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DIATOMS (BACILLARIOPHYCEAE) FROM SURFACE
SEDIMENTS IN THE
SAN FRANCISCO BAY ESTUARY

By

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ABSTRACT: Two hundred seventy-three diatom species were identified from sediments in the San Francisco Bay estuary. The most common species in surface sediment samples are *Thalassiosira decipiens*, *Paralia sulcata*, *Nitzschia acuminata*, *Ditylum brightwellii*, and *Cyclotella striata*, whereas the most diverse genera are *Navicula* (26 species), *Nitzschia* (25), *Fragilaria* (13), *Achnanthes* (11), and *Cocconeis* (9). Descriptive multivariate analyses of species frequency data from 51 surface sediment samples extracted seven Q-mode clusters and five principal components for the 50 most abundant species. Significant patterns of diatom abundance and distribution in surface sediments of the estuary include: (1) highest diatom abundance occurs in the shallow subtidal to intertidal areas, especially in Suisun Bay and northern San Francisco Bay (Albany mud flats); (2) areas of high diatom abundance in sediment samples correspond to areas of high microalgal biomass measured as chlorophyll-a and phaeophytin; (3) areas of high species diversity (richness) in San Pablo Bay and southern San Francisco Bay do not correspond to areas of high abundance; (4) the dominant species in the estuary based on sediment analysis are benthic or meroplanktonic; (5) the distribution of species assemblages, as determined by Q-mode cluster and R-mode principal components analyses, follows gradients of salinity and depth; (6) the ratio of *Paralia sulcata* to *Thalassiosira decipiens* varies directly with salinity and may serve as a salinity indicator in ancient sediments.

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INTRODUCTION

San Francisco Bay (Fig. 1) is the largest estuary in the western United States and is an outstanding, albeit large and complex, natural laboratory for the study of estuarine diatoms. It has been estimated that over 500 species may inhabit the San Francisco Bay system (pers. comm., R. L. J. Wong and A. D. Mahood 1980), and Wong and Cloern (1981) listed 105 species of diatoms from the plankton alone. Furthermore, the bay system includes a wide variety of habitats such as salt- and freshwater marshes, intertidal creeks that range from fresh water at low tide to highly

brackish at high tide, subtidal brackish water tidal creeks, extensive intertidal and subtidal mud flats, and channels to depths of 20 m. Yet, despite the bay's obvious commercial and esthetic importance, its varied habitats, and rich diatom flora, no illustrated systematic catalog of the diatoms in the bay exists.

The purpose of this report is to describe the taxonomic composition and distribution of diatoms from sediments in the San Francisco Bay system. Taxonomic data are based on examination of cleaned surface-sediment samples, and distributional studies are based on multivariate

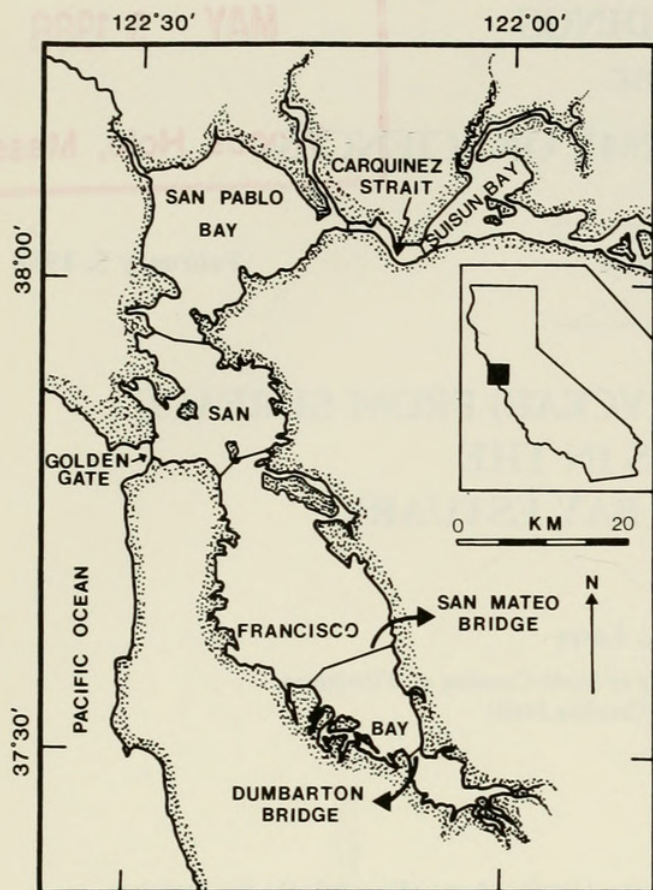


FIGURE 1. Location of study area.

analyses of relative species frequencies. The floral list and distributional data are no doubt incomplete, a result of the nature of the sampling and the immensity of the problem. However, I believe that this study presents a majority of the common species in the bay and portrays the significant large-scale distributional patterns of those species. Such data should be useful to researchers and governmental agencies currently studying the bay, and these data will provide a basis for comparison in future studies of diatoms in the bay.

Previous studies of diatoms in San Francisco Bay were directed largely toward the phytoplankton. Storrs et al. (1966) provided the first detailed systematic survey of phytoplankton in the bay. That report described seasonal variation in phytoplankton abundance along a transect from Suisun Bay to the Golden Gate. They recorded a summer phytoplankton maximum in Suisun Bay and a spring maximum in other areas. Subsequent studies (Peterson et al. 1975; Arthur and Ball 1979; Ball and Arthur 1979; Conomos 1979; Peterson 1979) supported those findings. Sitts and Knight (1979) described the daily, seasonal, and vertical changes in phytoplankton from a

single station at the eastern end of Suisun Bay. They reported a maximum abundance from February to May and also noted diel changes in composition and abundance at that station. Cloern (1979) summarized current information on phytoplankton dynamics in the bay. Wong (1975) reported phytoplankton species composition from three stations in the central bay near the Golden Gate. Mahood et al. (1986) in a comprehensive study of *Thalassiosira* recognized 23 species largely from plankton samples taken in Suisun Bay.

Studies of the benthic diatoms in the bay are few. Wong (1982) described seasonal changes in species composition in sediment samples from a single station in Suisun Bay. Thompson and Laws (1982) discussed seasonal changes in productivity and species composition of the microphytobenthos through a yearly cycle.

Atwater et al. (1977), Wagner (1978), Sloan (1981), and Laws (1982, 1983b) reported diatoms from borehole samples of late Pleistocene estuarine deposits preserved beneath the present bay. Atwater et al. (1977) distinguished between centrics and pennates and discussed their relative abundance. Wagner (1978) recognized 27 species of diatoms in the sand-sized fraction of sediments from two cores in the central area of the bay. Sloan (1981) recorded 16 taxa in the sand-sized portion of sediments from a series of boreholes which span the southern bay. Laws (1982, 1983b) discussed the composition and distribution of diatoms in the silt-clay fraction of samples from the same series of boreholes in the southern bay.

The physiography, hydrodynamics, physical and chemical properties, biota, and geological history of San Francisco Bay estuary are summarized by Conomos (1979).

MATERIALS AND METHODS

Samples were obtained in conjunction with studies of San Francisco Bay estuary by the U.S. Geological Survey, Bay and Estuarine Study Group (Menlo Park). Concurrent studies of the biochemical and physical aspects of the sediment samples by that group greatly facilitated this work (see Thompson et al. 1981).

Surface sediment samples were collected from the U.S. Geological Survey research vessel ESTERO, a shallow-draft boat capable of maintaining station in depths as shