basionym: *Cymbella pediculus* Kützing 1844
Synonyms: *Amphora ovalis* var. *pediculus* (Kützing) Van Heurck 1885
Cymbella caespitosum var. *pediculus* (Kützing) Brun 1880
Clevamphora ovalis var. *pediculus* (Kützing) Mereschkowsky 1906
Encyonema pediculus (Kützing) H. Peragallo 1889
Amphora ovalis var. *pediculus* (Kützing) Pero 1893

Fig. 1: Sample COAST011, Great South Bay, NY.
Fig. 2: Sample BBDC0047, Barnegat Bay, NJ.
Fig. 3: Sample BB0055, Barnegat Bay, NJ.
Fig. 4: Sample BBDC0071, Barnegat Bay, NJ.
Fig. 5: Sample BBDC0001, Barnegat Bay, NJ.
Fig. 6: Sample BB0089, Tuckerton Bay, NJ.
Figs 7-8: Sample COAST003, Peconic Bay, NY.



1 - 6

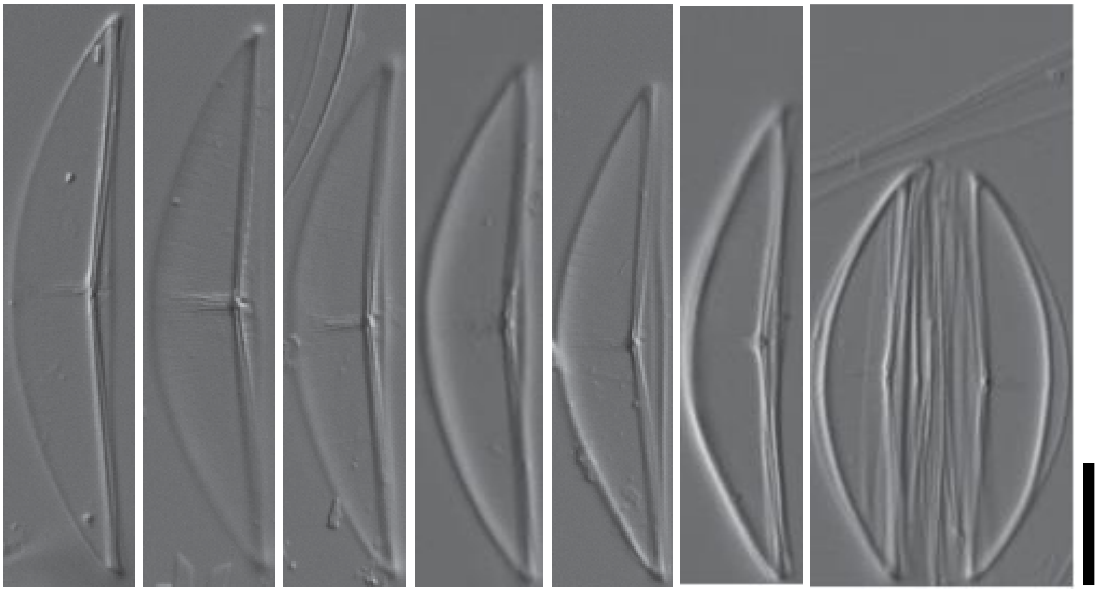




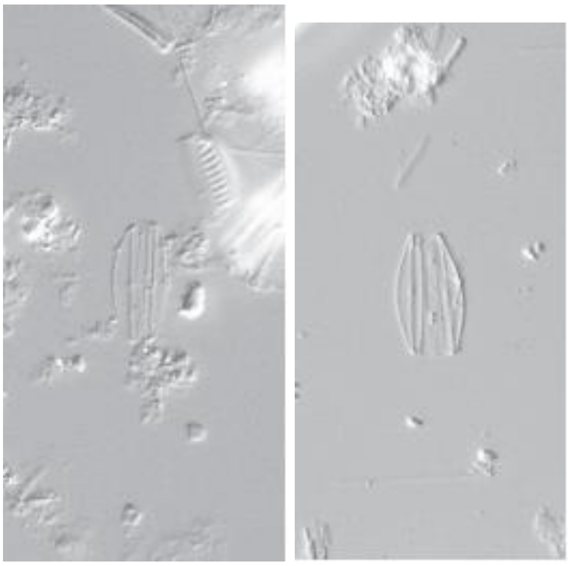
Figs 1-7: *Amphora pseudohyalina* Simonsen
Lit.: Simonsen 1960, p. 129; pl. 2, fig. 1-3

Figs 1-7: Sample RUTG0790, Tuckerton Bay, NJ.

Figs 8-9: *Amphora adumbrata* Hohn & Hellerman
Lit.: Hohn & Hellerman 1966, p. 119; pl. 1, fig. 20



1 - 7



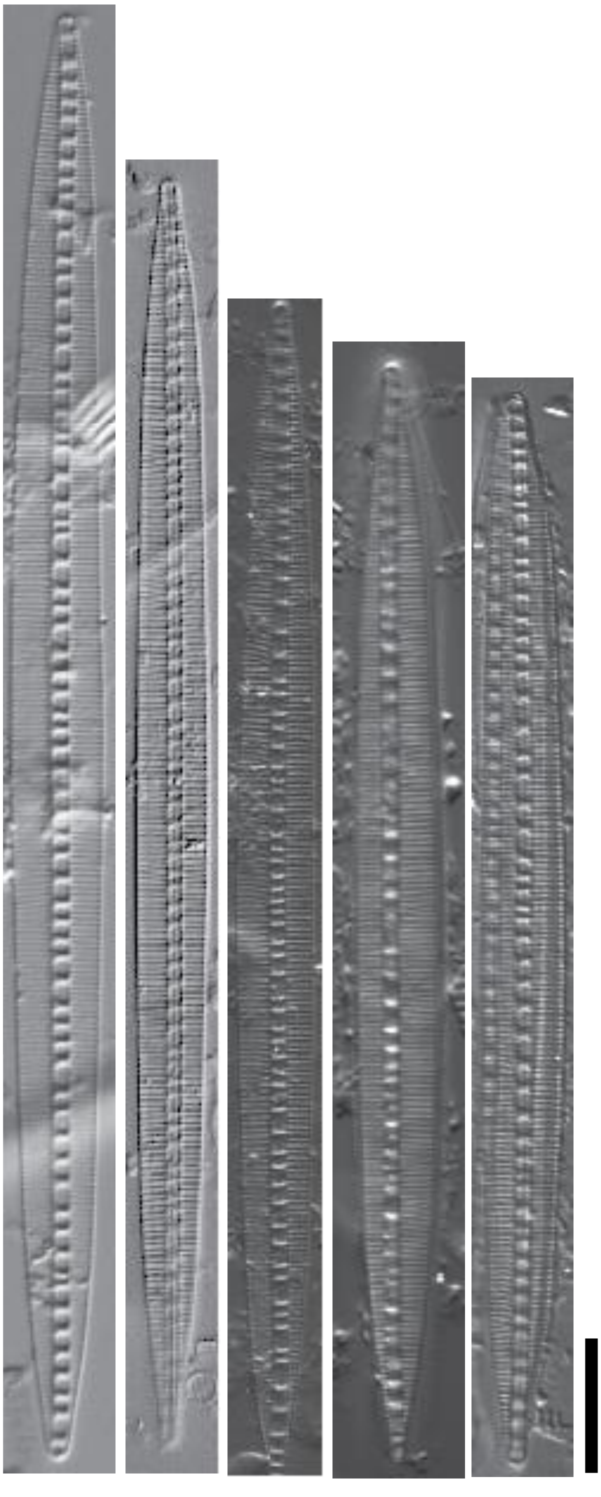
8 - 9

Plate 220 (Scale bar: Figs 1-5=10 μm)

Bacillaria paradoxa Gmelin

Lit.: Linneaeus 1788, p. 3903

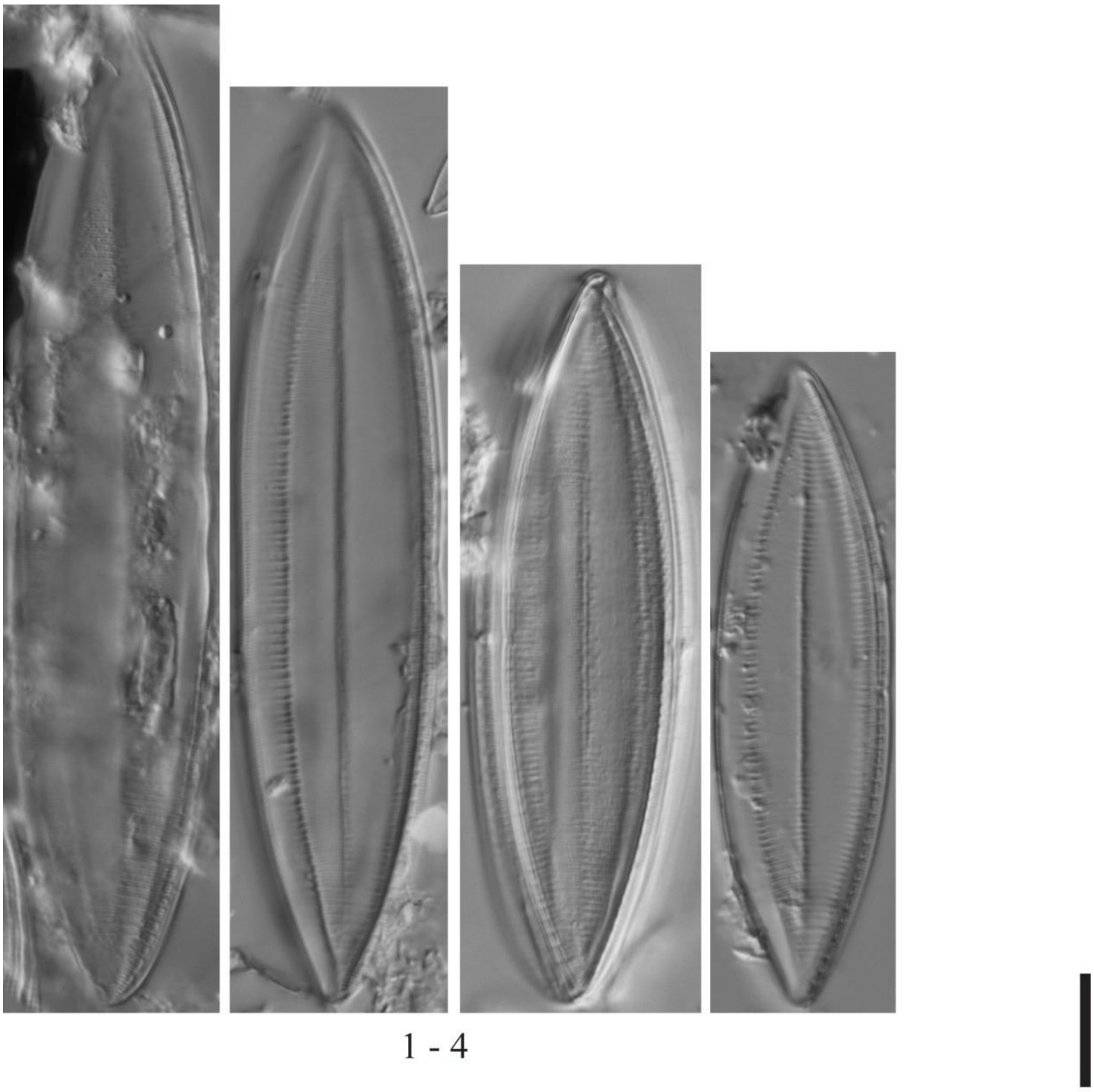
Synonym: *Nitzschia paradoxa* (Gmelin in Linneaeus) Grunow in Cleve & Grunow 1880



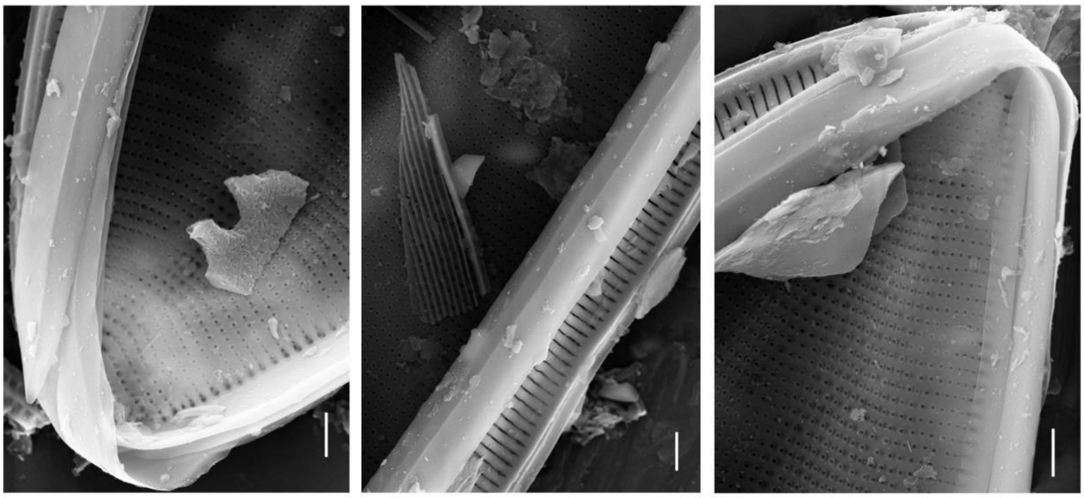
1-5

Plate 221 (Scale bars: Figs 1-4=10 µm; Figs 5-7=2 µm)

Tryblionella plana (Smith) Pelletan
Lit.: Pelletan 1889, p. 30
Basionym: *Nitzschia plana* Smith 1853
Synonym: *Homoeocladia plana* (Smith) Kuntze 1898



1 - 4

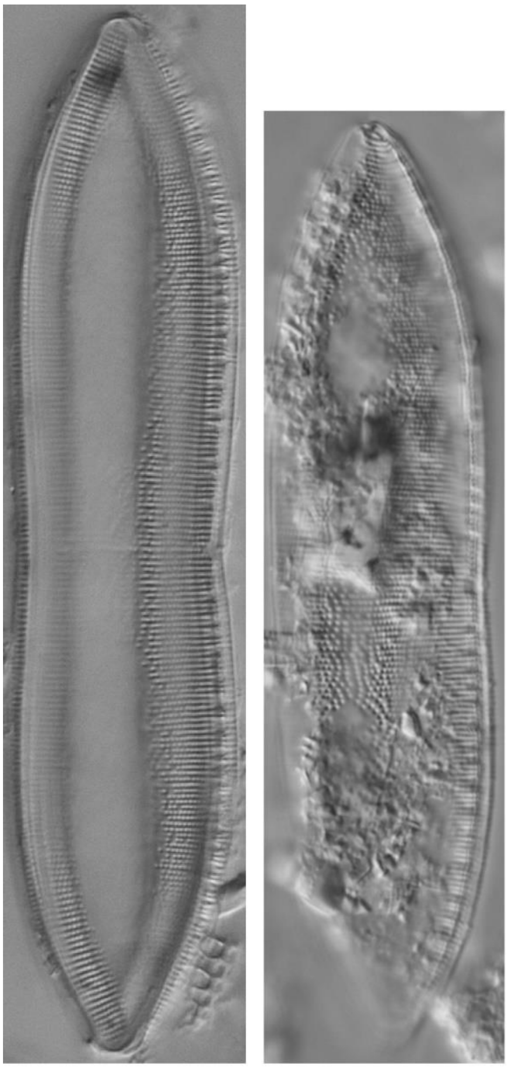


5 - 7

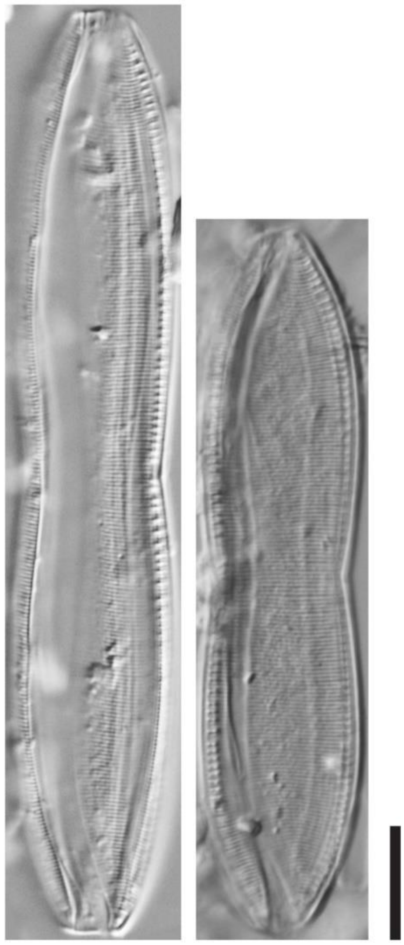
Plate 222 (Scale bar: Figs 1-4=10 µm)

Figs 1-2: ***Tryblionella* sp. 1**

Figs 3-4: ***Tryblionella* sp. 2**



1 - 2



3 - 4

Plate 223 (Scale bars: Figs 1-8=10 µm; Fig. 9=2 µm)

Tryblionella apiculata

Lit.: Gregory 1857, p. 79; pl. 1, fig. 43; Poulin, Berard-Therriault, Cardinal & Hamilton 1990, p. 96; fig. 107-108; Trobajo & Mann 2015, p.281-282.

Synonyms:

Nitzschia apiculata (Gregory) Grunow 1878

Homoeocladia apiculata (Gregory) Kuntze 1898

Synedra constricta Kützing 1844

Nitzschia constricta (Kützing) Ralfs in Pritchard 1861

Tryblionella constricta (Kützing) Poulin in Poulin, Berard-Therriault, Cardinal & Hamilton 1990

Tryblionella kuetzingii Álvares-Blanco & Blanco2014

Figs 1-2,4,6: Sample BB0173, Tuckerton Bay, NJ.

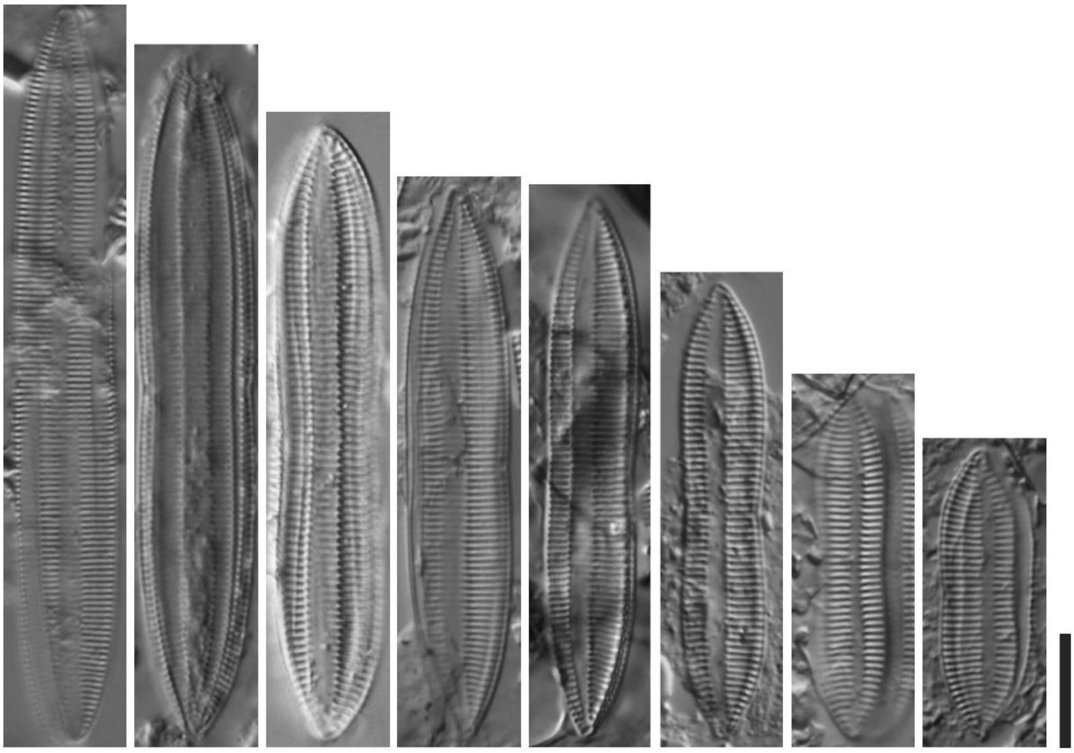
Fig. 3: Sample BB0054, Barnegat Bay, NJ.

Fig. 5: Sample BB0068, Barnegat Bay, NJ.

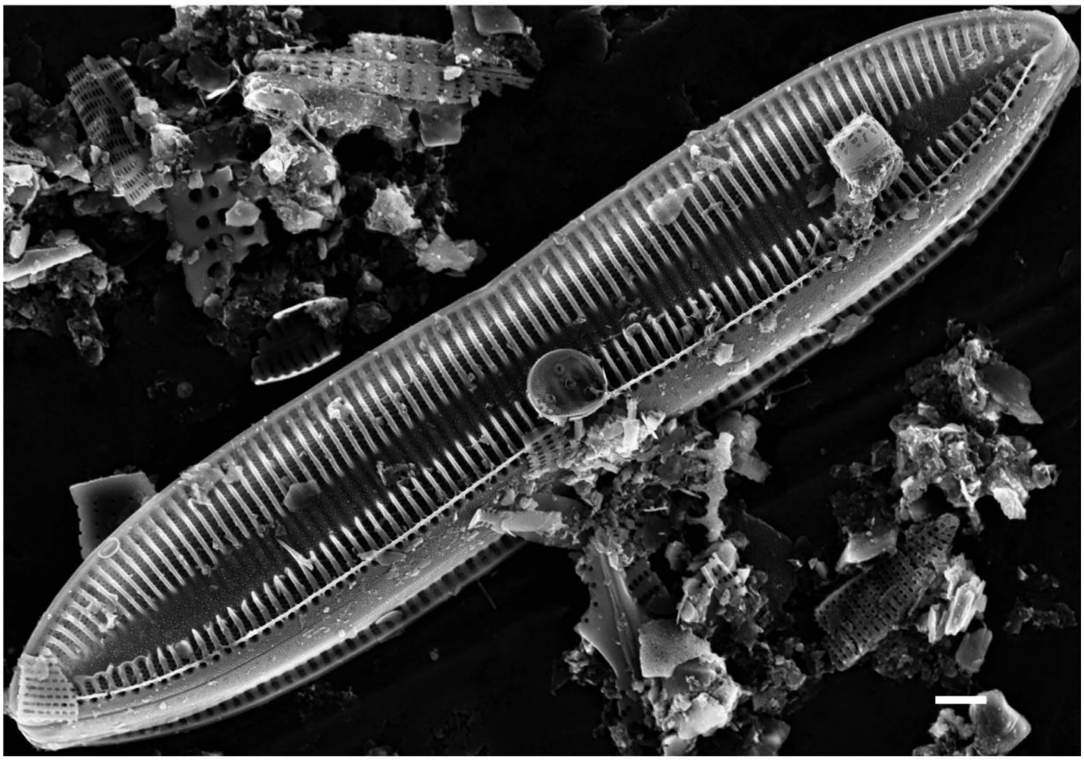
Fig. 7: Sample RUTG0833, Cheesequake State Park, NJ.

Fig. 8: Sample BB0158, Tuckerton Bay, NJ.

Fig. 9: Sample RUTG0001, Cheesequake State Park, NJ.



1 - 8



9

Plate 224 (Scale bars: Figs 1-12=10 µm; Figs 13-15=2 µm)

Tryblionella hungarica (Grunow) Frenguelli

Lit.: Frenguelli 1942, p. 178; pl. 8, fig. 12; Grunow 1862, p. 568; pl. 28/12, fig. 31; Witkowski, Lange-Bertalot, Metzeltin 2000, p.385, pl.188:10,11

Synonyms:

Homoeocladia hungarica (Grunow) Kuntze 1898

Nitzschia hungarica Grunow 1862

Nitzschia plicatula Hustedt 1953

Tryblionella hungarica (Grunow) Mann in Round, Crawford & Mann 1990

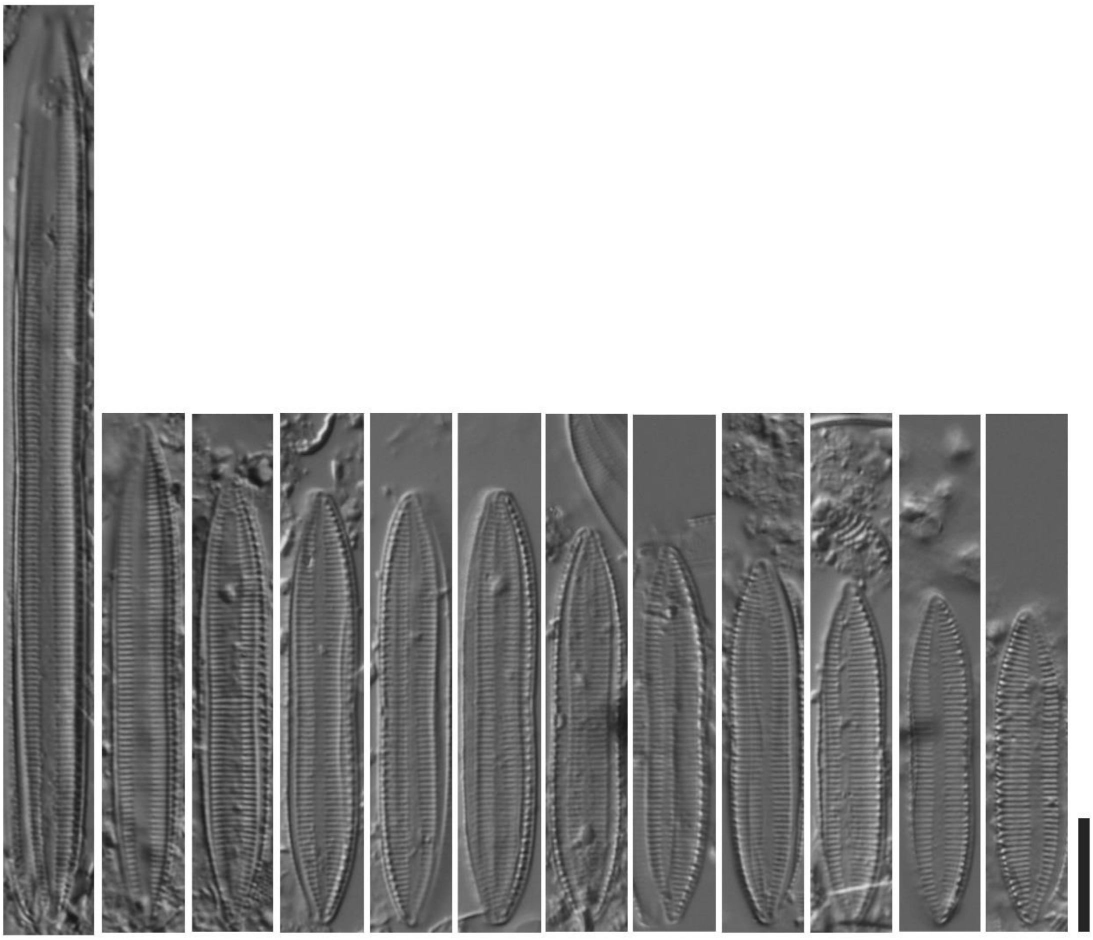
Tryblionella plicatula (Hustedt) Mann in Round, Crawford & Mann 1990

Fig. 1: Sample BBDC00100, Barnegat Bay, NJ.

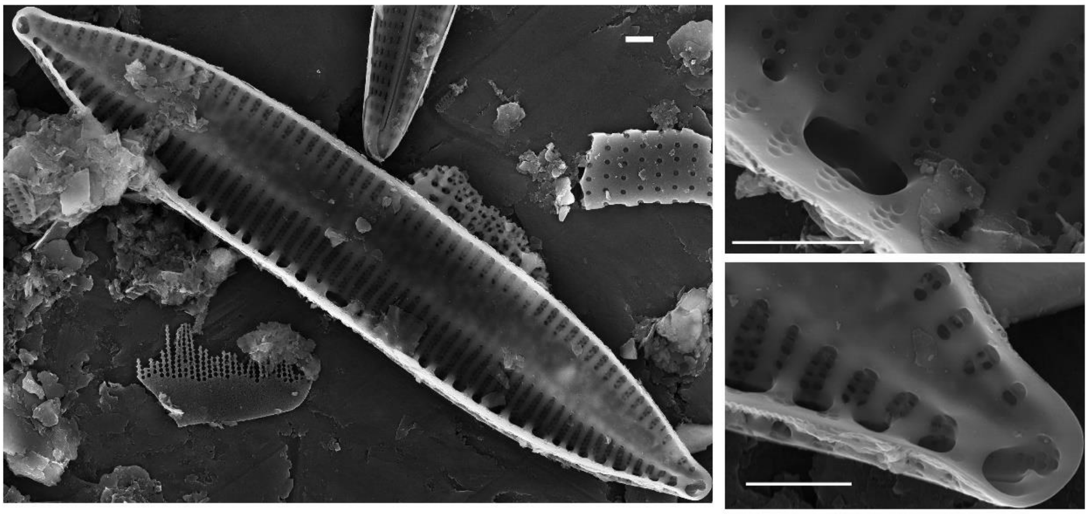
Figs 2-6,9,11: Sample BB0173, Tuckerton Bay, NJ.

Figs 7-8,10,12: Sample BB0174, Tuckerton Bay, NJ.

Figs 13-15: Sample RUTG0802, Sluice Creek at South Dennis, NJ.



1 - 12

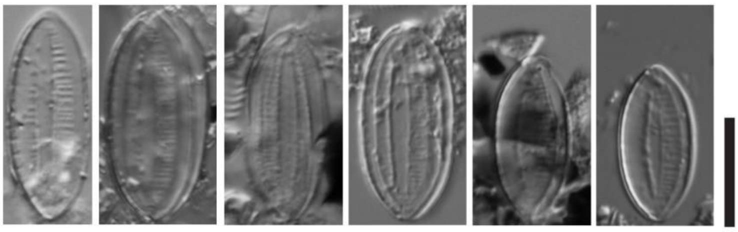


13 - 15

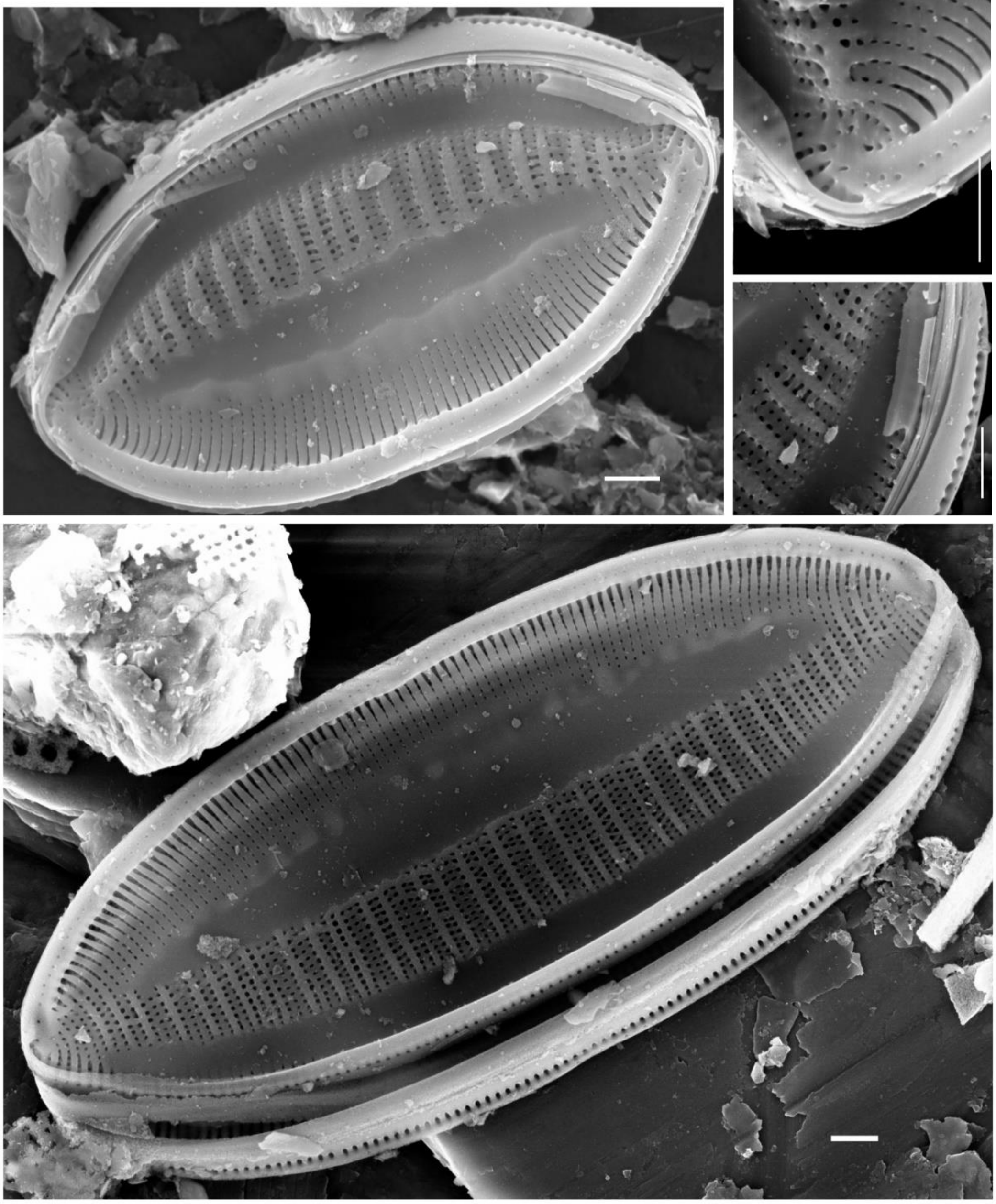
Plate 225 (Scale bar: Figs 1-6=10 µm; Figs 7-11=1 µm)

Tryblionella debilis Arnott ex O'Meara
Lit.: Arnott ex O'Meara 1873, p. 310

Synonyms:
Nitzschia debilis (Arnott in O'Meara) Grunow in Cleve & Grunow 1880
Nitzschia tryblionella var. *debilis* (Arnott) Hustedt 1913
Homoeocladia debilis (Arnott in O'Meara) Kuntze 1898



1 - 6



7 - 11

Plate 226 (Scale bar: Figs 1-35=10 µm)

Figs 1-5: ***Tryblionella levidensis*** Smith
Lit.: Smith 1856, p. 89

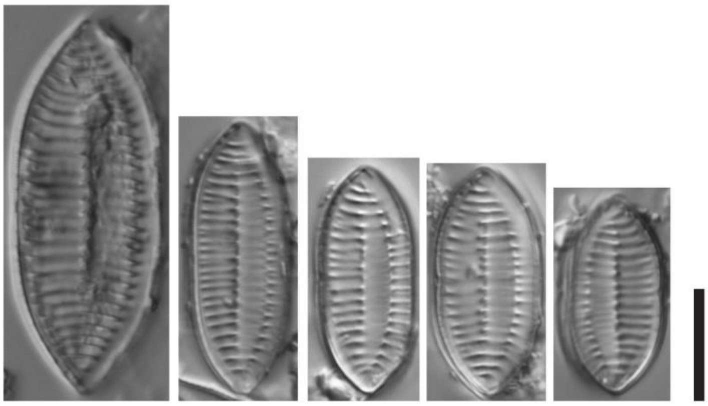
Synonyms:
Nitzschia levidensis (Smith) Grunow in Van Heurck 1881
Nitzschia tryblionella var. *levidensis* (Smith) Grunow in Cleve & Grunow 1880
Denticula levidensis (Smith) De Toni 1892
Tryblionella hantzschiana (hantzschia) var. *levidensis* (Smith) Frenguelli 1942
Tryblionella tryblionella var. *levidensis* (Smith) Prochazka 1923

Figs 6-8: ***Tryblionella* sp. 5**

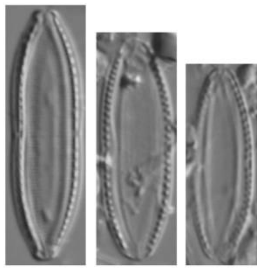
Figs 9-15: ***Tryblionella* sp. 3**

Figs 16-17: ***Tryblionella* sp. 6**

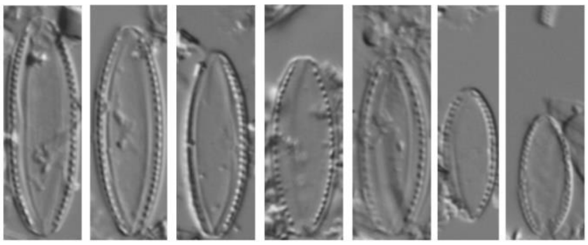
Figs 18-35: ***Tryblionella* sp. 2**



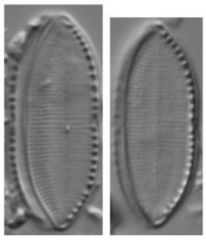
1 - 5



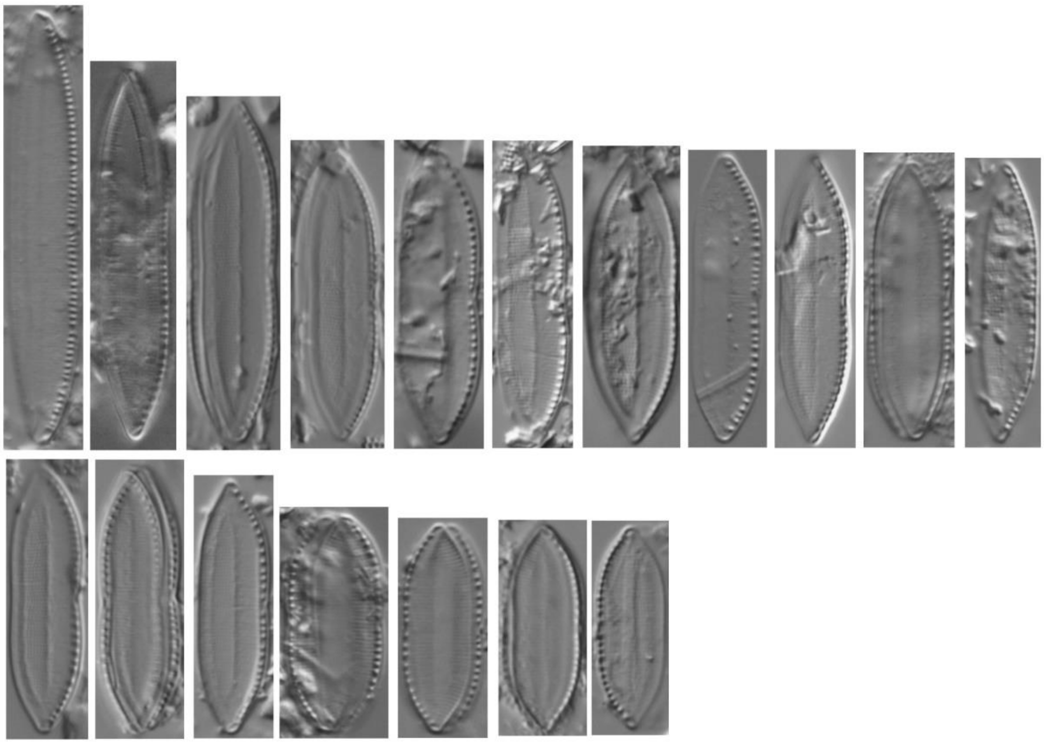
6 - 8



9 - 15



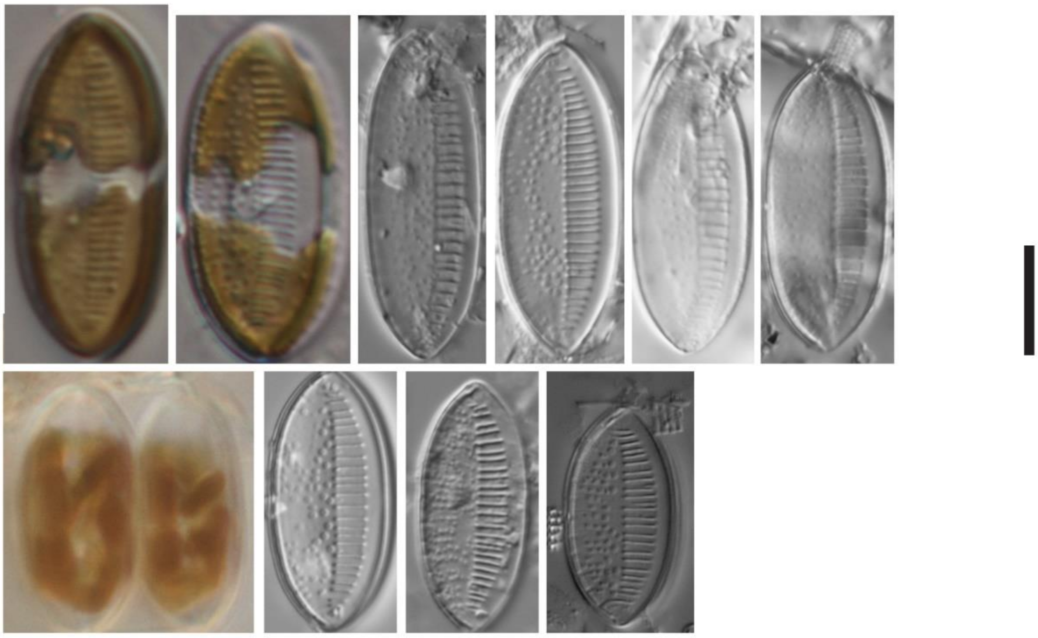
16 - 17



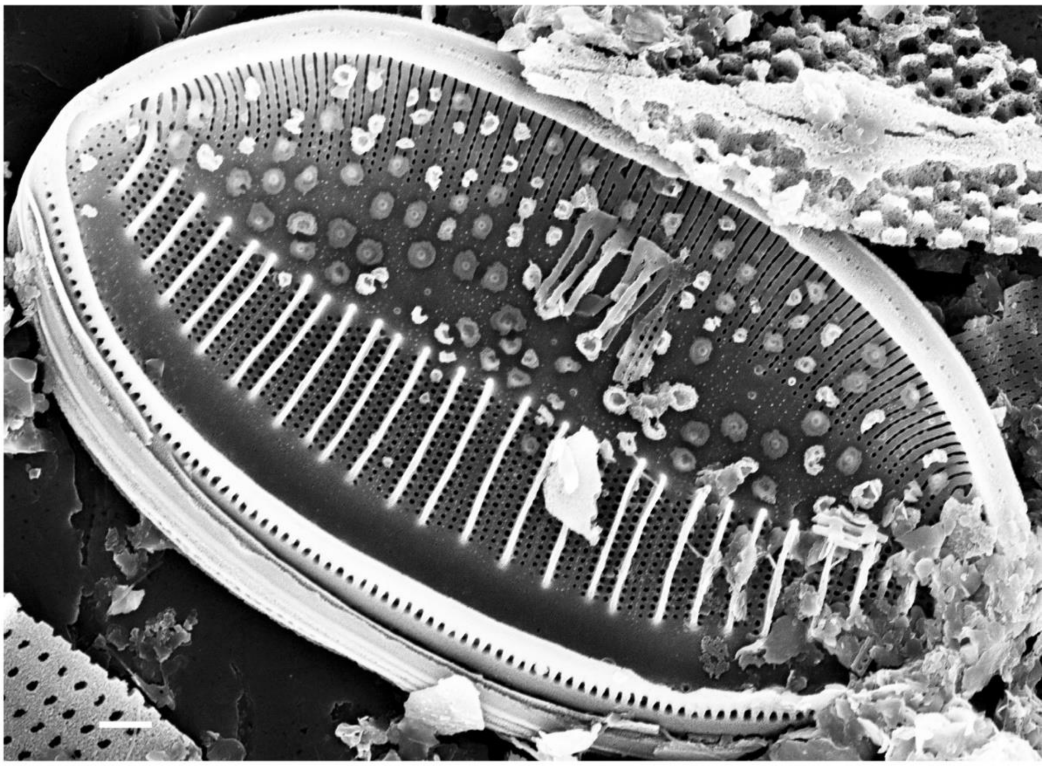
18 - 35

Plate 227 (Scale bar: Figs 1-10=10 µm; Fig. 11=1µm)

Nitzschia* cf. *perversa



1 - 10



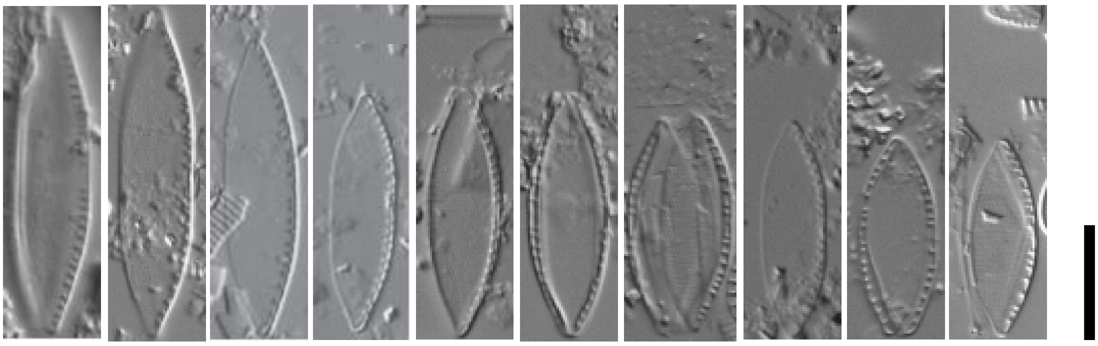
11

Plate 228 (Scale bar: Figs 1-10=10 µm)

Nitzschia amabilis Suzuki

Lit.: Suzuki et al. 2010, p. 223

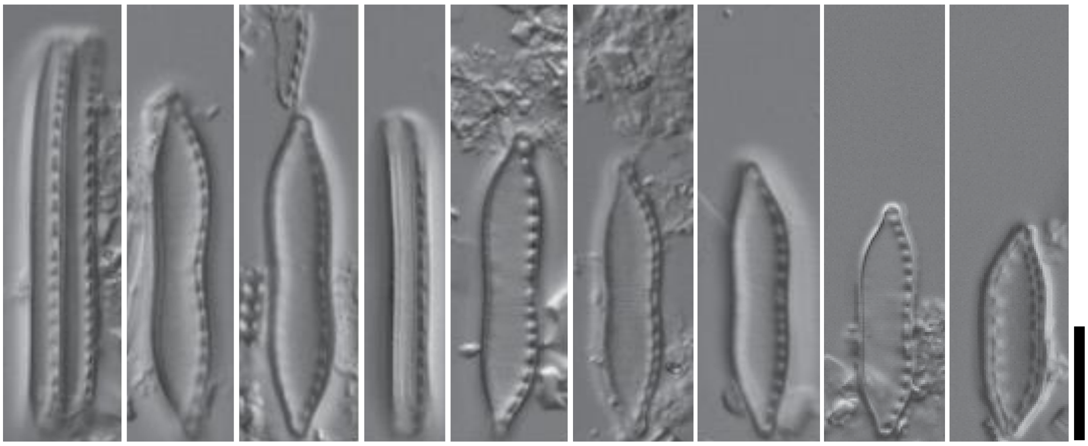
Synonym: *Nitzschia laevis* Hustedt 1939



1 - 10

Plate 229 (Scale bars: Figs 1-9=10 µm; Fig. 10=1 µm)

Nitzschia brevissima Grunow in Van Heurck Lit.: Van Heurck 1881, pl. 67, fig. 4



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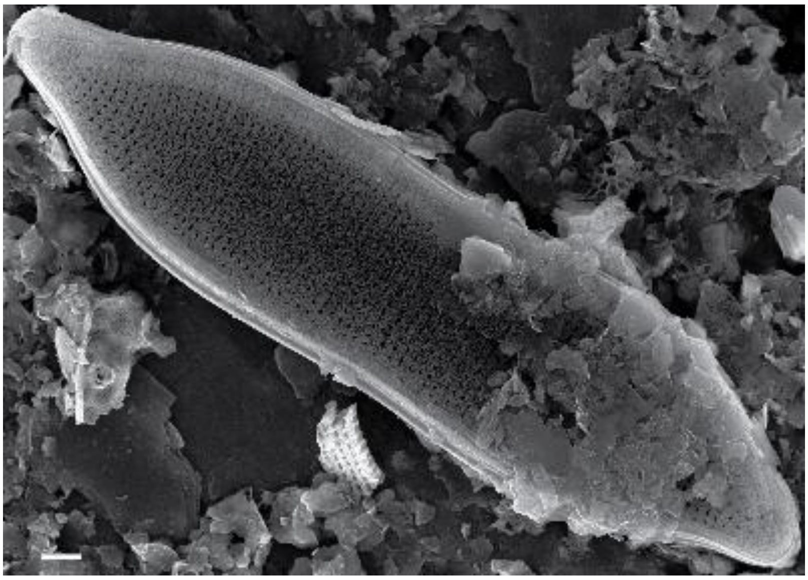


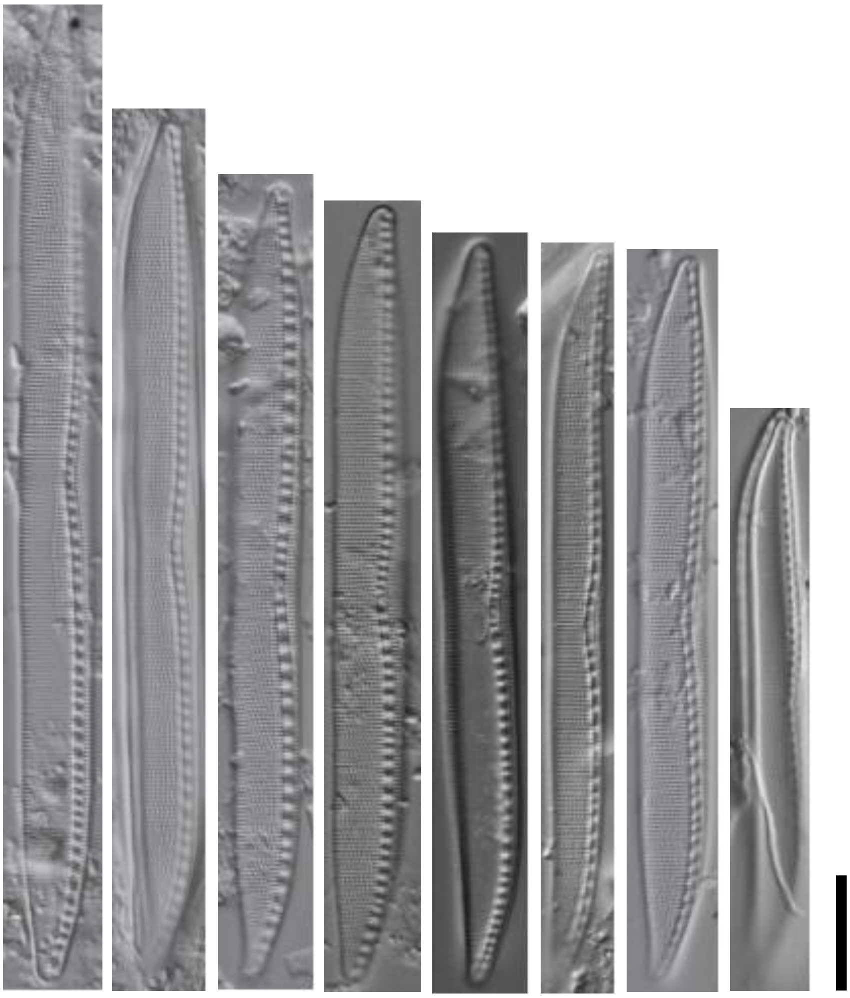
10

Plate 230 (Scale bars: Figs 1-8=10 µm; Figs 9-11=1 µm)

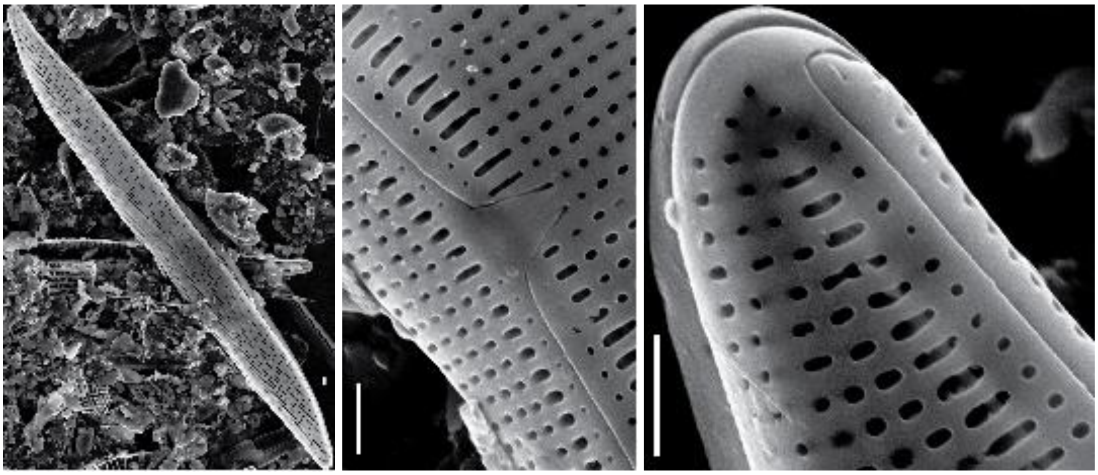
Nitzschia scalpelliformis Grunow

Lit.: Cleve & Grunow 1880, p. 92

Synonym: *Nitzschia obtusa var. scalpelliformis* (Grunow) Grunow in Van Heurck 1881



1 - 8

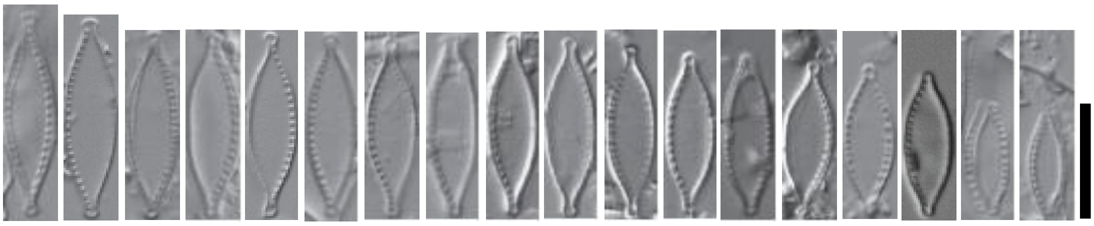


9 - 11

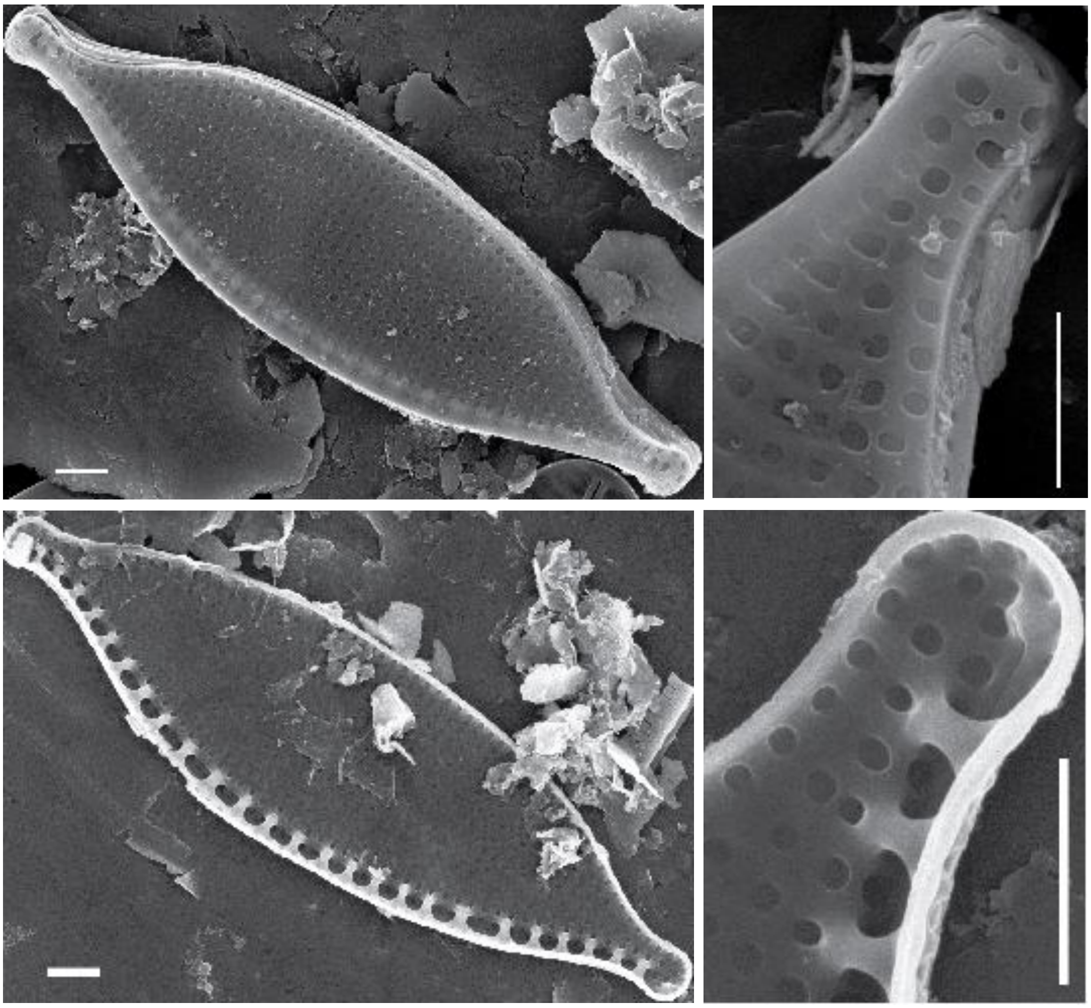
Plate 231 (Scale bars: Figs 1-18=10 µm; Figs 19-22=1 µm)

Nitzschia cf. *rosenstockii* Lange-Bertalot

Lit.: Lange-Bertalot 1980, p. 52-53; fig. 30-33, 133-136



1 - 18



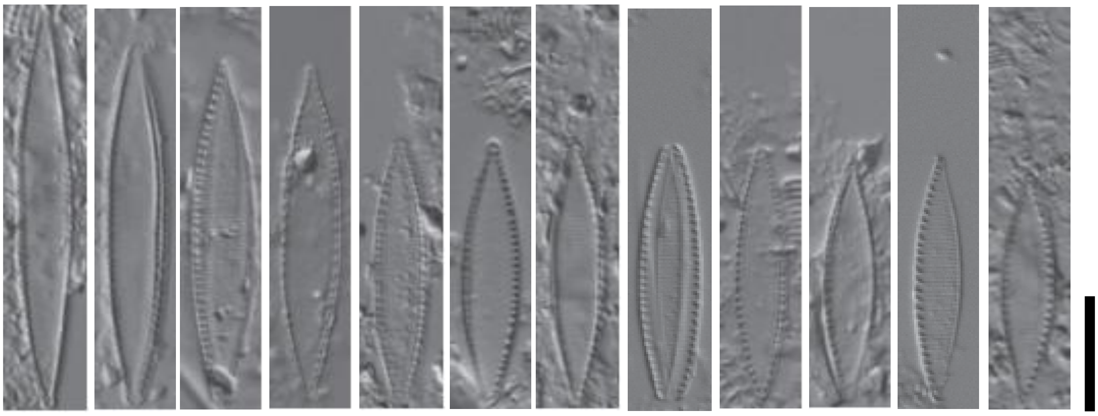
19 - 22

Plate 232 (Scale bar: Figs 1-30=10 µm)

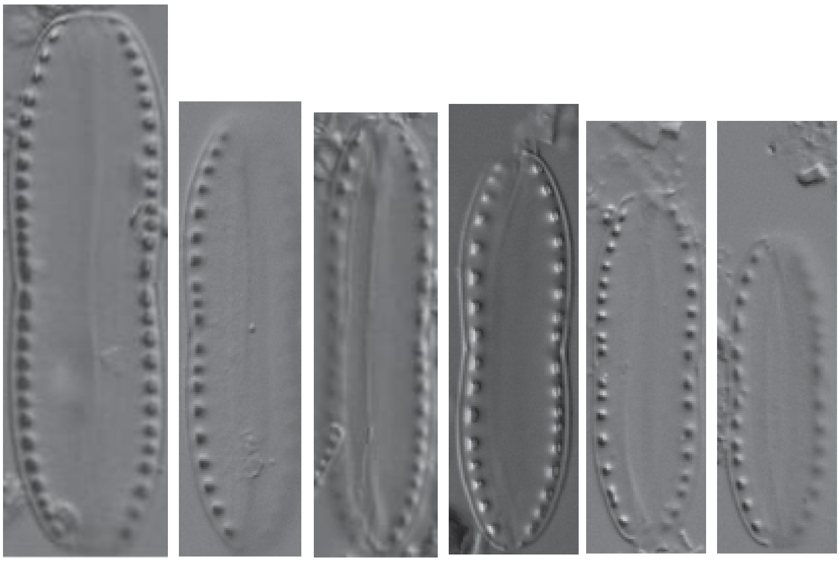
Figs 1-12: *Nitzschia calcicola* Aleem & Hustedt
Lit.: Aleem & Hustedt 1951, p. 18; fig. 4

Figs 13-18: *Nitzschia* cf. *brevissima*

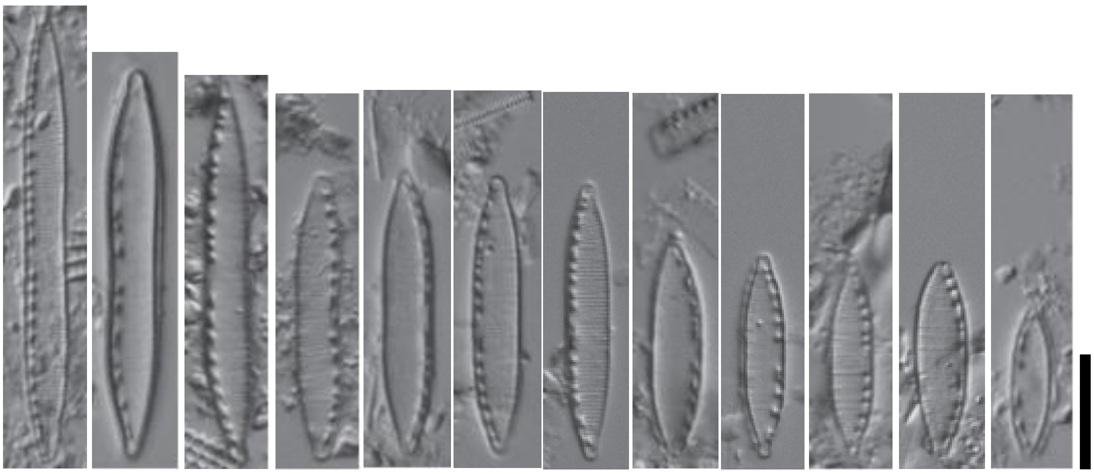
Figs 19-30: *Nitzschia vasta* Hustedt
Lit.: Hustedt 1939, p. 660; fig. 119



1 - 12



13 - 18

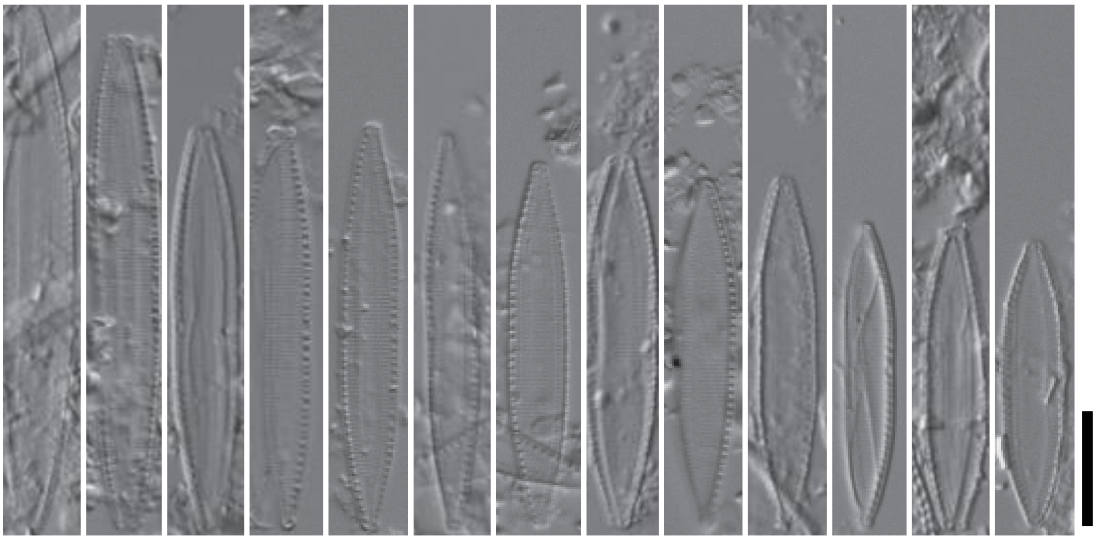


19 - 30

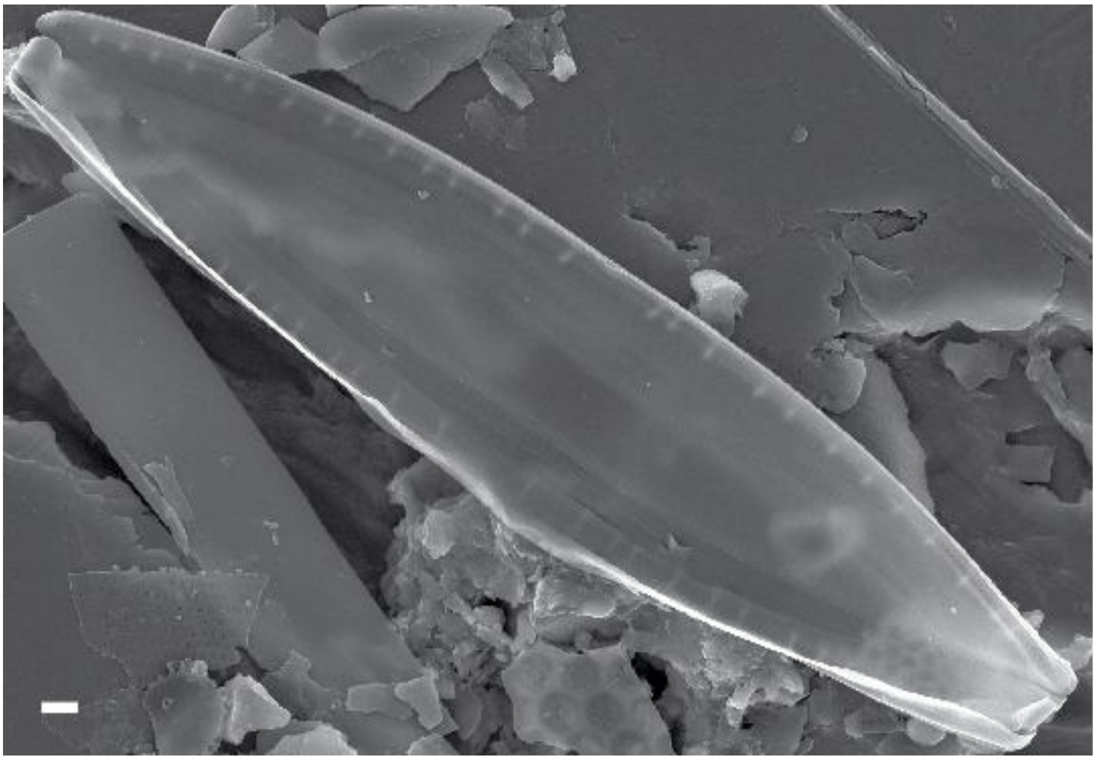
Plate 234 (Scale bars: Figs 1-13=10 µm; Fig 14=1 µm)

Nitzschia frequens Hustedt

Lit.: Hustedt 1957, p. 348; fig. 52-54



1 - 13



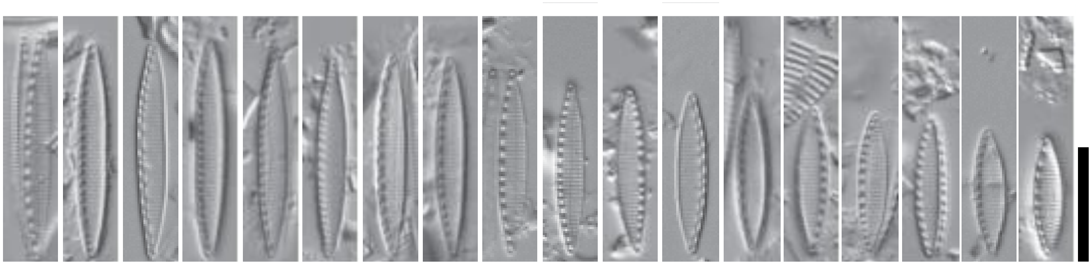
14

Plate 235 (Scale bars: Figs 1-18; 21-26=10 µm; Figs 19-20=1 µm)

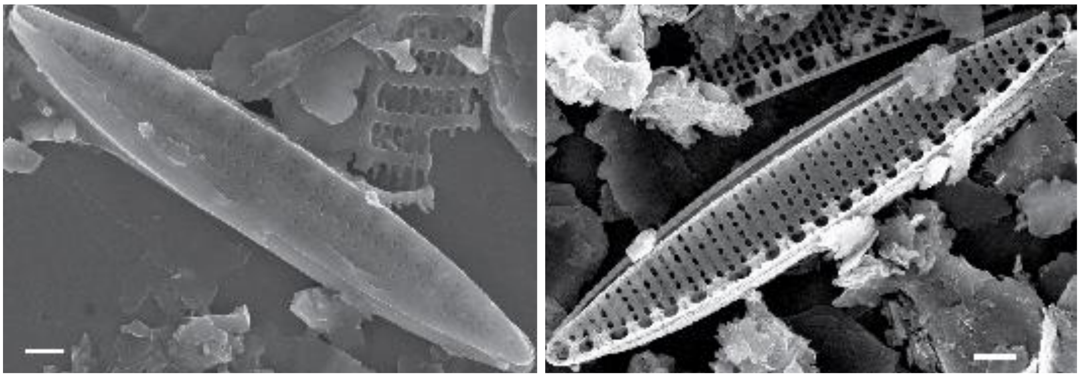
Figs 1-20: *Nitzschia frustulum* (Kützing) Grunow in Cleve & Grunow
Lit.: Cleve & Grunow 1880, p. 98

Basionym: *Synedra frustulum* Kützing 1844
Synonym: *Homoeocladia frustulum* (Kützing) Kuntze 1898

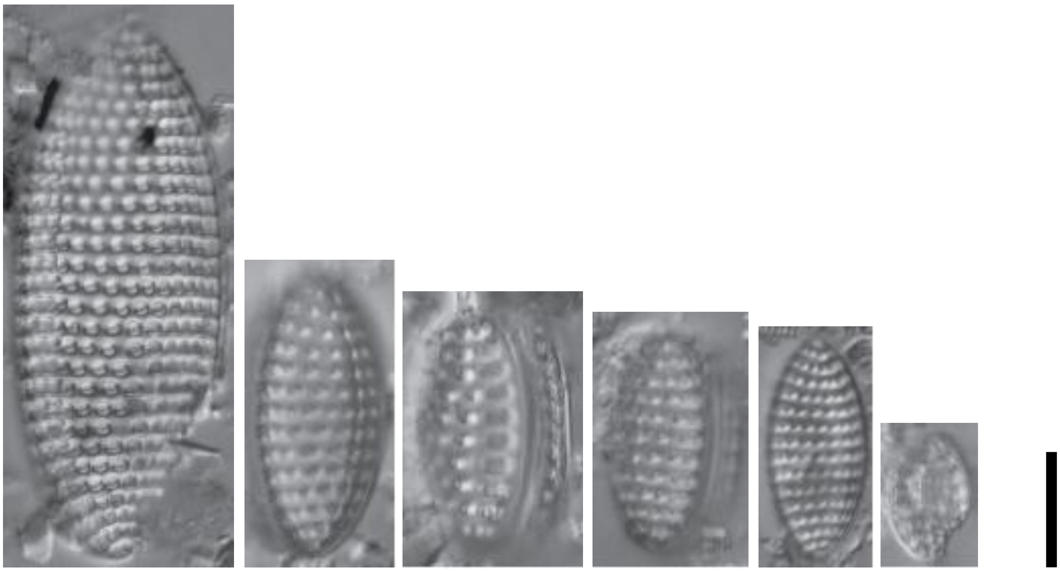
Figs 21-26: *Nitzschia granulata* Grunow
Lit.: Grunow 1880, p. 68



1 - 18



19 - 20



21- 26

Plate 236 (Scale bars: Figs 1-16; 18-44=10 µm; Fig. 17=1 µm)

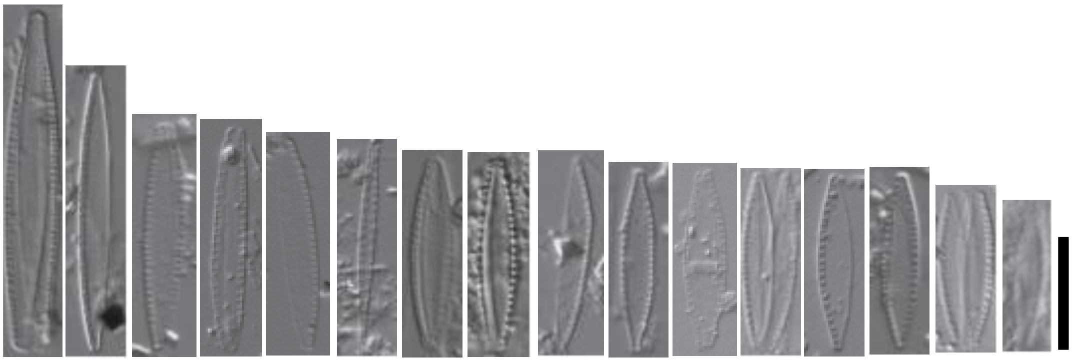
Figs 1-17: *Nitzschia palea* (Kützing) Smith

Lit.: Smith 1856, p. 89
Basionym: *Synedra palea* Kützing 1844
Synonym: *Homoeocladia palea* (Kützing) Kuntze 1898

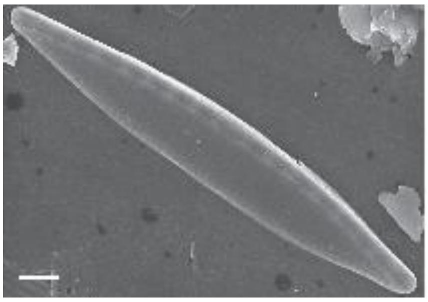
Figs 18-32: *Nitzschia pusilla* (Kützing) Lange-Bertalot

Lit.: Lange-Bertalot 1976, v. 28: p. 300; pl. 7, fig. 1-10

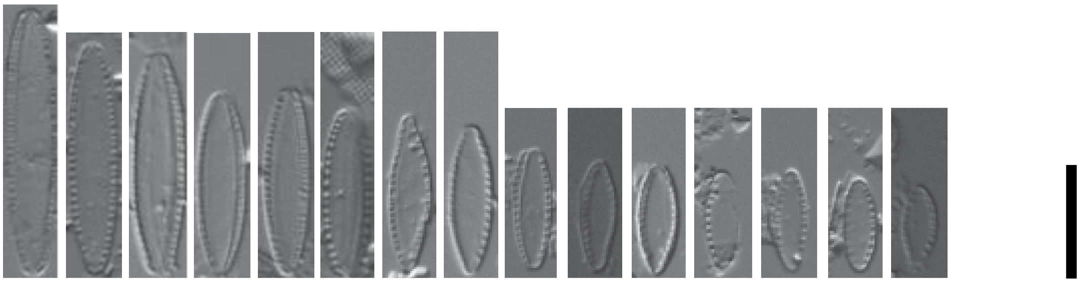
Figs 33-44: *Nitzschia* sp. 3



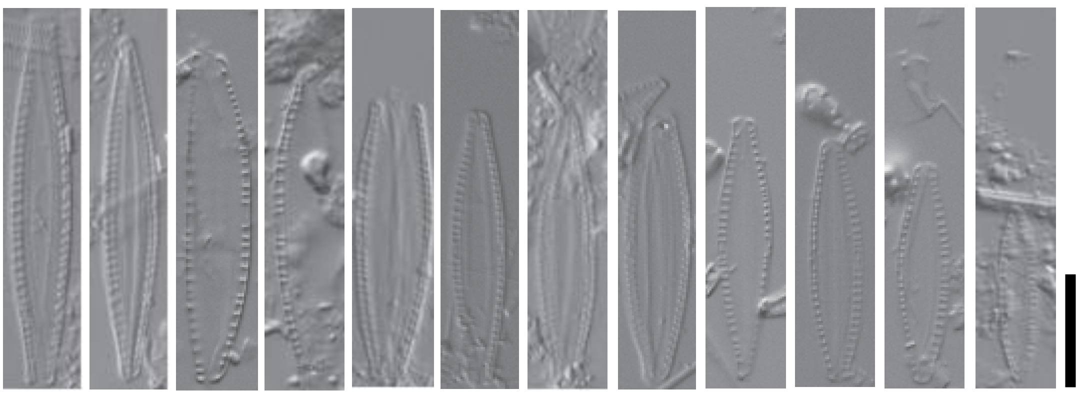
1 - 16



17



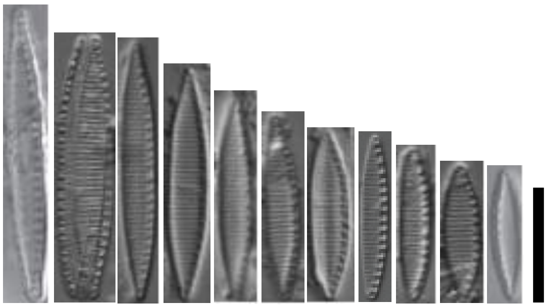
18 - 32



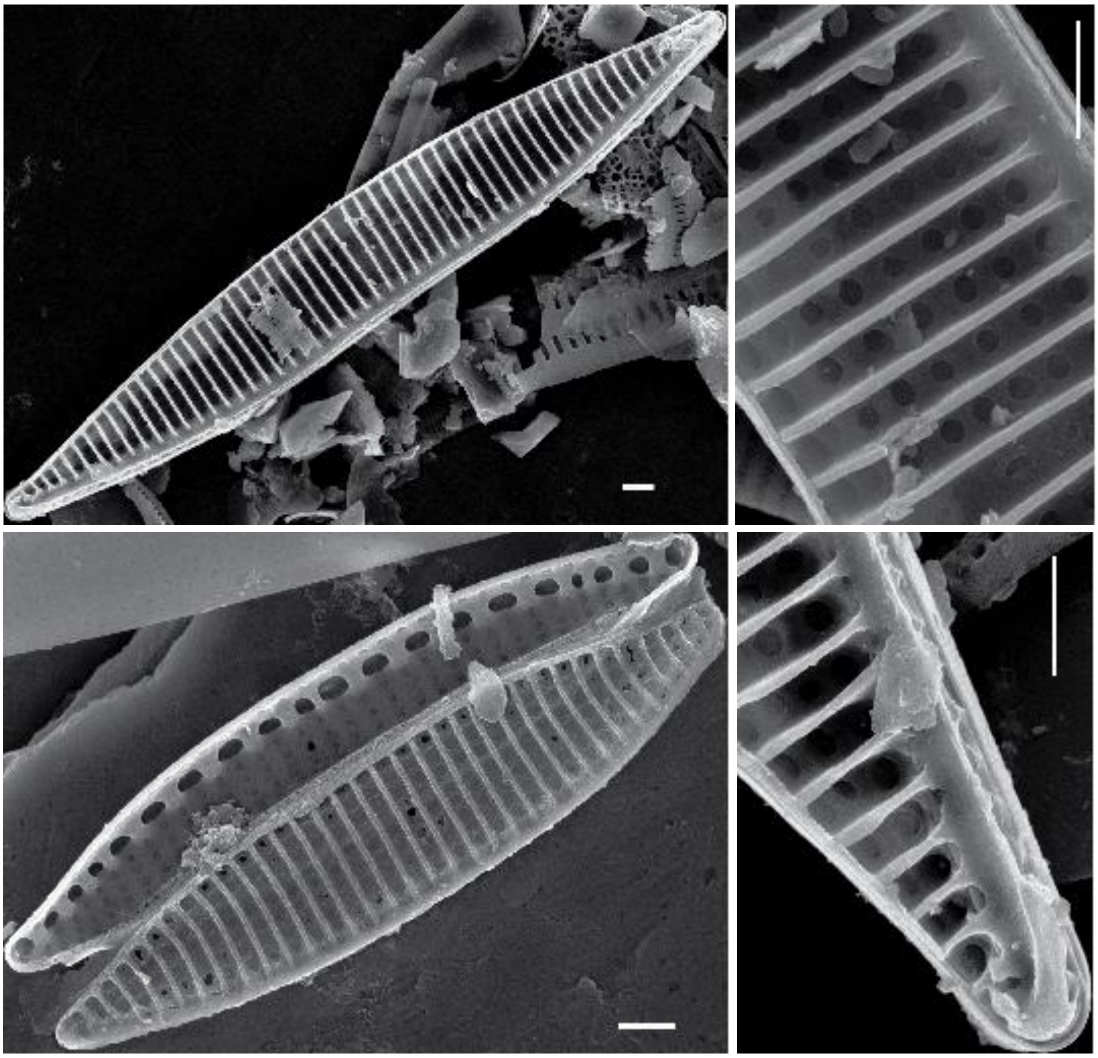
33 - 44

Plate 237 (Scale bars: Figs 1-11=10 µm; Fig 12-15=1 µm)

Nitzschia sp. 1



1 - 11

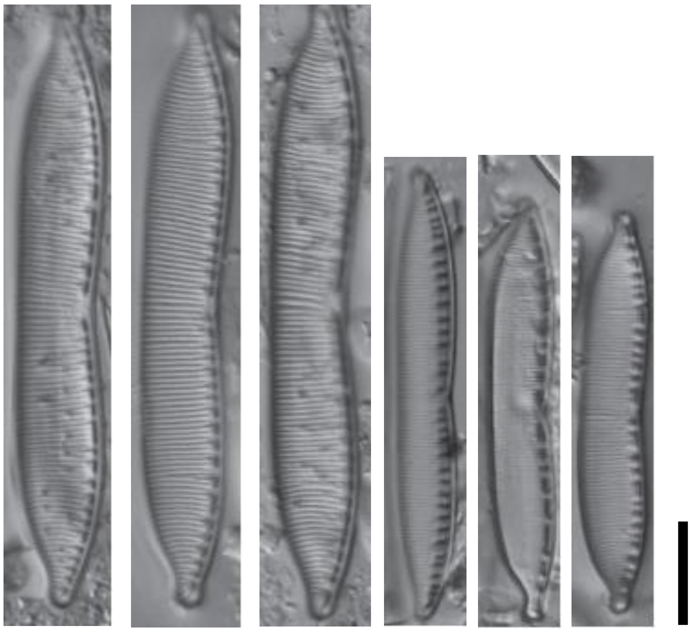


12 - 15

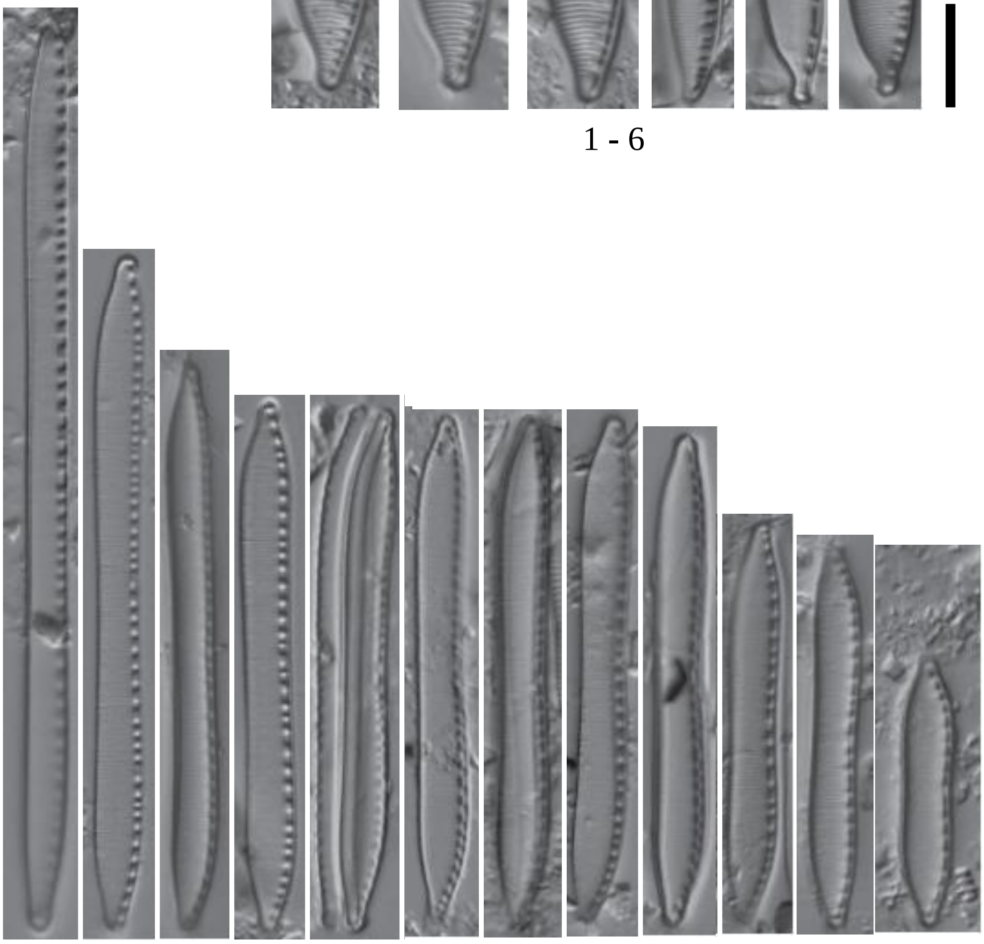
Plate 238 (Scale bar: Figs 1-18=10 µm)

Figs 1-6: *Nitzschia communata* Grunow
Lit.: Grunow 1880, p. 79

Figs 7-18: *Nitzschia terrestris* (Petersen) Hustedt
Lit.: Hustedt 1934, p. 396
Basionym: *Nitzschia vermicularis* var. *terrestris* Petersen 1928



1 - 6



7 - 18

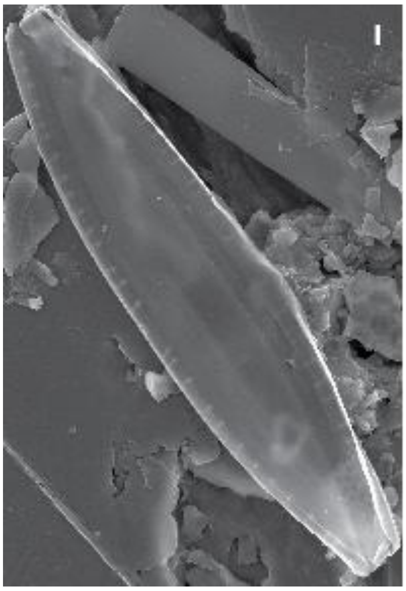
Plate 239 (Scale bars: Figs 1-14=10 µm; Fig. 15=1 µm)

Nitzschia distans var. *distans* Gregory

Lit.: Gregory 1857, p. 58; pl. 6, fig. 103

Synonym: *Homoeocladia distans* (Gregory) Kuntze 1898

1 - 14



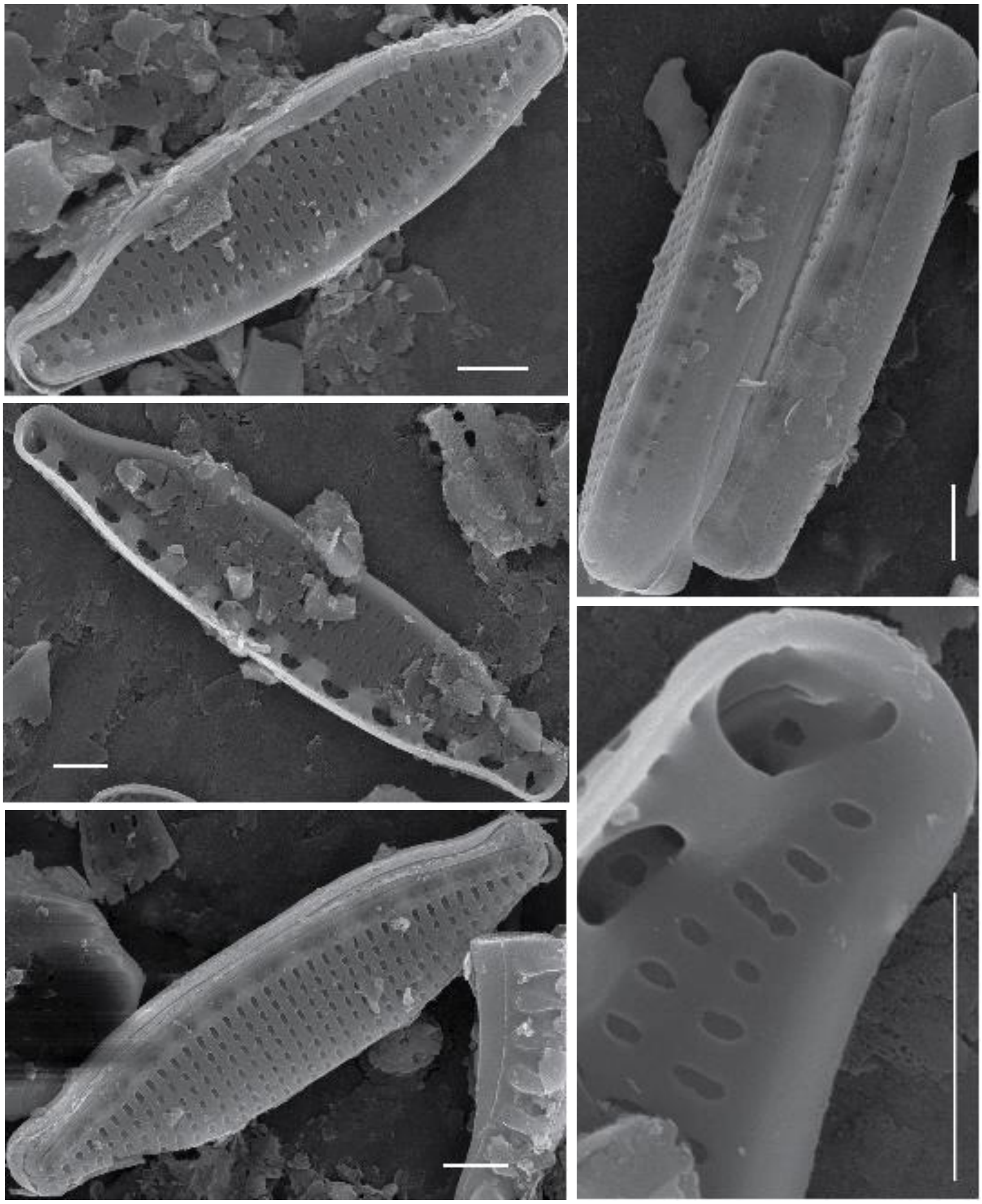
15

Plate 240 (Scale bars: Figs 1-19=10 µm; Figs 20-24=1 µm)

Nitzschia microcephala Grunow

Lit.: Grunow 1880, p. 96

1 - 19



20 - 24

Plate 241 (Scale bar: Figs 1-5=10 µm)

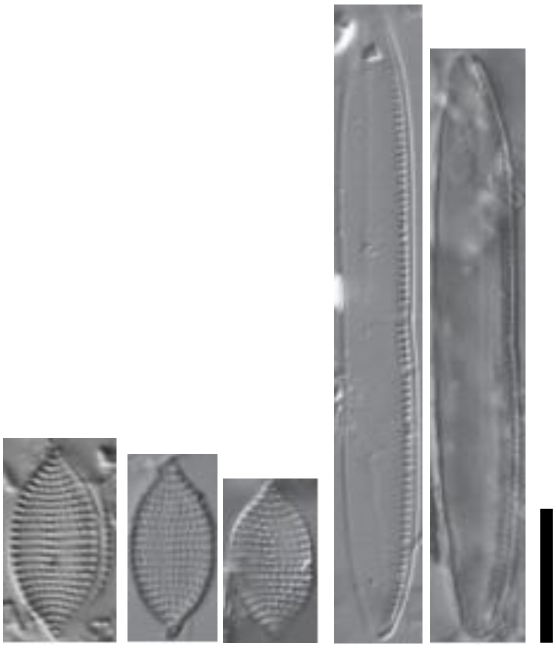
Figs 1-3: *Tryblionella pararostrata* (Lange-Bertalot) Clavero & Hernández-Mariné

Lit.: Lange-Bertalot, Kulbs, Lauser, Norpel-Schempp & Willmann 1996, v. 3: p. 164; pl. 48, fig. 6; Clavero 2009: 330 fig. 29

Basionym: *Nitzschia compressa* var. *pararostrata* Lange-Bertalot
Synonym: *Nitzschia pararostrata* (Lange-Bertalot) Lange-Bertalot 2000

Figs 4-5: *Nitzschia thermaloides* Hustedt

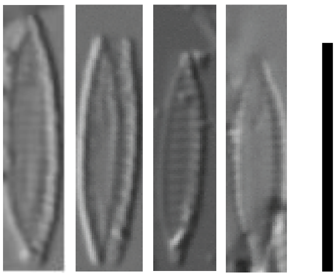
Lit.: Hustedt 1955, p. 44; pl. 15, ig. 13-15



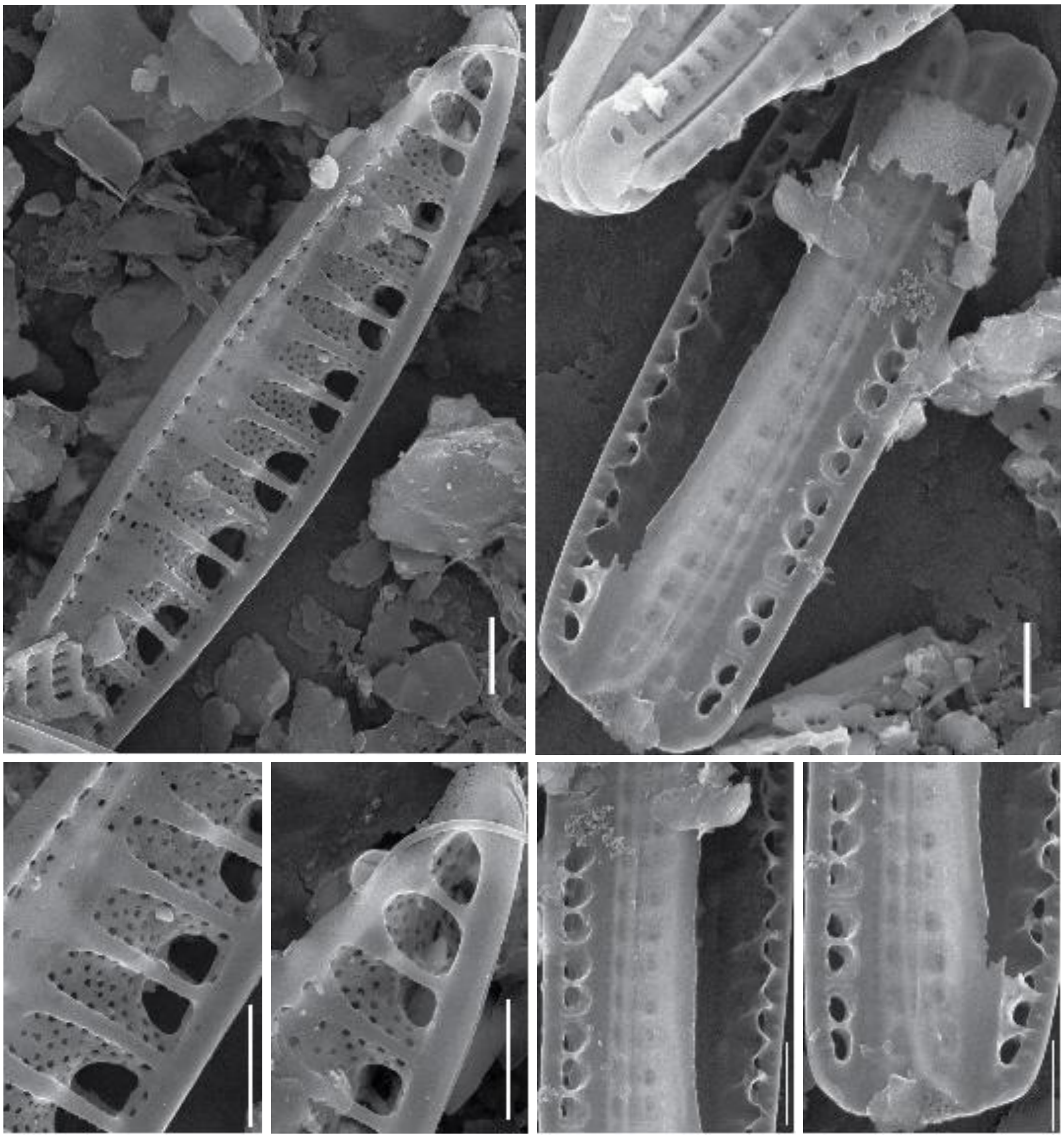
1 - 3 4 - 5

Plate 242 (Scale bars: Figs 1-4=10 µm; Fig 5-10=1 µm)

Simonsenia Sp. 1



1 - 4

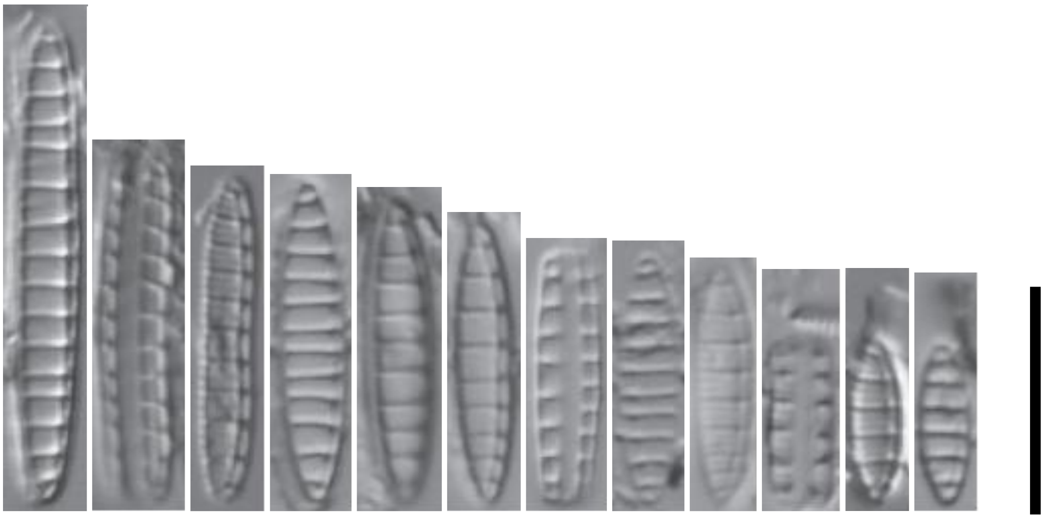


5 - 10

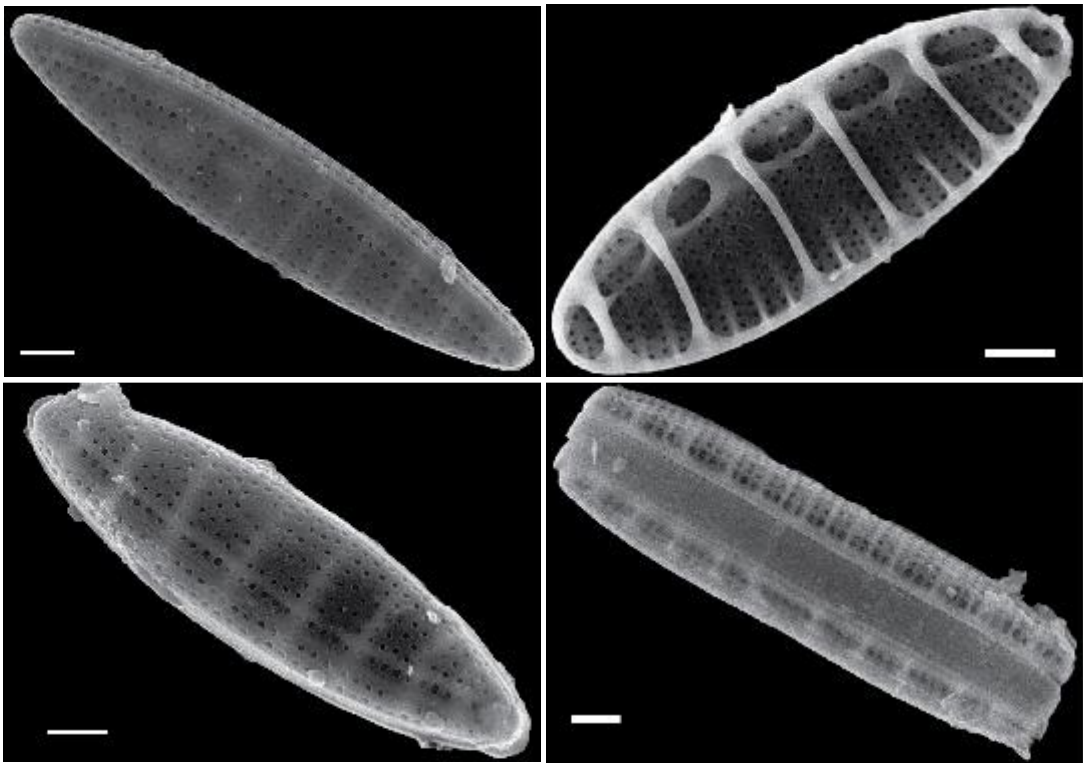
Plate 243 (Scale bars: Figs 1-12=10 µm; Fig 13-16=1 µm)

Denticula subtilis Grunow

Lit.: Grunow 1862, p. 547; pl. 28/12, fig. 36



1 - 12

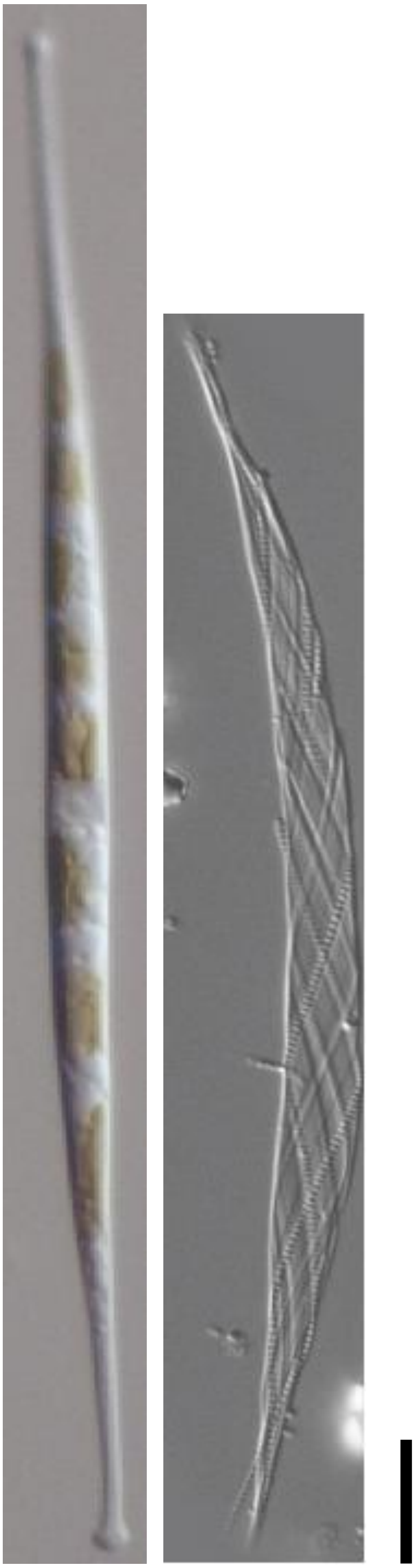


13 - 16

Plate 244 (Scale bar: Figs 1-2=10 µm)

Cylindrotheca gracilis (Brebisson in Kutzing) Grunow
Lit.: Van Heurck 1882, pl. 80, fig. 2

Basionym: *Ceratoneis gracilis* Brébisson ex Kützing 1849
Synonym: *Nitzschiella gracilis* (Brébisson in Kützing) Rabenhorst 1864



1 - 2

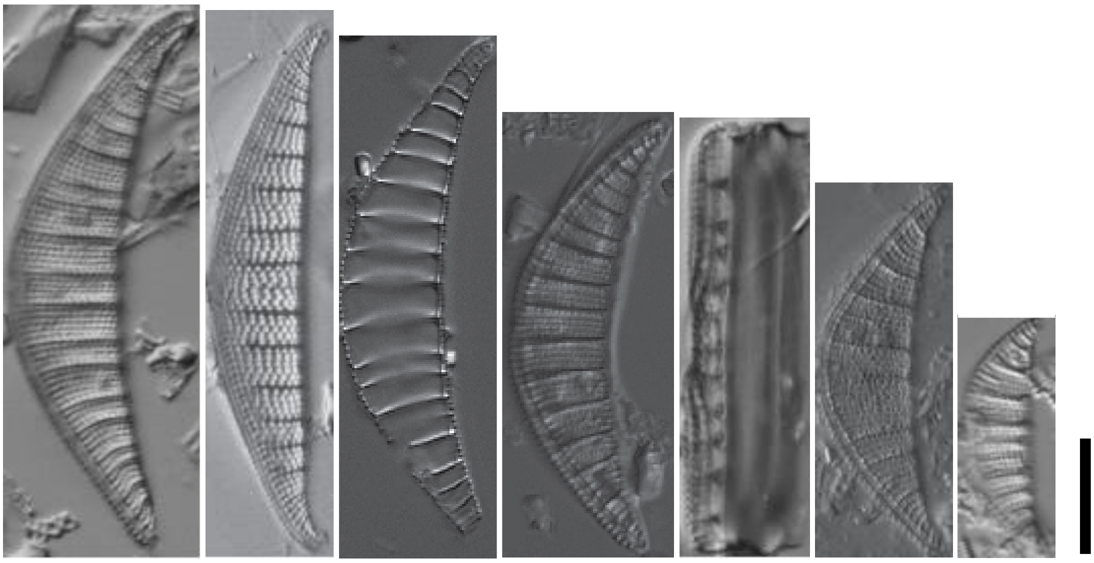
Plate 245 (Scale bar: Figs 1-7=10 µm, Figs 8-13=1 µm)

Rhopalodia musculus (Kützing) Müller

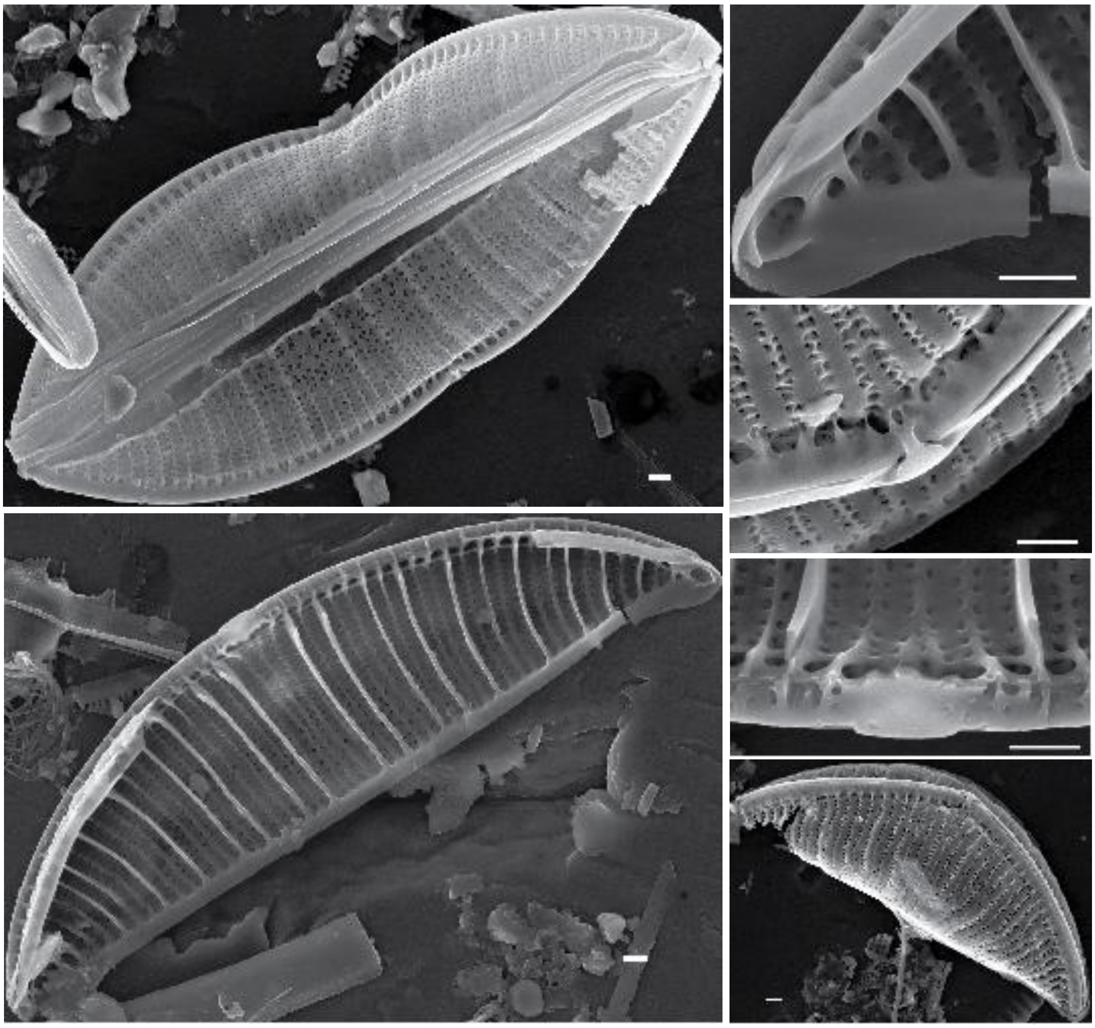
Lit.: Müller 1900, p. 278, 294

Basionym: *Epithemia musculus* Kützing 1844

Synonyms: *Rhopalodia gibberula* var. *musculus* (Kützing) Muschler 1908
Cystopleura musculus (Kützing) Kuntze 1891
Epithemia musculus Kützing 1844
Eunotia westermanni var. *musculus* (Kützing) Rabenhorst 1847
Rhopalodia gibberula var. *musculus* (Kützing) Cleve-Euler 1952



1 - 7



8 - 13

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Appendix 5

Project Name: Site Specific Intensive Monitoring (SSIM) of a Raritan River tidal marsh

Final Report
July 12, 2021

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NJDEP Project Manager:
Signature Matthea Jepsen Date 8/12/2021

Project Information Page:

1. Project Name**: Site Specific Intensive Monitoring (SSIM) of a Raritan River tidal marsh**

2. Date of Project Initiation: August 2019

3. NJDEP Project Manager: Metthea Yepsen

4. Quality Assurance Officer

5. Project Description

   A. **Objective and Scope Statement**:

The New Jersey Department of Environmental Protection, in partnership with the Mid-Atlantic Coastal Wetlands Assessment (MACWA), has developed a 4-tiered method to assess the health and status of coastal marshes and was designed to provide rigorous, comparable data across the Mid-Atlantic region. The objective of this project was install a Tier 4 Station along the upper tidal reaches of the Raritan River in an area of *Phragmites*-dominated marsh. *Phragmites*-dominated marsh was selected as this type of tidal wetland is comparatively under-represented in the larger network of SSIM Tier 4 sites statewide. Tier 4 involves the installation of 3 surface elevation tables (SET) to measure rates of elevation change and vertical accretion of the marsh surface. Intensive monitoring of the condition and function of the marsh vegetation and broader biotic community will be conducted along a series of transects associated with the SETS.

To advance green infrastructure, such as coastal marshes, which provide a range of ecosystem services, we need to account for the longevity of said marshes under continued, if not accelerated, sea level rise. These systems are not spatially fixed; instead, they continuously respond and shift in response to sea level rise. Therefore, their sustainability must be understood in the context of this variability. SET and marker horizon data from a SSIM Tier 4 station can be used by the NJDEP to determine whether a coastal marsh system is keeping pace with sea level rise by comparing among rates of elevation change, surface accretion, and current and projected sea level rise. In addition, marsh functioning can be determined by the various qualitative physical and biological observations thought to reflect pre-drowning stress. The SSIM Tier 4 station was selected as representative of *Phragmites*-dominated tidal wetlands in the lower Raritan River.

B. **Monitoring Network Design and Rationale**:

The objective of this project was install a Tier 4 Station along the upper tidal reaches of the Raritan River in an area of *Phragmites*-dominated marsh located on the New Brunswick River Conservation lands (Figure 1). The New Brunswick River Conservation Lands is a parcel of land owned by the City of New Brunswick and is protected open space. Permission was received from the New Brunswick Mayor's Office and City Council before proceeding with field work. *Phragmites*-dominated marsh was selected because this type of tidal wetland is comparatively under-represented in the statewide network of SSIM Tier 4 sites. This site is located between Route 1 and the NJ Turnpike, is downriver from the City of New Brunswick, and is quite urban in character. Urban systems are also comparatively under-represented in the statewide network of SSIM Tier 4 sites.

We referred to the Site Specific Intensive Monitoring protocols established by MACWA (https://s3.amazonaws.com/delawareestuary/pdf/Restoration/MACWA_QAPP_Umbrella_SSIM_09_21_2010_signature.pdf) to help design our Tier 4 station layout. Three areas of interest (AOI) were selected between 25 and 60 m from the riverbank. Each AOI is approximately 50 m in length. A random number generator was used to select a random geographic coordinate location within each AOI to locate the SET and marker horizons (Figure 1). Due to the difficulty in navigating through the thick stand of *Phragmites*, the final locations of the SETs were somewhat offset from the initial target locations. The final UTM Coordinates were: SET 1 550197 UTME4482403 UTMN ; SET 2 550393 UTME 4482309 UTMN; SET 3 550632 UTME 4482234 UTMN. Four marker horizons were installed around each SET; one in each cardinal compass direction ~2-3 m from the SET rod.

The spatial layout of the individual Tier 4 station is displayed in Figure 2. The sites are only accessible by boat from the south bank of the Raritan River. Due to the thickness of the *Phragmites* stand at these sites, it was difficult to traverse the site without first cutting a path through the reeds, which required some physical disturbance of the site. The disturbed path was offset from the site of SET installation by ~ 5 m to create a straight line transect from the river edge perpendicular into the marsh. Systematic quadrats were sampled on one side of the path and biomass plots and soil cores were sampled from the other side of the path to minimize disturbance of the systematic quadrats. This establishment of only one vegetation transect deviates from the general MACWA SSIM protocol of a main transect and an additional two transects related to the Marker Horizons. We opted for one transect to decrease the amount of disturbance to the vegetation; additional paths from the river through the dense reed beds to the area of the SET may increase the influx of flood water and associated sediment, thereby changing the estimates of vertical accretion. Due to the homogeneity of the *Phragmites* vegetation on these sites, we believe that one transect will adequately capture the vegetation characteristics. This assumption will be re-evaluated once the first year of data has been fully analyzed and an additional vegetation transect included in the future if warranted.

Figure 1. Location of SETs at the Raritan River Tier 4 Station on New Brunswick River Conservation Lands.

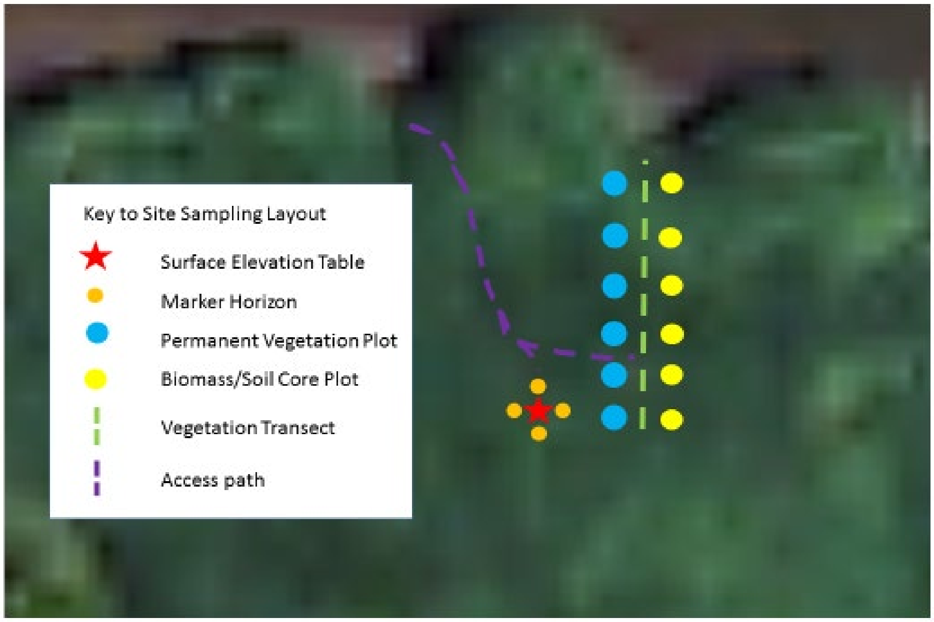


Figure 2. Layout of individual Raritan River Tier 4 Station on New Brunswick River Conservation Lands.

C. SET station installation

The SET and marker horizons were installed on July 24-25, 2019 using protocols established by the US Geological Survey, National Park Service and NOAA, as described in the document "The surface elevation tables and marker horizon technique: A protocol for monitoring wetland elevation dynamics" (https://pubs.er.usgs.gov/publication/70160049) (Lynch, 2015). At the site of each SET, phragmites were cleared in a ~2 m radius around the SET location. Using a temporary platform, we dug a ~50 cm deep, ~30 cm diameter hole and drove stainless steel rods into the marsh until refusal using a jackhammer. Each rod section is 4 ft long, 15 mm diameter. At site 1, we used 5.5 rods; at site 2, we used 4.5 rods; and at site 3 we used 5 rods. We cut the last rod so that the top was flush with the marsh surface and inserted a PVC collar into the hole the around the rod. Next, the SET receiver was attached to the top of the rod and capped before the PVC collar was filled with soil and cement. Four marker horizons were installed around each SET; one in each cardinal direction, ~2-3 m from the SET rod. To install the marker horizons, a ground area ~50 cm x 50 cm was scraped to bare earth and a PVC quadrat was laid out. White play sand was deposited and lightly tamped down to a depth of 2.4 cm above ground surface.

On July 21, 2020, we surveyed the location of the SET stations with a Leica RTK survey instrument (Datum WGS84).

SET	Latitude	Longitude	Elevation_ground (m)	Elevation Receiver (m)
LRR_01	40.49076° N	74.40750° W	0.982	1.1934
LRR_02	40.48991° N	74.40521° W	1.0156	1.2504
LRR_03	40.48924° N	74.40242° W	1.0109	1.2224

SET DATA

Year 1: 2019

The SETs were revisited on October 24, 2019 and an initial reading of SET data collected by Dr. Laura Reynolds (Table 1).

Table 1. Initial SET Data Collection: 10/24/19

Surface Elevation Table 1									
Directions	Pin 1	Pin 2	Pin 3	Pin 4	Pin 5	Pin 6	Pin 7	Pin 8	Pin 9
North	195 mm	174 mm	218 mm	187 mm	186 mm	208 mm	185 mm	220 mm	204 mm
South	208 mm	192 mm	197 mm	195 mm	221 mm	216 mm	204 mm	235 mm	223 mm
East	206 mm	210 mm	218 mm	216 mm	198 mm	202 mm	200 mm	194 mm	200 mm
West	195 mm	212 mm	216 mm	232 mm	198 mm	227 mm	220 mm	211 mm	181 mm

Surface Elevation Table 2									
Directions	Pin 1	Pin 2	Pin 3	Pin 4	Pin 5	Pin 6	Pin 7	Pin 8	Pin 9
North	94 mm	91 mm	84 mm	86 mm	65 mm	94 mm	49 mm	71 mm	83 mm
South	57 mm	85 mm	81 mm	73 mm	98 mm	98 mm	95 mm	103 mm	100 mm
East	98 mm	87 mm	87 mm	100 mm	83 mm	96 mm	143 mm	84 mm	77 mm
West	69 mm	77 mm	91 mm	100 mm	57 mm	106 mm	94 mm	108 mm	99 mm

Surface Elevation Table 3									
Directions	Pin 1	Pin 2	Pin 3	Pin 4	Pin 5	Pin 6	Pin 7	Pin 8	Pin 9
North	103 mm	102 mm	99 mm	94 mm	95 mm	89 mm	97 mm	104 mm	85 mm
South	105 mm	113 mm	100 mm	91 mm	120 mm	108 mm	94 mm	90 mm	109 mm
East	125 mm	114 mm	112 mm	130 mm	124 mm	127 mm	113 mm	120 mm	120 mm
West	120 mm	133 mm	108 mm	109 mm	112 mm	114 mm	123 mm	108 mm	124 mm

Year 2: 2020

The SETs were revisited on 7/24/2020, 8/26/2020 and 10/27/2020 and SET data collected by Dr. Richard Lathrop with graduate student Emelie Einhorn as notetaker. No Marker horizon data was collected as there was not sufficient accretion of sediment consistently across all the sites.

Table 2. SET Data Collection: 7/24/20

7/24/2020	10:12	Rick Lathrop		units = mm
SET 1				
Bearing	North	West	South	East
Pin	1	3	5	7
1	133	145	122	141
2	131	155	127	142
3	127	145	115	149
4	131	157	111	137
5	138	137	107	146
6	136	142	117	140
7	144	137	132	139
8	135	142	124	138
9	136	138	119	130

7/24/2020	10:55	Rick Lathrop		units = mm
Set 2				
Bearing	North	West	South	East
Pin	1	3	5	7
1	120	118	122	108
2	125	115	115	105
3	92	95	119	120
4	116	103	115	97
5	110	116	92	122
6	107	120	110	94
7	110	114	95	95
8	116	116	109	94
9	96	116	120	93

7/24/2020	11:43	Rick Lathrop		units = mm
Set 3				
Bearing	North	West	South	East
Pin	1	3	5	7
1	134	136	133	135
2	132	154	147	140
3	126	143	142	123
4	127	148	150	120
5	117	146	143	128
6	116	152	146	122
7	105	140	142	118
8	125	158	141	110
9	123	145	142	129

Table 3. SET Data Collection: 8/26/20

8/28/2020	8:45	Rick Lathrop		units = mm
SET 1				
Bearing	North	West	South	East
Pin	1	3	5	7
1	143	115	127	135
2	137	114	113	129
3	122	109	114	148
4	126	112	117	146
5	133	120	115	142
6	134	125	107	132
7	135	120	122	132
8	129	120	125	135
9	109	124	118	133

8/28/2020	10:16	Rick Lathrop		units = mm
Set 2				
Bearing	North	West	South	East
Pin	1	3	5	7
1	136	114	115	110
2	129	121	110	97
3	129	95	89	129
4	110	103	93	110
5	113	113	102	99
6	100	119	112	85
7	111	129	88	91
8	109	121	111	92
9	99	120	115	119

8/28/2020	11:39	Rick Lathrop		units = mm
Bearing	North	West	South	East
Pin	1	3	5	7
1	138	132	144	138
2	140	141	153	165
3	127	137	140	139
4	112	148	147	135
5	127	144	155	135
6	132	137	153	136
7	107	139	159	153
8	136	133	149	165
9	115	130	146	167

Table 4. SET Data Collection: 10/27/20

10/27/2020	11:12	Observer: Rick Lathrop			
Set 1	units = mm		Notetaker: Emelie Einhorn		
Bearing	North	West	South	East	
Pin	1	3	5	7	
1	130	134	127	126	
2	139	130	119	127	
3	127	127	121	136	
4	124	118	112	130	
5	123	115	112	136	
6	129	109	114	133	
7	140	111	125	129	
8	139	125	124	124	
9	136	128	122	150	

10/27/2020	9:55	Observer: Rick Lathrop			
SET 2	units = mm		Notetaker: Emelie Einhorn		
Bearing	North	West	South	East	
Pin	1	3	5	7	
1	127	117	120	112	
2	131	117	114	107	
3	125	117	110	119	
4	114	115	105	125	
5	108	125	106	124	
6	114	116	102	112	
7	115	120	101	102	
8	114	118	107	101	
9	99	120	113	101	

10/27/2020	9:13	Observer: Rick Lathrop			
	units = mm		Notetake: Emelie Einhorn		
Bearing	North	West	South	East	
Pin	1	3	5	7	
1	143	150	146	138	
2	139	142	150	146	
3	150	141	142	147	
4	113	145	149	131	
5	118	136	150	147	
6	134	141	147	140	
7	107	143	152	145	
8	124	141	147	129	
9	133	143	141	129	

D. Marsh Condition & Function Monitoring

We referred to the Site Specific Intensive Monitoring (SSIM) protocols established by MACWA in developing the marsh vegetation and soil sampling procedures. The SSIM protocols are described in the following documents: https://s3.amazonaws.com/delawareestuary/pdf/Restoration/SSIM_SOPs.pdf; https://s3.amazonaws.com/delawareestuary/pdf/Restoration/MACWA_QAPP_Umbrella_SSIM_09_21_2010_signature.pdf). The specific sampling procedures that were employed are outlined below.

I. Vegetation

Year 1: 2019 Data

One transect of permanent plots was established for each of the 3 SET study plots (1 for each SET) to monitor the vegetation community composition and status (Figure 2). Data were collected on the following parameters for a series of quadrats along the transects: Plant species richness, percent cover, peak canopy height (Table 2), and light intensity (Table 3) at the surface and ribbed mussel density. Data were collected between August 27th and August 29th, at a period in the growing season where the *Phragmites* has reached its greatest height and flowering.

For all the three SETS the only vegetation species observed was *Phragmites australis*. No Ribbed mussels (*Geukensia demissa*) were observed.

Table 2. Vegetation monitoring results. Data collected for permanent vegetation monitoring quadrat (.25m^2). Live and dead stems were counted, vegetation cover percentage was determined and assigned a class (lowest 1-6 highest), and three individual *Phragmites australis* plants from outside the quadrat were cut at the base and measured for length.

Set 1

Set 1 Vegetation Monitoring Data								
Transect Length (m)	**Live stem count**	**Dead stem count**	**Cover class**	**Cover (%)**	**Height 1 (m)**	**Height 2 (m)**	**Height 3 (m)**	**Average Height (m)**
0	5	2	5	75	4.15	3.58	3.52	3.75
5	5	13	5	70	3.75	3.65	3.49	3.63
10	4	8	6	95	4.02	3.9	3.76	3.89
15	7	13	6	95	3.3	3.29	2.4	2.99
20	4	4	5	60	3.75	3.55	3.43	3.58
25	17	26	6	95	3.5	3.9	3.9	3.77

SET 2

Set 2 Vegetation Monitoring Data								
Transect Length (m)	**Live stem count**	**Dead stem count**	**Cover class**	**Cover (%)**	**Height 1 (m)**	**Height 2 (m)**	**Height 3 (m)**	**Average Height (m)**
0	7	8	6	85	4.2	4.21	4	4.14
5	7	11	6	90	3.9	3.81	3.95	3.89
10	4	4	6	95	4.15	4.2	4.02	4.12
15	5	4	6	95	3.97	3.99	4.04	4.00
20	5	10	6	80	4.22	3.97	3.94	4.04
25	4	5	5	55	4.07	4.02	4	4.03
30	5	14	5	60	3.75	3.54	3.4	3.56

SET 3

Set 3 Vegetation Monitoring Data								
Transect Length (m)	**Live stem count**	**Dead stem count**	**Cover class**	**Cover (%)**	**Height 1 (m)**	**Height 2 (m)**	**Height 3 (m)**	**Average Height (m)**
0m	4	5	5	75	3.25	3.2	3.2	3.22
5m	4	8	5	60	3.82	3.81	3.65	3.76
10m	4	2	6	85	3.6	3.5	3.44	3.51
15m	3	7	4	50	3.72	3.59	3.44	3.58
20m	9	8	5	55	3.72	3.62	3.56	3.63
25m	6	5	5	75	3.72	3.66	3.66	3.68
30m	2	6	4	50	3.63	3.51	3.4	3.51
35m	3	5	5	75	4.54	4.27	4.3	4.37
40m	7	5	5	60	4.87	4.74	4.75	4.78
45m	3	3	5	65	4.75	4.55	4.26	4.52
50m	NA	NA	NA	NA	NA	NA	NA	NA

Table 3. Light Intensity Table 1. Using a LI-191R Line Quantum Sensor, light intensity penetrating the base of the quadrat was collected at each cardinal direction (North, South, East, and West). Initial measurements were taken before taking 15,30, 45, and 60 second averages. Calibration measurements were collected in an open canopy setting. All Results are reported in µmol s^{-1} m^{-2}. All measurements were collected on August 29th 2019; conditions were sunny with no cloud cover.

.

SET 1

Set 1 Light Intensity Readings (11:59AM)

Transect Length (m)	Initial (μmol)	15 Second Average (μmol)	30 Second Average (μmol)	45 Second Average (μmol)	60 Second Average (μmol)
0	356.4	429	370.3	456.6	555.4
5	514.5	506.1	476	453.8	409.3
10	196.79	224.7	278.3	153.53	181.94
15	10.35	17.34	13.37	35.75	38.46
20	49.48	151.1	43.21	129.14	99.68
25	52.33	36.99	36.88	27.35	28.04
Calibration		1448.6	1429.9	1448.4	1449.4

SET 2

Set 2 Light Intensity Readings (12:40 PM)					
Transect Length (m)	**Initial**	**15 Second Average**	**30 Second Average**	**45 Second Average**	**60 Second Average**
0m	38.44	25.36	27.75	23.33	27.26
5m	67.5	88.26	77.52	155.64	205.7
10m	20.92	20.78	29.52	24.87	28.83
15m	153.2	141.89	234.5	247.5	321.8
20m	27.28	27.82	26.73	26.25	25.95
25m	226.7	146.3	203.1	159.28	134.75
30m	576.7	280.5	281.2	380.4	150.34
Calibration		1717.5	1708.4	1731.5	1743.1

SET3

Set 3 Light Intensity Readings (1:43PM)					
Transect Length (m)	**Initial**	**15 Second Average**	**30 Second Average**	**45 Second Average**	**60 Second Average**
0m	76.02	44.33	38.49	56.33	50.17
10m	18.8	19.22	18.65	18.28	17.4
20m	33.02	31.07	41.2	43.34	41.34
30m	76.75	50.17	67.05	75.08	67.05
40m	23.26	30.23	26.53	48.02	34.22
50m	58.64	57.58	59.33	58.84	59.38
Calibration		1686.7	1670.4	1677.3	1665.5

II. Above-Ground Biomass

Above-Ground Biomass samples were collected using a .25m^2 quadrat. Aboveground biomass was harvested in the field and split into the following categories Aboveground plant biomass (leaves and stems/woody material), litter layer, and stems/woody material (taken from litter). Biomass was separated into different sampling groups and processed in lab. Biomass was stored in a cool location until processed. Biomass was sorted into live and dead biomass, washed, and dried at 60 C until material reached a constant weight. Dried Biomass was then ground and sent into the Rutgers Soils Lab for Loss on

Ignition (LOI) and Total Carbon tests. The biomass measurements will serve as the baseline for future measurements in subsequent years (at approximately 5 year intervals) (Table 4).

Table 4. Above-Ground Biomass Results for four different fractions: leaves, stems and woody material, litter layer leaves and litter layer stems and woody material

SET 1

	Set 1 Aboveground Biomass Leaves Results			
Plot	**Dry Weight (g)**	**Total Nitrogen (%)**	**Total Carbon (%)**	**Carbon: Nitrogen (Ratio)**
A	36.96	1.92	46.62	24.28
B	0.68	2.55	27.67	10.85
C	NA	3.09	38.76	12.53

	Set 1 Aboveground Biomass Plant Material Results			
Plot	**Dry Weight (g)**	**Total Nitrogen (%)**	**Total Carbon (%)**	**Carbon: Nitrogen (Ratio)**
A	120.81	0.72	45.85	63.59
B	75.69	2.67	32.96	12.33
C	NA	NA	NA	NA

	Set 1 Litter Layer Leaves Results			
Plot	**Dry Weight (g)**	**Total Nitrogen (%)**	**Total Carbon (%)**	**Carbon: Nitrogen (Ratio)**
A	1.55	2.09	35.64	17.05
B	NA	1.97	40.60	20.64
C	0.41	NA	NA	NA

	Set 1 Litter Layer Sticks and Woody Material Results			
Plot	**Dry Weight (g)**	**Total Nitrogen (%)**	**Total Carbon (%)**	**Carbon: Nitrogen (Ratio)**
A	92.46	0.93	42.34	45.77
B	NA	1.24	40.49	32.79
C	46.11	0.92	44.67	48.66

SET 2

	Set 2 Aboveground Biomass Leaves Results			
Plot	**Dry Weight (g)**	**Total Nitrogen (%)**	**Total Carbon (%)**	**Carbon: Nitrogen (Ratio)**
A	24.06	2.24	44.94	20.10
B	28.48	2.06	44.25	21.50
C	9.34	2.36	44.41	18.84

	Set 2 Aboveground Biomass Plant Material Results			
Plot	**Dry Weight (g)**	**Total Nitrogen (%)**	**Total Carbon (%)**	**Carbon: Nitrogen (Ratio)**
A	173.88	0.94	47.45	50.75
B	189.66	0.68	44.59	65.57
C	124.06	0.75	46.32	61.85

	Set 2 Litter Layer Leaves Results			
Plot	**Dry Weight (g)**	**Total Nitrogen (%)**	**Total Carbon (%)**	**Carbon: Nitrogen (Ratio)**
A	3.1	2.30	40.04	17.41
B	0.72	2.28	40.58	17.81
C	1.22	1.86	36.76	19.80

	Set 2 Litter Layer Sticks and Woody Material Results			
Plot	**Dry Weight (g)**	**Total Nitrogen (%)**	**Total Carbon (%)**	**Carbon: Nitrogen (Ratio)**
A	70.36	1.38	44.28	32.20
B	59.40	1.79	40.99	22.91
C	72.43	1.86	36.76	19.80

SET 3

	Set 3 Aboveground Biomass Leaves Results			
Plot	**Dry Weight (g)**	**Total Nitrogen (%)**	**Total Carbon (%)**	**Carbon: Nitrogen (Ratio)**
A	30.86	1.86	46.27	24.87
B	22.45	1.79	45.41	25.44
C	17.62	1.55	44.82	28.95

	Set 3 Aboveground Biomass Plant Material Results			
Plot	**Dry Weight (g)**	**Total Nitrogen (%)**	**Total Carbon (%)**	**Carbon: Nitrogen (Ratio)**
A	266.2	0.55	46.18	83.66
B	151.56	0.75	45.57	60.84
C	240.28	0.62	45.87	74.47

	Set 3 Litter Layer Leaves Results			
Plot	**Dry Weight (g)**	**Total Nitrogen (%)**	**Total Carbon (%)**	**Carbon: Nitrogen (Ratio)**
A	7.90	1.74	42.61	24.49
B	6.30	1.48	42.10	28.52
C	2.96	1.87	37.32	20.00

	Set 3 Litter Layer Stems and Woody Material Results			
Plot	**Dry Weight (g)**	**Total Nitrogen (%)**	**Total Carbon (%)**	**Carbon: Nitrogen (Ratio)**
A	84.58	1.65	32.87	19.98
B	119.58	0.60	45.25	75.42
C	122.34	1.32	35.75	27.13

III. Below-Ground Biomass

Below-Ground Biomass a 15-cm diameter x 30 x cm long core was used to extract biomass. Biomass collection used the SSIM SOP# 20 methods. Below ground biomass was stored in a cool location until processed. Biomass was kept in its PVC Collar to keep the consistency of the material intact (Fig 3). Biomass was soaked and washed to remove all sediment (Fig 4). Biomass was then separated into two classes of material, root and rhizome. Roots and rhizomes were then sorted once again into live and dead biomass.This biomass was then washed and dried at 60° C until material reached a constant weight. Dried Biomass was then ground and sent to the Rutgers Soils Lab for Loss on Ignition (LOI) and Total Carbon tests. The biomass measurements will serve as the baseline for future measurements in subsequent years (at approximately 5 year intervals) (Table 5).

Table 5. Below-ground biomass: live and dead.

		Set 1 Belowground Biomass Roots and Rhizomes (Live)			
Plot	**Material Type**	**Dry Weight (g)**	**Total Nitrogen (%)**	**Total Carbon (%)**	**Carbon: Nitrogen (Ratio)**
A	Roots	1.83	1.39	31.95	22.97
A	Rhizomes	4.42	0.81	42.25	52.29
B	Roots	0.01	1.42	44.66	31.50
B	Rhizomes	N/A	NA	NA	NA
C	Roots	1.32	1.52	44.04	29.05
C	Rhizomes	1.78	0.93	43.61	46.95

		Set 1 Belowground Biomass Roots and Rhizomes (Dead)			
Plot	**Material Type**	**Dry Weight (g)**	**Total Nitrogen (%)**	**Total Carbon (%)**	**Carbon: Nitrogen (Ratio)**
A	Roots	0.54	1.69	34.04	20.13
A	Rhizomes	6.01	0.86	34.51	40.31
B	Roots	NA	NA	NA	NA
B	Rhizomes	NA	NA	NA	NA
C	Roots	1.08	1.09	47.98	44.14
C	Rhizomes	NA	NA	NA	NA

	Set 2 Belowground Biomass Roots and Rhizomes (Live)				
Plot	**Material Type**	**Dry Weight (g)**	**Total Nitrogen (%)**	**Total Carbon (%)**	**Carbon: Nitrogen (Ratio)**
A	Roots	21.68	1.58	41.11	26.05
A	Rhizomes	48.55	0.51	45.60	89.06
B	Roots	21.68	1.44	36.04	24.99
B	Rhizomes	37.35	0.42	46.77	111.35
C	Roots	3.41	1.33	39.83	29.86
C	Rhizomes	31.71	0.43	45.57	105.24

	Set 2 Belowground Biomass Roots and Rhizomes (Dead)				
Plot	**Material Type**	Dead Dry Weight (g)	**Total Nitrogen (%)**	**Total Carbon (%)**	**Carbon: Nitrogen (Ratio)**
A	Roots	7.6	1.35	42.19	31.28
A	Rhizomes	11.67	0.67	44.44	66.52
B	Roots	7.6	1.54	40.88	26.57
B	Rhizomes	31.06	0.70	46.13	65.89
C	Roots	2.81	1.32	39.90	30.32
C	Rhizomes	13.06	0.70	41.78	59.94

	Set 3 Belowground Biomass Roots and Rhizomes (Live)				
Plot	**Material Type**	**Dry Weight (g)**	**Total Nitrogen (%)**	**Total Carbon (%)**	**Carbon: Nitrogen (Ratio)**
A	Roots	23.56	0.80	29.27	36.40
A	Rhizomes	42.91	0.32	44.13	136.21
B	Roots	23.89	0.97	35.81	36.95
B	Rhizomes	64.15	0.39	44.77	113.93
C	Roots	10.36	0.86	36.23	41.93
C	Rhizomes	37.66	0.31	38.26	121.83

	Set 3 Belowground Biomass Roots and Rhizomes (Dead)				
Plot	**Material Type**	**Dry Weight (g)**	**Total Nitrogen (%)**	**Total Carbon (%)**	**Carbon: Nitrogen (Ratio)**
A	Roots	4.5	0.84	40.48	48.19
A	Rhizomes	25.68	0.49	39.95	81.86
B	Roots	9.98	0.88	34.91	39.89
B	Rhizomes	19.92	0.46	39.37	85.39
C	Roots	3.75	0.91	41.26	45.44
C	Rhizomes	14.22	0.58	41.97	72.36

IV. Soil

Soil was collected by using a soil probe to collect samples at depths of 0-10cm, 10-20 cm. and 20-30cm. Soils were collected, refrigerated, and sent to be processed by the Rutgers Plan Diagnostic and Soil Testing Lab. Collect Soil cores coincident with the biomass sampling. The following parameters will be analyzed for each soil core by the Rutgers Plant Diagnostic and Soil Testing Laboratory using standard laboratory protocols: Nutrients, pH, estimated Cation Exchange Capacity (CEC) & cation saturation, soluble salts, organic matter content, percentages of sand/silt/clay, soil textural class, organic-inorganic nitrogen. The soil core measurements will serve as the baseline for future measurements in subsequent years (at a proximately 5 year intervals) (Table 6).

Table 6. Soil Core results.

SET 1 Soil Sample Lab Results

Plot ID	Depth (cm)	pH	LRI	P lb/A	K lb/A	Ca lb/A	Mg lb/A	B ppm	Zn ppm	Mn ppm	Cu ppm	Fe ppm	Ammonium-N ppm	Nitrate-N ppm	Electrical conductivity mmho/cm	Total %C by C-N Analyzer	OM%calc	%N	C:N
A	0-10 cm	5.29	7.60	101	308	1906	1347	2.80	11.51	23.17	5.39	389	1.3	2.2	1.93	9.77	16.85	0.67	14.6
	10-20 cm	5.17	7.56	105	332	1681	1351	2.39	10.03	17.14	3.43	513	1.0	0.9	1.68	8.89	15.32	0.47	18.9
	20-30 cm	5.93	7.31	130	419	1742	1369	2.52	10.36	27.76	2.74	506	1.5	0.7	2.13	8.70	15.01	0.47	18.5
B	0-10 cm	5.77	7.34	81	431	2230	1693	3.53	20.79	48.72	3.35	446	3.0	2.3	2.4	9.23	15.91	0.65	14.3
	10-20 cm	5.68	7.37	74	437	1703	1365	3.49	15.83	60.21	2.69	674	1.3	0.4	2.39	7.73	13.33	0.46	16.7
	20-30 cm	5.63	7.43	61	475	1736	1372	3.26	15.43	55.87	2.84	664	1.5	0.3	2.04	7.51	12.95	0.52	14.6
C	0-10 cm	5.89	7.45	106	330	2079	1497	2.31	19.28	38.21	5.80	378	1.2	2.2	1.5	5.36	9.23	0.41	13.2
	10-20 cm	5.95	7.57	94	274	1552	1229	1.73	13.53	29.54	5.11	377	1.1	1.7	1.36	3.51	6.04	0.26	13.8
	20-30 cm	5.93	7.57	81	319	1333	1150	1.74	10.61	27.92	2.86	459	0.6	0.8	1.23	2.37	4.09	0.18	13.2

SET 2 Soil Sample Lab Results

Plot ID	Depth (cm)	pH	LRI	P lb/A	K lb/A	Ca lb/A	Mg lb/A	B ppm	Zn ppm	Mn ppm	Cu ppm	Fe ppm	Ammonium-N ppm	Nitrate-N ppm	Electrical conductivity mmho/cm	Total %C by C-N Analyzer	OM%calc	%N	C:N
A	0-10 cm	5.61	7.54	162	303	1670	1156	2.96	15.40	31.88	1.42	520	5.7	1.0	1.31	15.12	26.07	1.30	11.6
	10-20 cm	5.36	7.50	163	271	1562	956	2.83	18.54	40.04	1.81	521	3.9	0.3	1.65	12.53	21.61	1.06	11.9
	20-30 cm	5.28	7.45	181	235	1667	1049	2.49	17.91	28.50	2.24	464	2.3	0.4	1.8	13.97	24.09	1.15	12.2
B	0-10 cm	5.42	7.41	136	272	1832	1289	3.32	20.35	50.55	1.83	418	2.2	1.6	2.38	11.37	19.61	0.96	11.9
	10-20 cm	5.38	7.51	161	211	1644	1093	2.98	17.68	41.22	2.44	404	3.2	0.8	2.59	11.22	19.35	0.94	12.0
	20-30 cm	5.38	7.54	156	207	1486	983	2.69	17.54	50.45	2.60	395	3.9	0.4	2.2	11.25	19.39	0.90	12.6
C	0-10 cm	5.69	7.53	131	380	2125	1389	2.26	21.23	33.67	7.95	328	2.8	4.7	1.86	9.06	15.62	0.66	13.8
	10-20 cm	5.72	7.52	128	345	2380	1593	2.37	25.64	46.58	8.76	332	1.2	1.8	2.07	8.23	14.19	0.60	13.7
	20-30 cm	5.64	7.50	142	322	2328	1541	2.40	23.31	52.37	6.55	345	1.6	1.7	2.49	9.16	15.78	0.67	13.6

SET 3 Soil Sample Lab Results																		
Plot ID	Depth (cm)	pH	LRI	P lb/A	K lb/A	Ca lb/A	Mg lb/A	B ppm	Zn ppm	Mn ppm	Cu ppm	Fe ppm	Ammonium-N ppm	Nitrate-N ppm	Electrical conductivity mmho/cm	Total %C by C-N Analyzer	OM%calc	%N	C:N
A	0-10 cm	6.04	7.51	104	336	2328	1614	2.65	25.09	30.27	12.19	281	1.0	8.1	1.33	5.16	8.89	0.41	12.8
	10-20 cm	5.93	7.47	68	258	1835	1367	2.36	18.81	24.94	17.64	253	0.6	5.4	1.29	4.93	8.50	0.34	14.4
	20-30 cm	6.00	7.59	65	268	1564	1139	1.95	15.20	22.84	12.22	255	0.9	4.4	1.09	3.70	6.38	0.25	14.6
B	0-10 cm	5.92	7.52	120	352	2510	1486	1.98	24.21	24.41	7.08	361	1.4	14.2	1.41	6.84	11.79	0.45	15.1
	10-20 cm	5.68	7.43	110	292	2031	1446	1.72	23.67	16.46	8.35	350	1.2	9.6	1.46	4.58	7.89	0.31	14.7
	20-30 cm	5.67	7.42	106	339	2161	1477	2.01	24.10	21.23	10.46	340	0.7	9.6	1.46	5.05	8.71	0.34	14.8
C	0-10 cm	5.90	7.49	110	317	2131	1402	1.80	22.11	16.00	10.64	347	4.7	18.4	1.11	3.96	6.82	0.28	14.3
	10-20 cm	5.81	7.53	102	299	2141	1387	1.90	23.49	13.75	12.62	328	1.0	8.8	1.44	3.87	6.66	0.27	14.2
	20-30 cm	5.84	7.48	114	341	2079	1337	1.83	22.98	28.26	14.79	323	0.9	5.6	1.28	4.03	6.95	0.26	15.3

Year 2: 2020 Data

V. Vegetation

One transect of permanent plots established in 2019 for each of the 3 SET study plots (1 for each SET) was revisited to monitor the vegetation community composition and status (Figure 2). Data were collected on the following parameters for a series of quadrats along the transects: Plant species richness, percent cover, peak canopy height (Table 7), and light intensity (Table 8) at the surface and ribbed mussel density. Data were collected on August 26, 2020, at a period in the growing season where the *Phragmites* has reached its greatest height and flowering. Data was collected by Richard Lathrop, Laura Reynolds and Emelie Einhorn.

For all the three SETS the only vegetation species observed was *Phragmites australis*. No Ribbed mussels (*Geukensia demissa*) were observed.

Table 7. Vegetation monitoring results. Data collected for permanent vegetation monitoring quadrat (.25m^2). Live and dead stems were counted, vegetation cover percentage was determined and assigned a class (lowest 1-6 highest), and three individual *Phragmites australis* plants from outside the quadrat were cut at the base and measured for length.

Set 1

SET 1				
Stem Count *Phragmites australis*			8/26/2020	
Transect Le	Living	Dead		Cover Class
0m	1	0m	3	5
5m	7	5m	19	5
10m	11	10m	20	5
15m	5	15m	11	4
Height of 3 tallest plants (cm)				
0m	344	330	337	
5m	330	339	334	
10m	359	362	345	
15m	342	343	340	

SET 2

SET 2					
Stem Count *Phragmites australis*			8/26/2020		
Transect	Living	Dead		Cover Class	Flower
0m	3	0m	14	4	Yes
5m	9	5m	23	6	Yes
10m	7	10m	3	4	Yes
15m	3	15m	10	5	Yes
20m	10	20m	3	5	Yes
25m	10	25m	15	6	Yes
30m	7	30m	17	6	Yes
Height of 3 tallest plants (cm)					
0m	383	372	406		
5m	353	355	394		
10m	351	371	382		
15m	363	374	366		
20m	370	377	389		
25m	422	411	400		
30m	380	393	402		

SET 3

SET 3					
Stem Count *Phragmites australis*			8/26/2020		
Transect	Living	Dead		Cover Class	Flower
0m	14	0m	18	6	Yes
5m	13	5m	12	4	Yes
10m	8	10m	21	4	Yes
15m	11	15m	25	4	Yes
20m	6	20m	13	5	Yes
25m	17	25m	30	5	Yes
30m	9	30m	27	4	Yes
35m	5	35m	22	4	Yes
40m	10	40m	17	5	Yes
45m	8	45m	14	4	Yes
Height of 3 tallest plants (cm)					
0m	322	340	345		
5m	350	360	374		
10m	340	342	355		
15m	328	332	358		
20m	324	332	374		
25m	352	366	367		
30m	343	354	370		
35m	340	343	403		
40m	396	409	412		
45m	375	389	401		

Table 8. Light Intensity Table 2. Using a LI-191R Line Quantum Sensor, light intensity penetrating the base of the quadrat was collected at each cardinal direction (North, South, East, and West). Initial measurements were taken before taking 15,30, 45, and 60 second averages. Calibration measurements were collected in an open canopy setting. All Results are reported in µmol s^{-1} m^{-2}. All measurements were collected on August 26, 2020; conditions were sunny with no cloud cover.

SET 1

LICOR	8/28/2020				
time (AM)	plot #	15s (umol	30s (umol)	45s (umol)	60s (umol)
9:21	open	851.9	863.4	862.7	867.8
9:25	0m	10.05	10.42	10.65	10.31
9:27	5m	18.05	18.99	16.64	18.92
9:29	10m	12.26	13.87	11.8	11.85
9:33	15m	9.29	8.8	8.86	9.24

SET 2

LICOR	8/28/2020				
time (AM)	plot #	15s (umol	30s (umol)	45s (umol)	60s (umol)
9:44	open	1081	1084.9	1097	1114.7
9:53	0m	27.05	25.37	25.39	26.84
9:57	5m	62.12	59.43	60.07	56.62
10:00	10m	20.98	23.81	24.98	19.94
10:03	15m	8.82	8.82	8.12	7.17
10:06	20m	26.41	22.14	21.62	18.44
10:09	25m	5.16	7.43	6.3	8.35
10:12	30m	3.83	4.11	4.08	4.15

SET3

LICOR	8/28/2020				
time (AM)	plot #	15s (umol	30s (umol)	45s (umol)	60s (umol)
10:53	open	1386.3	1383.8	1394	1412.7
11:00	0m	187.92	166.97	199.72	221.6
11:03	5m	87.52	93.59	92.53	90.26
11:06	10m	136.76	180.84	178.87	185.4
11:09	15m	64.83	68.5	74.93	72.91
11:12	20m	80.82	92.7	130.08	118.08
11:15	25m	85.28	87.1	88.41	88.46
11:18	30m	67.79	70.89	68.55	69.61
11:20	35m	200.9	197.21	213.4	216.6
11:23	40m	278	228.6	172.74	209.3
11:27	45m	56.72	56.89	64.33	55.64

VI. Water

Year 1: 2019 Data

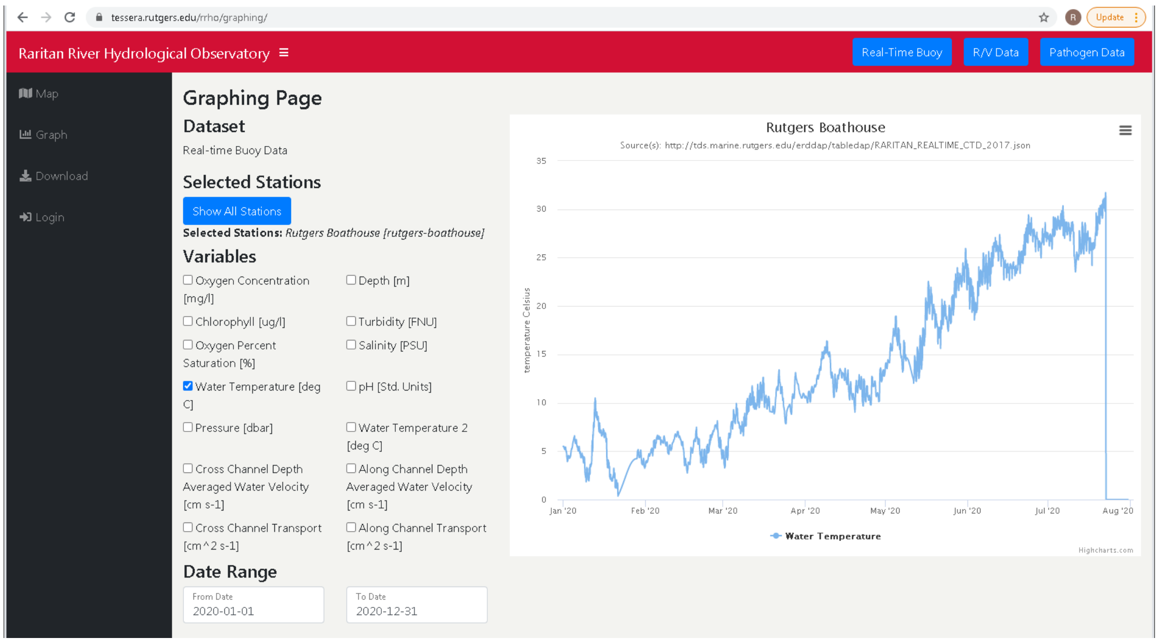
Surface water samples were collected from the Raritan River during an outgoing tide coincident with the fall sampling date (Table 9). A bucket was used to collect a surface water sample and transferred to a 1 liter bottle with 3 replicate 1 liter samples collected. Each sample were analyzed by the Rutgers Plant Diagnostic and Soil Testing Laboratory using standard laboratory protocols: pH, soluble salt content, nitrate-nitrogen, phosphorus, iron. Additional data were collected on temperature, turbidity, pH, salinity, dissolved oxygen and chlorophyll at a water quality monitoring station 2.5 km upstream. These data are accessible at https://tessera.rutgers.edu/rrho/

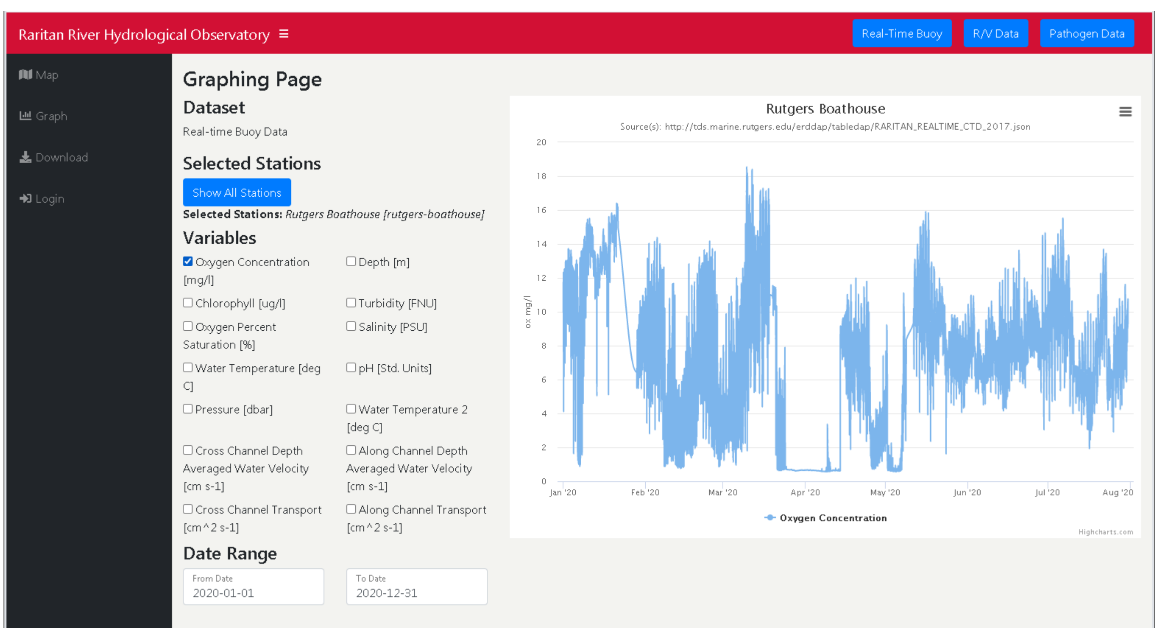
Table 9. Water Samples

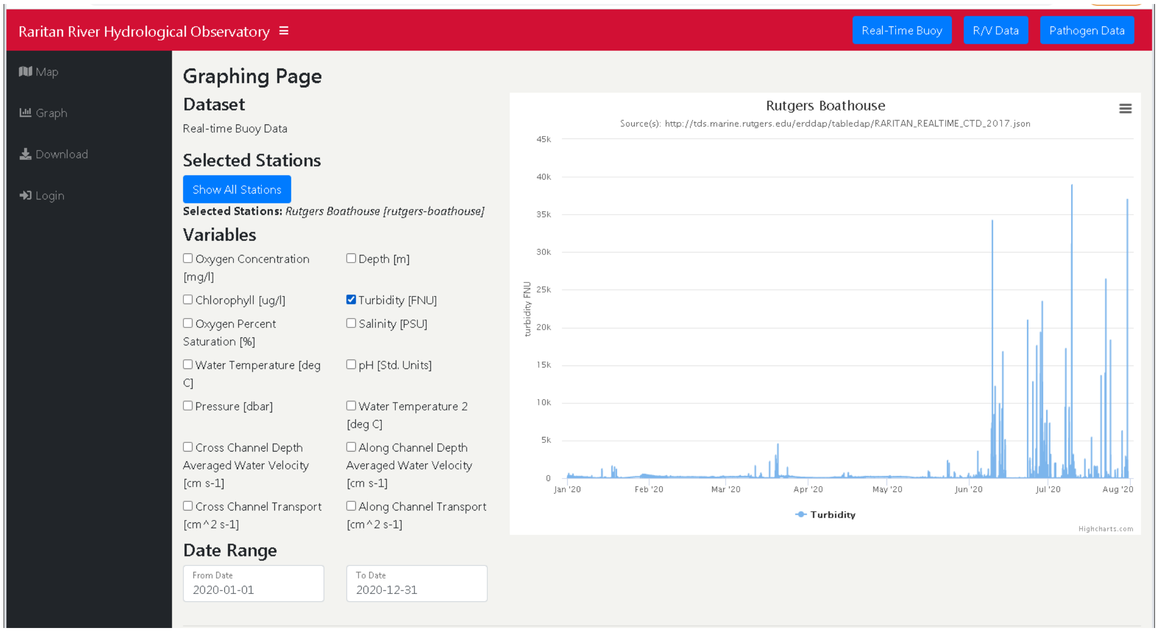
Raritan River Water Sample Lab Results													
Sample	pH	EC mmho/cm	P ppm	K ppm	Ca ppm	Mg ppm	B ppm	Zn ppm	Mn ppm	Cu ppm	Fe ppm	Ammonium-N ppm	Nitrate-N ppm
Set 1 Raritan	7.32	1.16	0.29	6.52	29.44	24.11	0.13	<0.01	<0.01	<0.01	0.06	0.52	1.36
SET 1 Porewater	No	Sample	Collected										
Set 2 Raritan	7.20	1.18	0.40	6.78	32.00	25.05	0.14	<0.01	0.04	<0.01	0.07	0.05	1.36
Set 2 Porewater	6.55	2.07	0.27	6.57	48.87	54.92	0.26	0.01	3.90	0.01	0.52	<0.01	0.29
Set 2 Porewater 2	6.65	1.87	0.33	6.57	32.58	42.23	0.32	<0.01	1.73	0.03	1.04	0.02	0.07
Set 3 Raritan	7.22	1.20	0.31	6.77	31.38	25.42	0.14	<0.01	0.02	<0.01	0.09	0.04	1.40
Set 3 Porewater 1	6.43	3.17	0.18	16.07	51.56	73.89	0.38	0.03	0.82	0.03	0.89	<0.01	0.08
Set 3 Porewater 2	6.74	4.07	0.42	15.05	39.38	64.76	0.60	0.01	1.24	0.05	4.02	<0.01	0.18

Year 2: 2020 data

Data were collected on temperature, turbidity, pH, salinity, dissolved oxygen and chlorophyll at a water quality monitoring station 2.5 km upstream. Data plots are included below. A technical malfunction took the station out of commission in mid-August 2020. Due to COVID were unable to access the site to service the station for the remainder of 2020. These data are accessible at https://tessera.rutgers.edu/rrho/






Raritan River Hydrological Observatory
Real-Time Buoy
R/V Data
Pathogen Data
Map
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Real-time Buoy Data
Selected Stations
Show All Stations
Selected Stations: Rutgers Boathouse [rutgers-boathouse]
Variables
Oxygen Concentration [mg/l]
Depth [m]
Chlorophyll [ug/l]
Turbidity [FNU]
Oxygen Percent Saturation [%]
Salinity [PSU]
Water Temperature [deg C]
pH [Std. Units]
Pressure [dbar]
Water Temperature 2 [deg C]
Cross Channel Depth Averaged Water Velocity [cm s-1]
Along Channel Depth Averaged Water Velocity [cm s-1]
Cross Channel Transport [cm^2 s-1]
Along Channel Transport [cm^2 s-1]
Date Range
From Date
2020-01-01
To Date
2020-12-31
Rutgers Boathouse
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turbidity FNU
Turbidity
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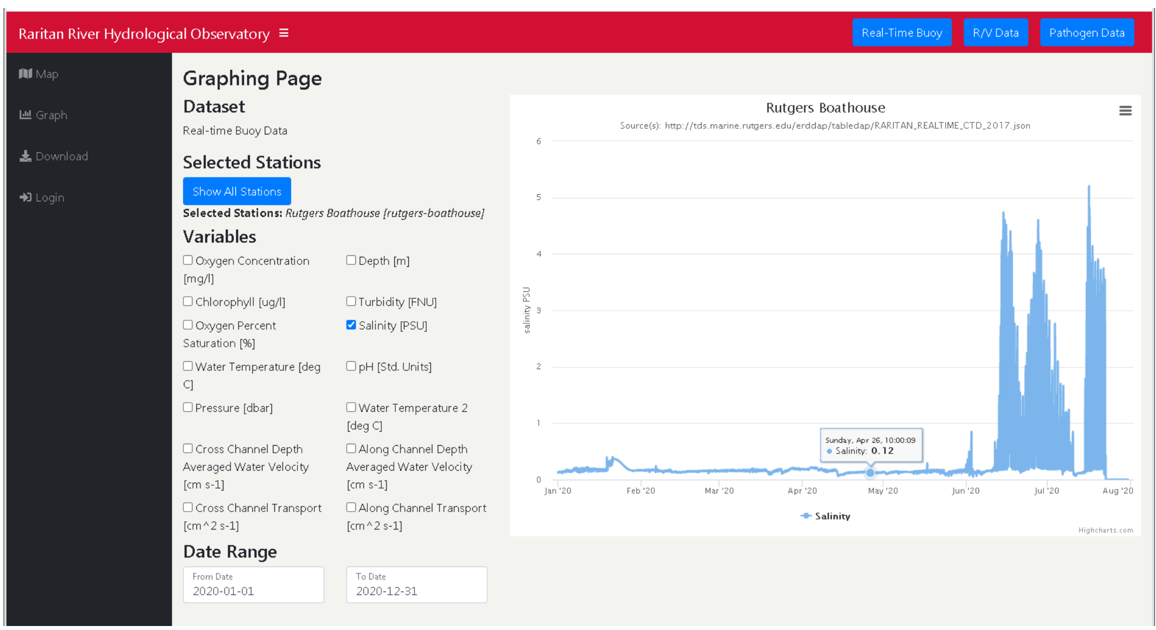
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Water Temperature 2 [deg C]
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Cross Channel Transport [cm^2 s-1]
Along Channel Transport [cm^2 s-1]
Date Range
From Date
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To Date
2020-12-31
Rutgers Boathouse
Source(s): http://tds.marine.rutgers.edu/erddap/tabledap/RARITAN_REALTIME_CTD_2017.json
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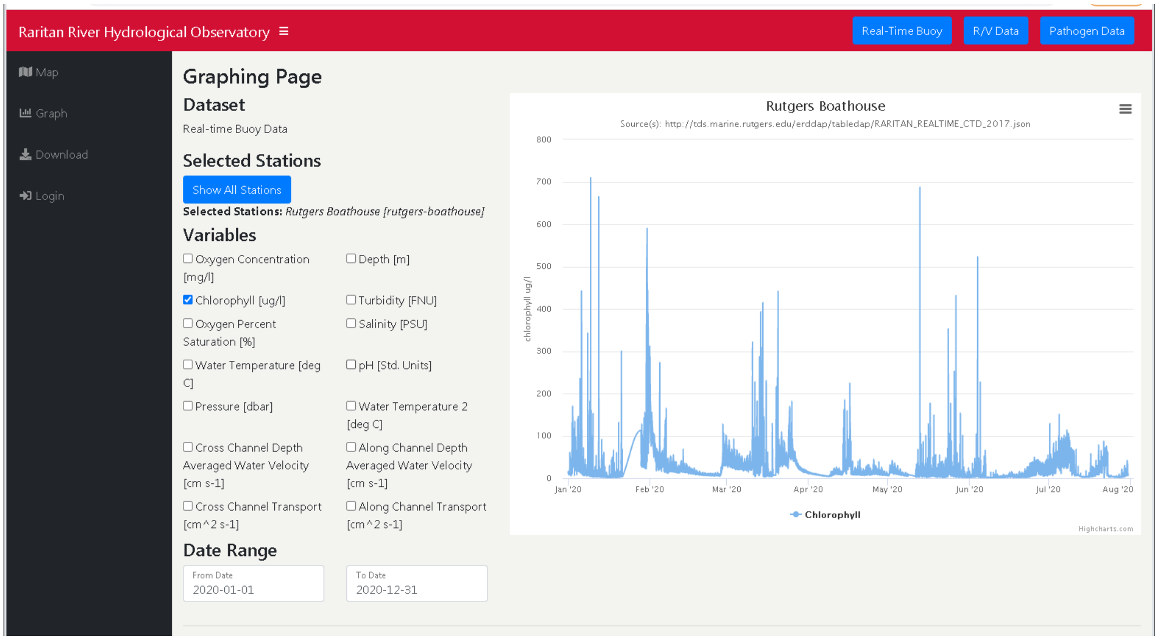
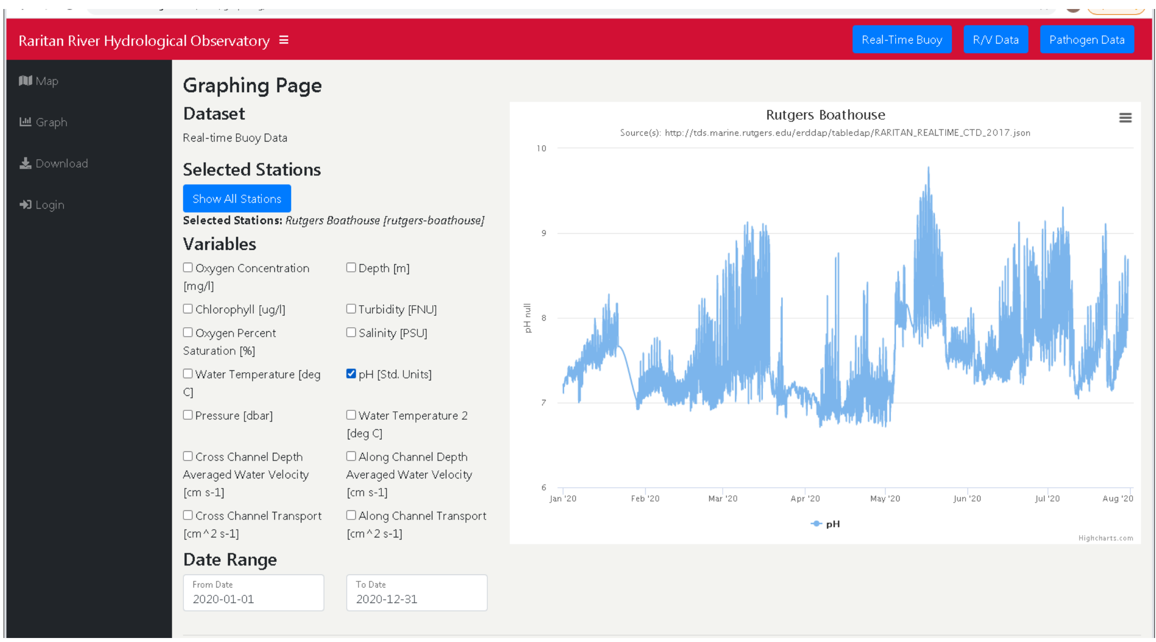
Highcharts.com





H. Data Organization and Archiving

The data collected above were organized into a series of data tables along with accompanying documentation on field collection and subsequent laboratory protocols and archived at CRSSA. SET monitoring data was also submitted to the NJDEP in the “official” MACWA spreadsheet format.

Appendix 6

Applicability of a Rapid Assessment Method for Evaluating Restoration Sites Using the New Jersey Reference Wetland Tool

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Introduction

Coastal wetlands provide numerous benefits to coastal communities around the world, from the broad range of ecosystem services they provide (Friess et al. 2020; Barbier 2019; Mitsch and Gosselink 2015). However, it has been estimated that up to 87% of the global wetland habitat, including 50% of all coastal wetlands, has already been lost since 1700 AD (Davidson 2014; Mitsch and Gosselink 2015). Furthermore, these systems also face threats to their long-term integrity, especially from sea level rise (Borchert et al. 2018; Webb et al. 2013). Stakeholders throughout New Jersey are seeking ways to improve knowledge of coastal wetland condition and identify vulnerable areas that could benefit from a range of restoration practices, including beneficial use of dredged sediments, bank stabilization, and hydrologic alterations (Yepsen et al. 2016). In response to these needs, The New Jersey Reference Wetland Tool (or the Tool) was developed through a partnership between the New Jersey Department of Environmental Protection (NJDEP) and Riparia at Penn State University to summarize available reference data for New Jersey's coastal wetlands, increase accessibility of the reference data, and provide a resource to help plan and inform restoration efforts. The Tool also highlights sites with condition assessment Final Scores that exceed a threshold, specific to the assessment methodology, which was determined via statistical analysis for designation as Reference Standard sites (Table 1). These higher quality Reference Standard sites have metrics indicating they have the best ecological condition with minimal disturbances, making them useful references for comparing against other sites that may be degraded or impacted (see Brooks et al. 1998). Intended applications of the Tool include identification of sites in need of intervention (e.g., restoration), setting measurable targets for restoration goals using reference values available in the Tool, and potentially evaluating the success of already completed restoration projects. However, restoration success is notably difficult to assess, as it can be measured relative to a range of restoration goals, or natural background conditions that may not be well-documented or fully understood (Yepsen et al. 2014). Ideally, restoration outcomes should be monitored for more than the typical 1 to 5 years, as vegetation populations may take up to a decade to establish and stabilize following restoration activities, while soils could take multiple decades to generate functions similar to reference sites (Buchsbaum and Wigand 2012; Yepsen et al. 2016). But long-term monitoring of restoration sites is often deemed too expensive and infeasible.

Table 1. Statistically calculated thresholds from different condition assessment methods used for designation of a Reference Standard site in the Tool.

Condition Assessment Method	Abbreviation	Threshold
Mid-Atlantic Tidal Wetlands Rapid Assessment Method	MidTRAM	≥ 81
Ecological Integrity Assessment	EIA	≥ 74
National Wetland Condition Assessment	NWCA	≥ 74

With the first version of the Tool now completed and available online, an appropriate demonstration of its application is warranted. While the Tool's reference data may be useful under a variety of different applications, the primary focus in this study is the comparison of these reference data to newly collected data at sites that received some form of management for restoration in the last 5 years. This approach is intended to highlight whether restoration sites exhibit similar structure and function to other wetlands in the region, as well as provide insight for strategies to quantify restoration success using a range of metrics already being monitored in New Jersey. Additionally, this study is an opportunity to help identify any aspects of the Tool that could use further development, in order to improve its function for future updates. For this project, we evaluate the differences in the metric values between recently restored sites and available local reference data included in the Tool.

Methods

Background

Our initial efforts focused on reviewing the reference data available in the Tool, including all the metrics displayed from the different data sources. Data sources available in the Tool at the time this work was conducted included the NJ Beneficial Use of Dredged Material Restoration pilot project, the Ecological Integrity Assessment (EIA), the National Wetlands Condition Assessment (NWCA), and Mid-Atlantic Tidal Wetlands Rapid Assessment Method (MidTRAM or RAM). The EIA, NWCA, and RAM methods evaluate wetland condition and produce a Final Score to reflect the overall assessment. Reference sites in the Tool were not evenly distributed across New Jersey, so we looked for areas of the State where the Tool had plenty of data, allowing for a more robust analysis. Categorical data filters in the tool include tide range, salinity, 8-digit hydrologic unit codes (HUC8), and watershed management areas (WMA). Because the tool contained an abundance of reference data from RAM, we focused on this assessment method for this study. The most recent iteration of the RAM protocol (version 4.1) was used. Our comparisons of restoration sites against reference data were drawn at the HUC level and did not filter other factors, resulting in a larger dataset with greater variability.

Three recently restored sites in southern New Jersey were selected, based on proximity to reference sites, accessibility, variability in project goals, and time since restoration (Figure 1). For each restoration site, one to two nearby reference sites were reassessed to consider whether historic RAM data included in the Tool has remained consistent (Table 4). At the time of writing this report, there were nine RAM metrics included in the Tool, all of which are considered in our evaluation.

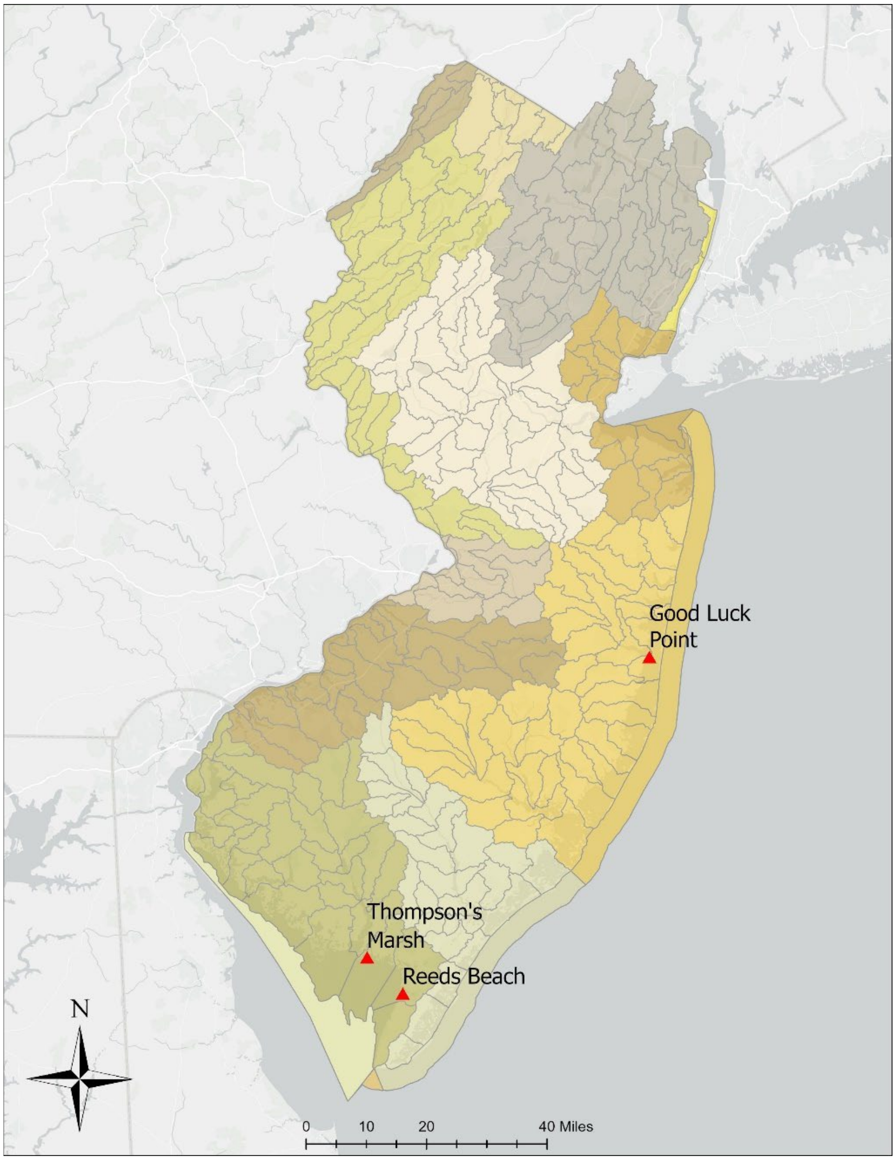

Figure 1. Map of New Jersey with boundaries showing boundaries of the 12-digit Hydrologic Unit Codes (HUC12), where different colors indicate HUC8 boundaries. The red triangles display the restoration sites assessed in this study.

Reassessing sites required accessing coordinates for the historic data. While much of the data can be downloaded through the Tool, locations are not included. Comprehensive data records for historic reference data, including geolocations, were provided upon request from The Partnership for the Delaware Estuary (PDE), who co-developed the RAM protocol and spearheaded much of the data collection in New Jersey. When additional supporting data were available from PDE's records, they were considered in our interpretations. To review the value of historic data, we documented any point differences for the Final Scores from the reassessed sites and their original assessments. We also noted whether any changes affected their categorical disturbance level, where >81 is minimally disturbed, 63-81 is moderately disturbed, and < 63 is severely disturbed. These thresholds were derived statistically by the RAM authors.

In this study, we sought to (1) review temporal data consistency, (2) apply RAM at restoration sites, (3) and compare restoration sites to reference data in the Tool. These efforts supported the goal of evaluating how the Tool may be useful in setting restoration targets and assessing restoration success. As an added benefit of using RAM methods in the project, we were able to make suggestions on how RAM Methods could be adapted for use in tidal wetland restoration project monitoring. It was not feasible to adequately assess restoration success in this study, as each restoration project had its own baseline conditions and goals that were not specifically evaluated and some of the sites had been restored too recently to show uplift. Additionally, it was not initially clear whether the Tool's data would be applicable to restoration projects, as the reference data were not originally collected for that purpose.

Table 2. List of RAM metrics included in the Tool with brief descriptions.

Metric name	Description
Buffer Attribute Score	Five buffer metrics are scored between 3 and 12, then summated and divided by the total possible value of 60. The value is adjusted to a 0-100 scale. Higher values indicate healthier conditions.
Hydrology Attribute Score	Three buffer metrics are scored between 3 and 12, then summated and divided by the total possible value of 36. The value is adjusted to a 0-100 scale. Higher values indicate healthier conditions.
Habitat Attribute Score	Five buffer metrics are scored between 3 and 12, then summated and divided by the total possible value of 60. The value is adjusted to a 0-100 scale. Higher values indicate healthier conditions.
Final Score	Average of the three attribute scores (buffer, hydrology, habitat). Higher values indicate healthier conditions.
QDR	Qualitative Disturbance Rating, ranging from least to most disturbed (1 to 6, respectively)
Salinity	Salinity measured in nearest tidal channel or water source
% Invasive Species Coverage	Total percent coverage of all invasive species in the assessment area
Species Richness	Species present with at least 10% coverage in the assessment area
% Natural Buffer	The percent of the buffer area that is contiguous and in a natural or semi-natural state

RAM Protocol

Reference data collected using RAM protocols were selected for the focus of this project because it is the dominant data source in the Tool. RAM was developed to "learn more about tidal wetland processes and stressors and how these impact the ecological integrity or condition of wetlands" (Rogerson and Haaf 2017). One major benefit of using RAM for condition assessments is the design and intent of rapid application. This is evident by its broad reaching data collection efforts, with data coverage available throughout numerous NJ watersheds in randomized locations. In this study, our data collection followed the most recent iteration of the RAM protocol (version 4.1). The historic data available in the Tool were collected using version 4.1, or previous versions that were standard at the time of a survey. RAM data collected between June 2010 and May 2016 followed RAM version 3.0, which applies to the original assessments for all the reference sites that we reassessed in this study. Thus, comparing the reassessment data to the original assessment data must be interpreted with caution as there have been substantial alterations to the protocol since 2016. Affected scoring metrics included in the Tool are described in Table 3.

Table 3. Overview of scoring metrics included in RAM versions 3.0 and 4.1, highlighting changes to the protocol metrics that determine the three attribute scores (Buffer Attribute Score, Hydrology Attribute Score, Habitat Attribute Score) and the Final Score for assessing overall site condition. Maximum raw scores are shown for version 4.1, which are later adjusted to a 0-100 scale for scoring and reporting. Historic assessments in this study used version 3.0, while this study's assessments used the current version, 4.1.

Metric	MidTRAM 3.0 Descriptions	MidTRAM 4.1 Descriptions	Notable changes	Max Score
B1	% AA perimeter with 5m buffer	% Assessment Area (AA) Perimeter with 10m Buffer	Version 4.1 increased buffer size from 5m to 10m and altered scoring percentages	12
B2	Average buffer width	Natural Land Uses in Buffer	Version 4.1 updated from buffer width (avg of 8 lines or "spokes") to proportion of contiguous natural land use	12
B3	Surrounding development (between AA Edge and 250m)	Altered and High Impact Land Use (between AA Edge and 250m)	Version 3.0 used aerial imagery to estimate % of buffer developed; version 4.1 incorporates land use land cover data for more consistent areal estimates	12
B4	250m Landscape Condition	250m Landscape Condition	no major changes; version 4.1 adds mention of point source inputs	12
B5	Barriers to Landward Migration	Barriers to Landward Migration	no changes	12
BAS	**Buffer Attribute Score**	**Buffer Attribute Score**	All buffer metrics are scored between 3 and 12. Those scores are averaged, with values adjusted to a 0-100 scale.	**60**
H1	Ditching & Draining	Ditching & Excavation	Version 3.0 is based on ditch count, while 4.1 is based on the % of AA that is ditched	12
H2	Fill & Fragmentation	Fill	Version 3.0 is based on relative categorical descriptors of fill, while 4.1 is based on estimated % of fill in AA	12
H3	Diking/Tidal Restriction	Wetland Diking/ Tidal Restriction	Version 3.0 used qualitative % estimates of flow restriction, while 4.1 is based on simplified descriptors and photo examples	12
H4	Point Sources	NA - metric discontinued	Point sources are only assessed at freshwater sites in version 4.1 under metric H1, part b	NA
HAS	**Hydrology Attribute Score**	**Hydrology Attribute Score**	All hydrology metrics are scored between 3 and 12. Those scores are averaged, with values adjusted to a 0-100 scale.	**36**
HAB1	Bearing Capacity	Bearing Capacity	no changes for salt marsh sites	12
HAB2	Horizontal Veg Obstruction	Horizontal Vegetative Obstruction	Version 4.1 added measurements for taller vegetation and altered the scoring scale	12
HAB3	# Plant Layers	Number of Plant Layers	no major changes; 4.1 simplified into a checklist	12
HAB4	Percent co-dominant invasive spp	Plant Species Richness	Version 3.0 metric (Percent Co-dominant Invasive Species) was removed and replaced with a Plant Species Richness checklist for 4.1	12
HAB5	Percent invasive cover	Percent Invasive Cover	no changes	12
HAB	**Habitat Attribute Score**	**Habitat Attribute Score**	All habitat metrics are scored between 3 and 12. Those scores are averaged, with values adjusted to a 0-100 scale.	**60**
Final	**Final Score**	**Final Score**	Average of the three attribute scores (buffer, hydrology, habitat) adjusted to 0-100 scale	**100**

Overview of Restoration Sites

Mullica-Toms (02040301)

Good Luck Point

At the mouth of Toms River in northern Barnegat Bay, The United States Fish and Wildlife Service's (USFWS) Edwin B. Forsythe National Wildlife Refuge manages salt marsh along Good Luck Point. Prior to restoration efforts, this microtidal (<0.25m tidal range) marsh habitat could be characterized by having an extensive ditching network, tidal restrictions, and interior marsh dieback areas. "Waffle" pooling, including vegetation dieback and persistent interior ponding, is a phenomenon that is more likely to occur in microtidal environments with hydrological alterations (Smith et al. 2021). In the effort to restore this impacted area, local dredge materials were transported to strategically fill in the ditches and raise the elevation of the ponded dieback areas. These restoration activities aim to restore marsh elevation and more natural drainage networks. While restoration activities are ongoing in this area, the recent activities discussed in this report ended in December 2020. The Good Luck Placement Restoration site was selected within the sediment placement area to capture potential effects of restoration activities on RAM metrics and resulting scores (Figure 2). While it is generally inadvisable to conduct condition assessments immediately after restoration activities, unless for adaptive management purposes (Buchsbaum and Wigand 2012), we wanted to compare data collected in restoration sites with the data summarized in the reference wetland tool. At this site, RAM data were collected on August 10, 2021 for comparison against other local reference data available in the Tool. Validation of the Tool's reference data was attempted by reassessing a nearby RAM reference site, which we named Good Luck Control.

Cohansey-Maurice (02040206)

Thompsons Marsh

Within the Heislerville Wildlife Management Area, The American Littoral Society manages a restoration project at the Thompsons Marsh Placement Restoration site. This site has a history of impoundment for salt hay farming, a practice which has been described as the largest cause of marsh loss and degradation along the Delaware Estuary (Smith et al. 2017). Since then, the Public Service Enterprise Group (PSEG) removed the impoundments and restored the flow of estuarine waters. However, due to the impoundments, these marshes lacked decades-worth of sedimentation. Prior to American Littoral Society' restoration efforts, this section of the PSEG restoration remained severely degraded, with elevation deficits that would not support wetland vegetation. The goal of restoration here was to improve resilience to sea level rise by dredging nearby tidal creeks and applying the sediments into a nearly one-acre area outlined with coconut fiber logs to contain the sediment. This technique was intended to raise the elevation and improve marsh health by turning mudflat into a more stable, vegetated, low marsh platform. These restoration activities began on December 14, 2018 and were completed on February 27, 2019. RAM data were collected on August 9, 2021 and compared to other local RAM data included in the Tool. Efforts for Tool data validation included reassessing one of the nearest RAM reference sites, which we labeled Thompsons Marsh Control.

Reeds Beach

The USFWS's Cape May National Wildlife Refuge manages coastal marsh area along Reeds Beach. This marsh's history includes salt hay farming and ditching, resulting in vegetation dieback and interior ponding caused by prolonged inundation periods and elevation losses. Restoration activities here focused on digging shallow runnels to improve drainage to the impacted areas with persistent ponding and vegetation dieback. Excavations occurred in 2017, 2019, and 2020. We selected the Reeds Beach Restoration site (RBR) based on its relatively high density of runnels that were excavated in 2017. RAM data were collected here on September 30, 2021 and compared to other local RAM data included in the Tool. Additionally, this restoration area created a unique opportunity, in that a RAM reference site (named Reeds Beach Extra for this study) had also been previously assessed prior to these restoration activities. Reeds Beach Extra was also affected by the 2017 runnel excavations, although less intensively than RBR. However, an unaltered control site was still needed. The Reeds Beach Control site was selected for reassessment to help with data validation in the Tool.

Results and Discussion

In this study, we (1) reviewed data consistency of RAM across two versions over time, (2) considered the potential to apply RAM to restoration sites, and (3) compared RAM metrics at restoration sites to a large pool of reference data using the New Jersey Reference Wetland Tool. At the time of writing, the Tool included data from 234 sites. This includes 3 sites from the NJ Beneficial Use of Dredged Material pilot project, 17 from the Ecological Integrity Assessment (EIA), 14 from the National Wetlands Condition Assessment (NWCA), and 200 RAM sites.

Summarizing the 2021 RAM assessments (Table 4), the three restoration sites had RAM Final Scores that ranged 34.1 to 69.6, with an average of 57.3. The four reassessed sites ranged 48.9 to 80.7, with an average Final Score of 65.2. None of our 2021 assessments resulted in Final Scores high enough to meet the threshold for RAM Reference Standard site status. One notably promising detail was that the Final Scores for restoration sites were higher with respect to time since restoration activities. Of course, this study only includes three restoration sites, which used different activities under shorter timelines than may be ideal for evaluating restoration goals.

Our restoration site assessment data were compared against all available reference data within the relevant HUC. While this did provide a larger dataset for comparisons, it also introduced a larger range of potential variability, due to different wetland types, watersheds, salinities, tide range, methodologies, and other factors that could affect the data. Our approach allowed us to identify several key challenges with the Tool, including how it currently summarizes Final Scores across different methodologies. We generally recommend that users be more selective in filtering the available reference data to get the most representative subset of data for their applications.

Table 4. The list of our seven 2021 RAM 4.1 assessment sites. Site names, previously documented RAM site names, abbreviations, site types, HUC8, and Final Scores are listed.

Abbreviation	Site Name	MidTRAM Name	HUC8	Site Type	Final Score
GLR	Good Luck Restoration	Good Luck Restoration	Mullica-Toms	Restoration	34.1
GLC	Good Luck Control	Water's Edge	Mullica-Toms	Control/Reassessment	48.9
TMR	Thompsons Marsh Restoration	Thompsons Marsh Restoration	Cohansey-Maurice	Restoration	68.1
TMC	Thompsons Marsh Control	Bad Kayak Experience	Cohansey-Maurice	Control/Reassessment	80.7
RBR	Reeds Beach Restoration	Reeds Beach Restoration	Cohansey-Maurice	Restoration	69.6
RBE	Reeds Beach Extra	Revisiting the Big Fancy House	Cohansey-Maurice	Restoration/Reassessment	65.2
RBC	Reeds Beach Control	First Forest Walk	Cohansey-Maurice	Control/Reassessment	65.9

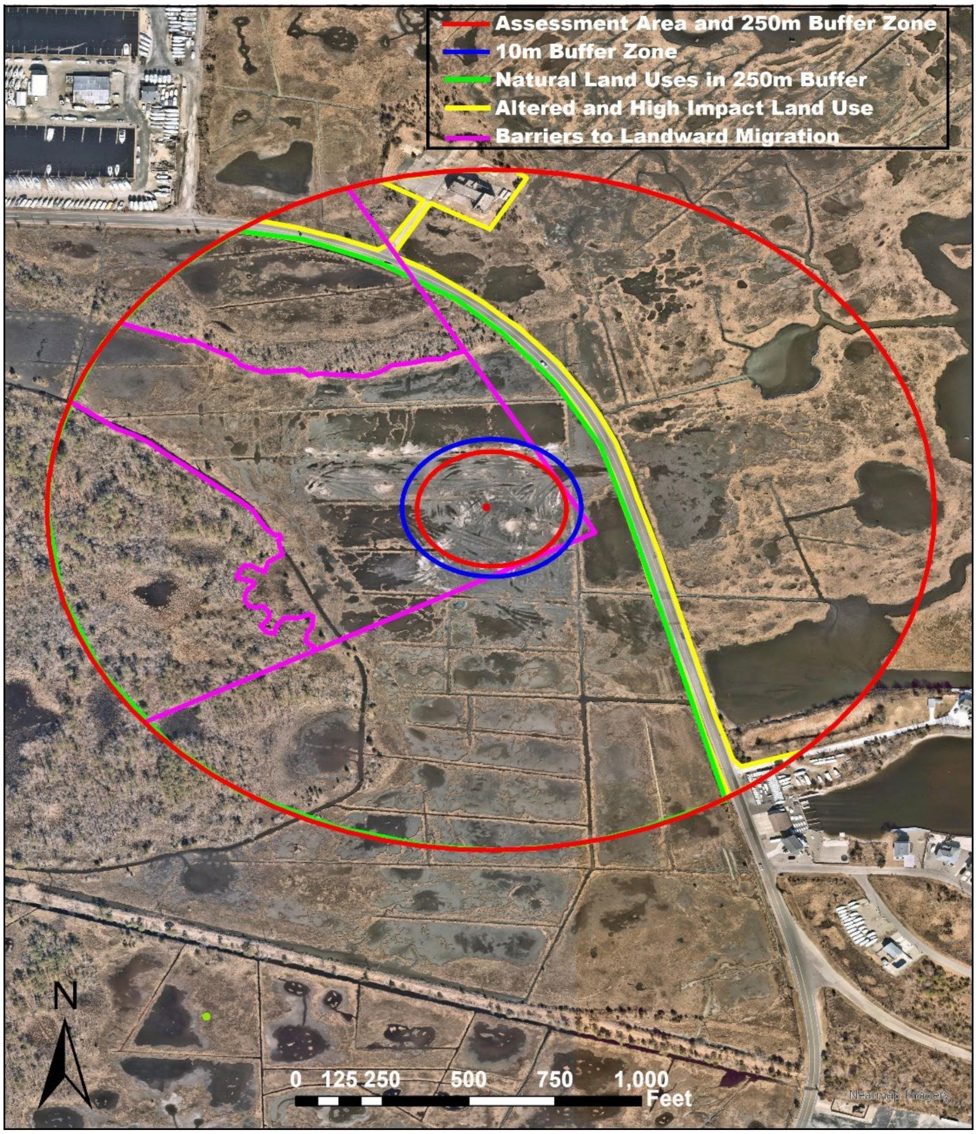

Figure 2. RAM desktop analyses overview at the Good Luck Point Restoration site with 2021 Nearmap imagery detailing the extent of restoration activity within the assessment area. Colors are indicated in the legend, highlighting the relevant features used for various desktop scoring metrics in the RAM 4.1 protocol. “Waffle” pooling is visible to the west and south of the assessment area.

Reassessment of Reference Sites - Historic data validation

In total, we reassessed four of the reference sites found in the Tool. Despite substantial changes to the RAM scoring metrics in different versions over time, the overarching goal of scoring site condition did not change. Therefore, we attempted to draw direct comparisons of metrics where possible, while describing caveats and problems in those comparisons (refer to Table 3). Sections below are organized by the 8-digit Hydrologic Unit Codes (HUC8) that were included in this study. Metric abbreviations and descriptions can be referenced in Tables 2 and 3, while sites are listed in Table 4. In addition, we breakdown the metrics used in calculating the attribute scores (Buffer Attribute Score, Hydrology Attribute Score, and Habitat Attribute Score) and Final Scores. These four primary scores are discussed relative to the adjustment to a maximum of 100 points. However, scores for raw attributes are frequently discussed below, which are given one of four scoring options according to the RAM protocol's criteria (3, 6, 9, and 12; refer to Table 3 for scoring descriptions).

Table 5. Original assessment Final Scores using RAM 3.0, reassessment Final Scores in 2021 using RAM 4.1, and the differences for all four reassessed sites in this study.

Site ID	Site Name	Original Final Score	2021 Reassessment Final Score	Difference
GLC	Good Luck Control	52.2	48.9	3.3
TMC	Thompsons Marsh Control	91.1	80.7	10.4
RBC	Reeds Beach Control	84.4	65.9	18.5
RBE	Reeds Beach Extra	79.4	65.2	14.3

Mullica-Toms (02040301)

Good Luck Point

At Good Luck Point in Upper Barnegat Bay, the Good Luck Control site was originally assessed on July 17, 2013 using RAM 3.0. For this project, the site was reassessed on August 10, 2021 using RAM 4.1. Overall, the Good Luck Control site was similar in both assessments. The Qualitative Disturbance Rating did not change over time, with both assessments issuing a 5 to indicate high disturbance. In both instances, the Final Score was comparably low and fell below the MACWA threshold for inclusion as a Reference Standard site (>81). Final Scores for the historic and new surveys similarly categorized the site to be "severely" affected (< 63), with the score decreasing 3.3 points from 52.2 to 48.9. The change in Final Score is primarily attributable to differences in values for metrics contributing to the Hydrology Attribute Score.

The Buffer Attribute Score was 66.7 in both assessments, with all contributing metrics remaining the same despite RAM protocol changes. The Hydrology Attribute Score was 16.7 points lower in 2021 than the first survey, driven largely by the removal of the point source metric in the newer RAM version 4.1. This caused a reduction from four to three metrics and had a large influence on the effect of averaging. Notably, if the original assessment score had not included the point source metric in its averaging, the Hydrology Attribute Score would be the same score for both assessments. The ditching/excavation metric increased by 3 due to the version changes to the metric, as no substantial differences in number of ditches or percent of ditched area were obvious in satellite imagery over time. The fill metric decreased by 3, which could either be due to alterations of this metric's criteria or the subjectivity of the definition or observability of fill. Diking and tidal restriction scores maintained the lowest possible score despite some changes to the metric, due to severe tidal restrictions at the site.

Habitat Attribute Score was 6.7 points higher in the 2021 assessment. Interestingly, horizontal vegetative obstruction and plant species richness metrics have been altered and are not directly comparable, but they happened to score the same over time. The bearing capacity index and number of plant layers metrics are directly comparable and scored the same. However, the percent cover of invasive species metric is directly comparable over time and was the only scored habitat metric with a changed value. The 2021 assessment had a higher score for this metric, which could be due to an actual decrease in *Phragmites australis* coverage within the assessment area (AA) over time. Alternatively, this change could be due to subjectivity in estimating coverage in a relatively large assessment area (7,854 m^2). Additional supporting data for both assessments showed the estimated percent coverage of *P. australis* decreased from 30% to 3% of the AA, while the species richness rating remained at 3 species. Also, the measured salinity increased from 10 to 18 parts per thousand (ppt or ‰), despite rainfall the day before 2021 sampling. If salinity is generally increasing at this site, this could certainly decrease survival and percent coverage of *P. australis*, which has been shown to successfully invade in marshes with salinities < 10 ‰ (Chambers et. al. 2003; Hellings and Gallagher 1992). It is possible these data reflect vegetative changes occurring from saltwater intrusion and sea level rise.

Cohansey-Maurice (02040206)

Thompsons Marsh

Within the Maurice River watershed, the Thompsons Marsh Control site was originally assessed on July 15, 2011 and again on September 15, 2021. The Final Score changed from 91.1 to 80.7, decreasing by 10.4 points. This shifted the site's disturbance level from minimally to moderately disturbed. The 2011 assessment results met the requirement for status as a Reference Standard site in the Tool. However, our reassessment in 2021 fell slightly below the threshold for that status, where scores >81 are considered minimally impacted. The largest influence on this change was the Habitat Attribute Score, but Hydrology Attribute Score also decreased in 2021. Salinity had a negligible increase from 14 to 16 ppt. The Qualitative Disturbance Rating was 2 for both assessments, indicating minimal disturbance.

The Buffer Attribute Score maintained 93.3 for both assessments, with all the contributing buffer metrics remaining the same between the two assessments. The Hydrology Attribute Score decreased from 100 to 88.9, due to a decrease in the diking/tidal restriction metric values from 12 to 9, due to qualitative differences in perspective on the influence of an elevated band that appears to restrict tidal flow. The Habitat Attribute Score decreased from 80 to 60. This was driven by RAM version differences in the number of plant layers and plant species richness metrics (Table 3). Bearing capacity index and invasive species coverage had the same score in both assessments. The number of plant layers was lower in 2021 and reflected a reduced score in the species richness metric, where plant species went from 8 to 3. Additionally invasive species cover decreased from 15% to < 1%. However, satellite imagery for the 2021 AA does not include a nearby elevated band, where upland species were likely documented in 2011. Thus, it is suspected this shift in species composition is not due to actual vegetation change. It is possible that there were different interpretations or applications of the method in 2011. Alternatively, the GPS data may have been inaccurately documented, causing our 2021 assessment to occur in a slightly different geolocation and to not overlap with the same elevated band.

In 2021, we did not find *Spartina patens*, *Baccharis halimifolia*, *Juniperous virginiana*, or *Myrica pensylvanica* to be present in the AA, though they were in the surrounding buffer.

Reeds Beach

Reeds Beach Control

In the Reeds Beach watershed, two sites were reassessed. The Reeds Beach Control site was assessed on September 15, 2015 and again on October 5, 2021. The Final Score changed from 84.4 to 65.9, decreasing by 18.5 points. This was driven by reductions in all three attribute scores. The 2015 assessment results met the requirement for status as a Reference Standard site. However, in our 2021 reassessment it fell below the threshold for that status and was considered moderately disturbed. Other differences were negligible, including consistent results of zero percent invasive species coverage, salinity at 20 to 21 ppt, and the Qualitative Disturbance Rating remained at 3.

The Buffer Attribute Score had the smallest effect, decreasing from 73.3 to 66.7 points. But both Hydrology Attribute Score and Habitat Attribute Score were substantially lower in 2021. The Hydrology Attribute Score decreased by 22.2 points, from 100 to 77.8. In 2021 the diking/tidal restriction metric was given only 6 of 12 points, due to a tidal restriction in the northwest corner of the 250-meter buffer area. Satellite imagery indicates no substantial change in infrastructure during this time. Thus, the difference in the Hydrology Attribute Score value was probably caused by different interpretations for scoring this qualitative metric. The Habitat Attribute Score had the largest decrease of 26.7 points, from 80 to 53.3. The largest effect was from the HAB4 metric change, which made the score go from the highest possible value to the lowest possible value. The bearing capacity index score was also slightly lower despite metric consistency, which was reflected in the averaged data values increasing from 3.6 and 4.8 cm of soil penetration. Additionally, the species richness rating decreased from three to one species documented.

Reeds Beach Extra

The Reeds Beach Extra site was located adjacent to the restoration site in Cape May NWR and was uniquely a reassessment site that was also affected by restoration activities. This site was originally assessed prior to restoration activities on September 17, 2015 and again on September 30, 2021. In both instances, the Final Score fell below the MACWA threshold for inclusion as a Reference Standard site (>81). The Final Score changed from 79.4 to 65.2, decreasing by 14.3 points. This did not alter the status from the moderately disturbed level. All three of the attribute scores, which determine the Final Score, decreased in our 2021 assessments. Other metrics were similar over time, including 1 ppt reduction of salinity, no invasive species coverage, and only *Spartina alterniflora* present for species richness. Qualitative Disturbance Rating was 3 and did not change over time. While the scores were lower, the largest effects seem to not be directly caused by restoration activities, but rather the changes to metric protocols and subjectivity of qualitative assessments.

The Buffer Attribute Score decreased by 13.3 points, from 80 to 66.7. This was largely due to the barriers to landward migration metric scoring lower in 2021, although actual change is not apparent in reviewing satellite imagery. The natural land uses in buffer metric was lower in 2021, but metric changes make direct comparisons not possible. The Hydrology Attribute Score decreased negligibly from 91.7 to 88.9. While the lower score for the ditching metric was affected by the restoration efforts in this area, version changes to the RAM method played a role as well, because the total ditched area is now used for scoring, rather than the number of ditches. The diking/tidal restriction metric increased in 2021, but metric changes make a direct comparison over time not possible. The Habitat Attribute Score had the largest decrease of 26.7 points, from 66.7 to 40. Notably, there were only differences in the two metrics (horizontal vegetation obstruction and HAB4) that were not directly comparable over time due to version changes to the metric protocols. To consider this change, 2021 horizontal vegetation obstruction data were additionally processed under the RAM 3.0 scoring criteria, which received the same score as with version 4.1. Most notably, HAB4 again had the highest possible score in 2011 and the lowest possible score in 2021, a major difference that can clearly affect the overall site scoring and in this case quite negatively.

Comparing Restoration sites to Reference data

Mullica-Toms (02040301)

Good Luck Point

At the time of writing, the Tool includes 109 sites in the Mullica-Toms HUC8 (Figure 3). Final Scores ranged from 41.1 to 100, with an average of 72.7. The Good Luck Point Restoration site (GLR) was scored using RAM 4.1, and the data were compared against the reference data available in the New Jersey Reference Wetland Tool. This assessment occurred on September 30, 2021, receiving a Final Score of 34.1, which fell below the entire data range of reference sites in this HUC. The Buffer, Hydrology, and Habitat Attribute Scores were 60.0, 22.2, and 20.0, respectively (Figure 3). In comparison to all reference sites in this HUC8 area, GLR scoring metrics were among the lowest. It is important here to acknowledge that restoration is inherently disruptive, and a site should never be expected to meet reference conditions within the first growing season after restoration activities.

While the Buffer Attribute Score was similar to Good Luck Control, the 250 m landscape condition metric was notably lower due in part to the visible landscape effects of the restoration effort, including highly disturbed soils, minimal vegetative coverage, and presence of *Phragmites australis*. The Hydrology Attribute Score was very low, as its fill and the diking/tidal restriction metrics were given the lowest possible value. The exception was the ditching/excavation metric, where the ditches were largely filled in and the resulting total ditched area was less than 1% of the AA. The Habitat Attribute Score was also particularly low, where metrics for bearing capacity index, horizontal vegetative obstruction, and HAB4 metrics were given the lowest scores possible. The extensive inundation and recently placed sediments were unconsolidated, resulting in a broad range (1.75-14.75) and poor average (6.25) for bearing capacity index measurements, scarce pockets of vegetation (~59 to 81% of AA unvegetated), and only one species that met the species richness metric criteria, respectively.

The Good Luck Restoration site was included in the study, in part to consider scoring of a recent restoration effort. It was also selected for the layered restoration approach that included sediment placement to raise elevation in ponded areas and filling of artificial linear ditches. The resulting low scores, which indicate poor condition or severe impact, in part reflect how recent this restoration activity occurred. Restoration sites need recovery time prior to determining meaningful measures of success (Matthews and Endress 2008). Unfortunately, restoration is commonly designed and implemented, but not necessarily monitored to learn the positive and negative results of restoration efforts, which may not come to fruition for several years or longer in some cases (Moreno-Mateos et al. 2012). On the other hand, assessing restoration success in the short term, when it may be possible to write into a grant funded project, is also problematic as shown in this RAM condition assessment. We generally recommend not conducting condition assessments within the first few years of a restoration project, unless for use in adaptive management strategies (Buchsbaum and Wigand 2012), as scoring is likely to be negatively affected. An exception to this recommendation is if future assessments are also planned to demonstrate restoration success with condition scoring metrics.

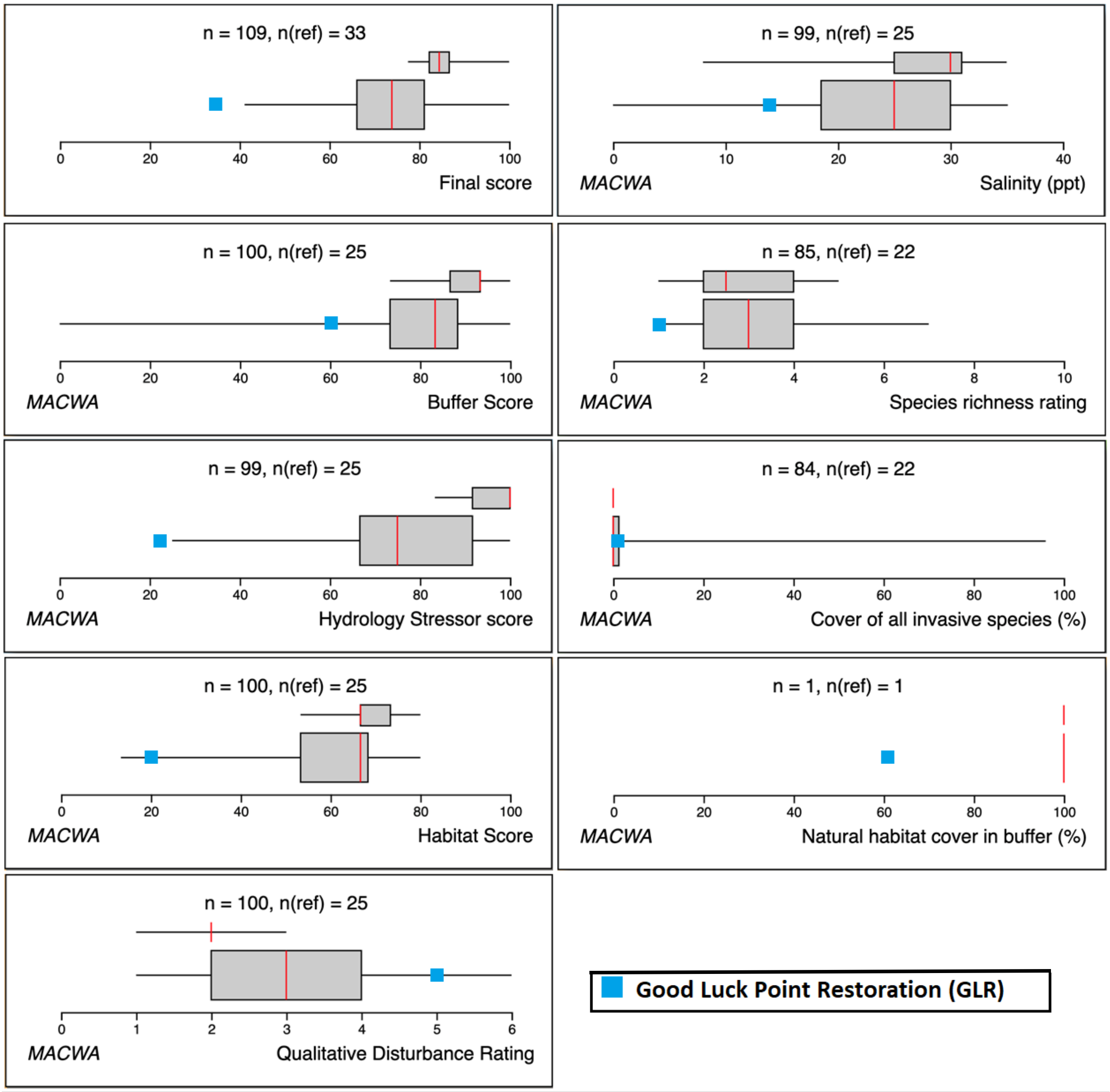

Figure 3. Reference data figures as generated in the New Jersey Reference Wetland Tool for all sites in the Mullica and Toms River watersheds of the HUC8 classification 02040301. Box and whisker plots include the minimum, quartiles, median, and maximum values for each metric. Additional data were overlayed for the Good Luck Point Restoration site to illustrate the values for restoration sites in this region. Note the tool displays Buffer Attribute Score, Hydrology Attribute Score, and Habitat Attribute Score as Buffer Score, Hydrology Stressor score, and Habitat Score, respectively.

Cohansey-Maurice (02040206)

At the time of writing this report, the Tool included a total of 99 sites in the Cohansey-Maurice watersheds of this HUC8 area. Final Scores for this unit ranged from 47.2 to 93.3, averaging 76.8. The restoration sites were compared against the reference data available in the Tool (Figure 4). There were two restoration sites located within this HUC8, Thompsons Marsh Restoration (TMR) and Reeds Beach Restoration (RBR). Compared to available data in this HUC, both had Final Scores that fit into the lowest 25% of the reference data distribution (n=99).

Thompsons Marsh

Thompsons Marsh Restoration was assessed on August 9, 2021 and received a Final score of 68.2, below that of the Thompsons Marsh Control site. The Buffer, Hydrology, and Habitat Attribute Scores were 80.0, 77.8, and 46.7, respectively, all of which were lower than the Thompsons Marsh Control site. The Thompsons Marsh restoration site had a remarkably positive vegetation response since the sediment placement efforts, which ended in early 2019. The Final Score was well within the normal data range for reference sites in this HUC, barely falling in the lowest 25% of the reference data distribution (Figure 4). Potentially, given a few more years of compaction, stabilization and accretion, this score could continue to rise towards the Reference Standard status. The Qualitative Disturbance Rating was 3, in line with the HUC median. Salinity was slightly above average, but within the HUC data range. Invasive species coverage was zero.

The Buffer Attribute Score was below the median, but well within the normal range of reference values. However, Hydrology and Habitat Attribute Scores fell in the lowest 25% of the HUC's data distribution. Habitat Attribute Score had the largest effect on the lower Final Score, which was driven by bearing capacity index and HAB4. The bearing capacity index ranged from 4.5 to 20.25 cm, with the lowest 2021 average of 10.9 cm soil penetration depth. In part, this is due to how recently this restoration effort occurred and the understanding that it can take several years for consolidation of sediments to occur. HAB4 deals with plant species richness, and this site was exclusively dominated by *Spartina alterniflora*. However, this site was designed for low marsh elevation, which is typically dominated by *S. alterniflora*. Considering the low diversity of species that persist in salt marshes, the new HAB4 metric present in RAM 4.1 appears to be too stringent for low marsh sites, which may be healthy and normal but score poorly under this metric. Notably, the landscape condition and fill metrics were not marked down, as there was positive vegetation response and soil disturbance was not apparent.

Reeds Beach

Reeds Beach Restoration was assessed on September 30, 2021 and received a Final Score of 69.6, slightly higher than both the reassessed reference sites nearby including one directly adjacent (Reeds Beach Extra). The Buffer, Hydrology, and Habitat Attribute Scores were 80.0, 88.9, and 40.0, respectively (Figure 4). The Qualitative Disturbance Rating was 3, indicating moderate disturbance that matched the HUC median. Salinity was slightly above average, but within the HUC data range. Invasive species coverage was zero.

A major driver of this site receiving a higher Final Score than the 2021 reassessment sites was the Buffer Attribute Score being about 13 points higher, which was mostly due to this location's relative distance to any roads, resulting in the highest value for the barriers to land migration metric. The Hydrology Attribute Score was similar to the adjacent Reeds Beach Extra site, but was higher than the Reeds Beach Control site due to scoring reduction from a tidal restriction. The excavation of runnels for restoration did negatively affect the Hydrology Attribute Score, although not drastically because the areal coverage of ditching remained low (<2.5%). Although the Buffer and Hydrology Attribute Scores were relatively high (80+), the Habitat Attribute Score fell in the lower 25% of the reference data distribution. This was mainly due to the bearing capacity index and species richness metrics having the lowest possible scores. Likely due to the recent movement of sediments in the AA, the bearing capacity averaged had a broad range (2 to 14.75 cm) and poor average of 6.9 cm of soil penetration depth. Only *Spartina alterniflora* met the species richness criteria for 10% coverage in the AA.

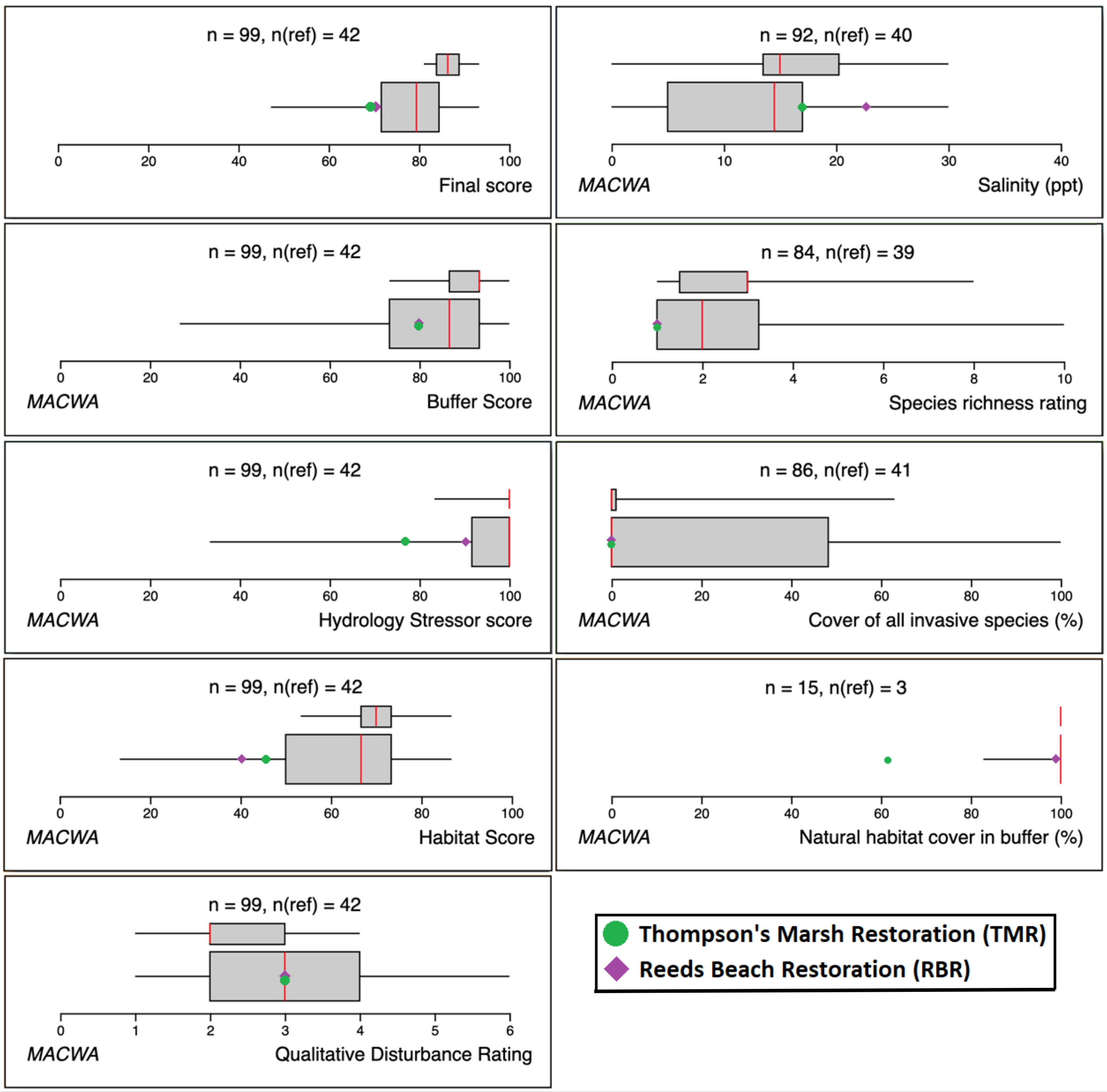

Figure 4. Reference data figures as generated in the New Jersey Reference Wetland Tool for all sites in the Cohansey-Maurice watersheds of the HUC8 classification. Box and whisker plots include the minimum, quartiles, median, and maximum values for each metric. Additional data for the Thompsons

Marsh Restoration and Reeds Beach Restoration sites were overlayed to illustrate the values for restoration sites in this region. Note the tool displays Buffer Attribute Score, Hydrology Attribute Score, and Habitat Attribute Score as Buffer Score, Hydrology Stressor score, and Habitat Score, respectively.

Tool Application for Restoration Sites

When this research was conducted, the Tool was not as refined is it is currently in 2022. Several additional metrics have since been added, and it is worth considering their use as reference conditions for setting targets in restoration site applications. Given the information available at the time, our application of the Tool using RAM reference data indicated several challenges related to validation, replicability, and comparability. Our efforts in this study have identified some key areas for refining the potential to use RAM data in the Tool for restoration applications. Generally, we advise more consistent methodologies to allow for better temporal comparisons. Without comparable reference data sets over time, data will not be reliable enough for use in setting restoration targets. For this reason, when using RAM reference data, one must consider which RAM version was used and which metrics are directly comparable. This is a serious limitation in RAM data applications for reference datasets. In future iterations, to better serve the restoration community RAM could improve by adjusting some scoring metrics and incorporate more raw numeric values, even if they do not contribute directly to scoring. Below, a few examples are highlighted.

At the Reeds Beach Restoration and Reeds Beach Extra sites, our data indicates that the restoration practice of creating runnels caused a small scoring reduction in the ditching metric. However, the areal coverage protocol seems to be a great improvement over the RAM version 3.0 metric which only counted the number of ditches. By design, runnels are narrow channels intended to help drain water off areas with drainage issues to prevent vegetation dieback and promote plant health. While this restoration practice deserves further investigation for adapting RAM restoration metrics, our first take is that scoring seemed reasonably fair for restoration sites and the percentage of the AA covered by ditching could be usable as a raw data value in the Tool.

Both the Good Luck Restoration and Thompsons Marsh Restoration site AAs were entirely impacted by the restoration practice of sediment placement, designed to increase elevation for and establish marsh vegetation. At the former, ditches were also filled in with materials, which undoubtedly improved the score for the ditching metric. But the fill metric was not designed to score incidents of sediment placement for restoration. Sediment placement is literally filling in a wetland; however, the difference for these restoration efforts is the intent to recreate an elevation for the benefit of wetland vegetation and associated processes, including sediment stabilization, accretion, carbon sequestration, and nutrient processing. In this report, we used our best professional judgement, in correspondence with RAM authors and users, to adjust the scoring criteria of fill for applications at restoration sites. We considered that this metric docks points for the amount of fill present, as it assumes negative functional effects typical of traditional filling activities in wetlands, such as tidal restrictions and alteration of plant communities. We opted to score fill based on the vegetation response. In other words, if there is a positive effect with re-establishment of typical marsh vegetation, especially to the extent that the use of sediments is no longer readily apparent, the site’s score should not be docked for that use of fill. We have encouraged consideration be given to altering the fill metric to be more flexibly scored to reflect the range of positive and negative impacts of fill. This could be done by incorporating responses in the vegetation assemblages related to elevation thresholds like mean high water (MHW) or mean higher high water (MHHW). For example, if sediment were placed and the ground surface stabilized above MHHW, this would support more upland species, and scoring should reflect this negative effect on the marsh habitat. On the other hand, if the effects of sediment placement are not noticeable due to successful tidal wetland vegetation reestablishing, the fill metric should not be given a low score. For the Good Luck Restoration site, the fill metric was given the lowest possible score, as vegetation had not yet had time to reestablish while the effect of sediment placement remained a dominant feature. But at the Thompsons Marsh Restoration site, the fill metric was not marked down, as there was positive vegetation response and soil disturbance was not readily apparent. Using our adapted fill metric, future assessments of restoration sites can be expected to potentially improve in scoring over time, assuming there is a positive vegetation response as the site settles to a desirable elevation for marsh vegetation.

The bearing capacity index raw data was identified as a potentially valuable metric for setting post-restoration sediment compaction targets. For one, this metric has remained unchanged since at least RAM version 3.0. With the first major update to the Tool, bearing capacity data is now available by HUC, allowing broader comparisons of reference sites, restoration sites, and sites with no restoration activities (Figure 5). The average bearing capacity index in the reference data was higher in the Cohansey-Maurice HUC than in Mullica-Toms, and the restoration sites consistently penetrated the soil at greater depths regardless of HUC background rates. While this difference was significant in our study, the sample pool was too small to be a robust analysis and should only be used as a preliminary finding.

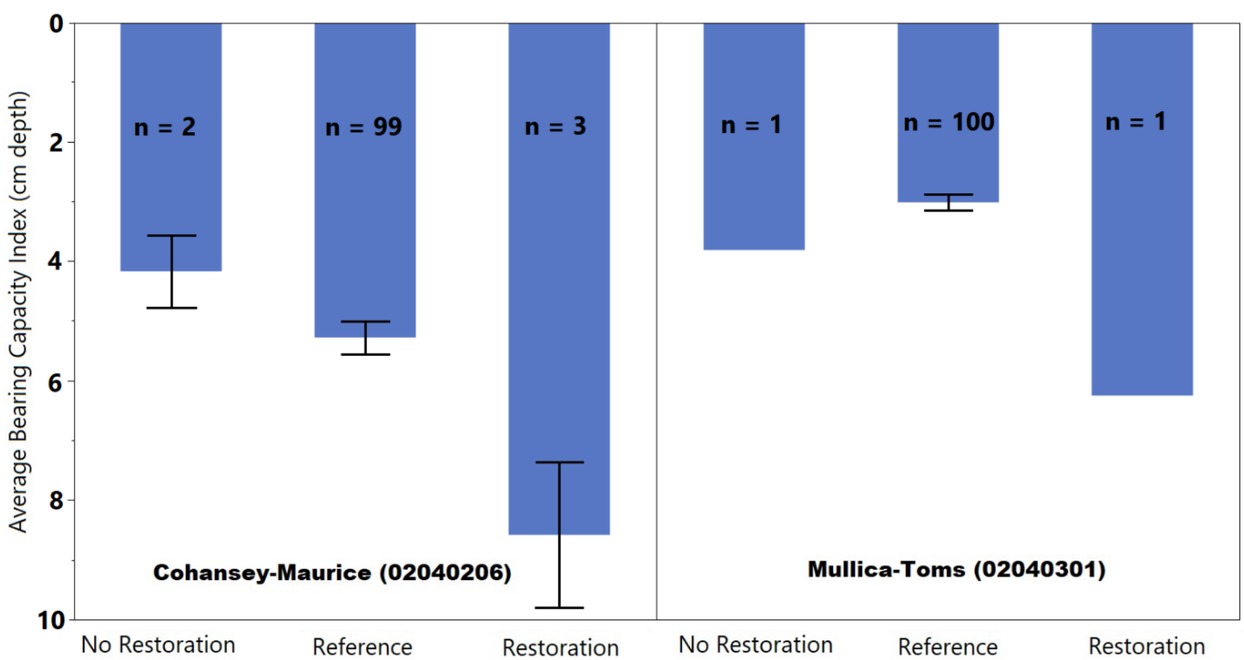

Figure 5. Average bearing capacity index, measured as soil penetration depth (cm), at 2021 assessment areas affected by restoration activities (including Reeds Beach Extra), not affected by restoration, and all the reference data, compared by HUC8. Error bars indicate standard error, where possible.

The HAB4 metric is a species richness rating, which is categorically scored based on the number of species that cover at least 10% within the AA. We found that this metric was problematic in multiple instances. First, this was a new metric that tends to score quite low in salt marshes, particularly *Spartina alterniflora* dominant low marsh that commonly has low diversity. Out of the seven sites assessed in 2021, five received the lowest categorical score (3 out of 12) and two were given a 6. Focusing on reassessed sites for comparison, we found HAB4 had a large effect on comparisons over time because the protocol it replaced focused on invasive species impacts and tended to score much higher in low marsh habitats. In the original assessments, HAB4 averaged 10.5 while the 2021 assessments averaged 5.0. In addition to the general scoring concerns and RAM scoring comparability over time, we also feel that the metric values themselves are not useful due to inconsistent documentation over time and the unusual species richness requirement of 10% coverage for counting species. These concerns led us to recommending that Riparia remove the RAM species richness data from the Tool, which has since been done. For future iterations of RAM, regardless of any adaptation for use in restoration sites, we recommend a less stringent scoring protocol for the species richness metric, especially as it is applied to low saltmarsh habitats that may be naturally less diverse due to higher salinities. At minimum, it would be prudent to require the protocol to provide a more useful data metric for defining reference conditions that is comparable with other condition assessments. This could easily be done by adding a requirement to count all plant species present, per the definition of species richness, regardless of whether those species are scored based on % coverage.

Conclusions

In this study, we provided a preliminary evaluation of the reference data available in the NJ Reference Wetland Tool and its applicability for tidal wetland restoration projects. We looked at data consistency of RAM across two versions over time, reviewed the potential to apply RAM to restoration sites, and compared RAM metrics at restoration sites to a large pool of reference data summarized in the Tool. While there was much to gain from this exercise, our results indicate a variety of challenges for the Tool concerning RAM data comparability over time due to different iterations of the RAM protocols and the subjectivity of metrics. Additionally, the applicability of RAM metrics at restoration projects is currently inadequate and would need refinement for such purposes. This is not surprising given that RAM was developed to "learn more about tidal wetland processes and stressors and how these impact the ecological integrity or condition of wetlands" (Rogerson and Haaf 2017) and not for evaluating restoration projects, which are inherently disruptive. These challenges currently limit some of the desired practical applications of the Tool.

It is important to stress that the RAM protocol is described as a living document, which has undergone iterative updates over the years. It was not developed for repeat assessments or uses in restoration sites, although we are advocating for its adaptation for such applications. Some metrics included in RAM condition scores, namely scoring the influence of fill in the AA, are not well suited for certain restoration activities such as the beneficial use of dredged sediments. By using the RAM protocol and reviewing its iterative differences over time, we provided feedback to the Delaware Department of Natural Resources and Environmental Control (DNREC) and PDE with recommendations of including more consistent datasets over time, improvements to protocol description language, and potential updates for future RAM iterations to allow scoring in restoration settings.

In reviewing and processing our data, we provided recommendations to Riparia to improve the Tool for a more streamlined user experience, such as updates to data organization, more comprehensive descriptions and definitions, and consistency across the Tool, its User Guide, Data Dictionary, and Data Download features. We also advised changes to which metrics were included in the Tool, to provide more meaningful characterization of reference sites. This included separating the Final Scores by methodology, removing the species richness RAM data due to a lack of standardization over time, adding a hydrogeomorphology dataset from ArcGIS desktop analyses, and adding RAM metric raw values used to determine scores, such as bearing capacity index, horizontal vegetative obstruction, and number of plant layers (Rogerson and Haaf 2017). While this report was being completed, Riparia has addressed several of our recommendations for improving the Tool, including the organizational structure and additional metrics and datasets. As such, the bearing capacity metric was not previously available in the Tool, but with its addition we were able to include a preliminary analysis to show how it may be useful in separating reference sites from recently restored sites, due to impacts of soil disturbance and changes in belowground biomass. However, applicability of RAM ratings and Attribute Scores, including the Final Score, to assist in setting restoration targets remains uncertain. A more comprehensive analysis with greater sample sizes would be necessary to address this question more adequately. But our initial findings indicate inconsistency in scoring over time, which was not necessarily due to changes in site characteristics. Instead, scores were different, in part, due to the qualitative nature of some metrics and the changes to scoring criteria with different RAM versions. All four reassessed sites had lower Final Scores than their previous assessments (Table 5), with two cases resulting in scores with potential to remove their status as Reference Standard sites. All three restoration sites fell below the interquartile range of the Tool's reference data Final Scores within their respective HUCs. However, we have outlined how this may be partly due to changes in the RAM protocol and the amount of time since restoration activities were implemented. Future applications of an updated RAM protocol for use in restoration sites may be worth consideration. If such a revised protocol is developed, we recommend applying RAM to restored sites that have had at least a few years of recovery time, to allow soil compaction and reestablishment of vegetation.

Considering the reiterative nature of RAM, we recommend future updates emphasize more meaningful metrics and raw data values that could be useful in evaluating condition over long-term applications and for establishing reference conditions for restoration project goal setting, even if those values aren't used in RAM scoring. We recommend quantitative metrics that remain consistent over time, such as percent cover of vegetation, bearing capacity index, and percent of area with permanent inundation. If scoring outcomes are to be used for reference site comparisons, we recommend revising RAM scoring for better consistency over time. For users that may intend to apply the Tool's RAM data for reassessments or comparison with restoration site conditions, it may be worth considering assessing sites using the version of RAM that was originally applied to allow more direct comparisons. Overall, there is valuable takeaway information in our initial applications of the Tool, including the identification of metrics that are useful for assessing altered conditions. Future investigations into other applications of the Tool are warranted and encouraged.

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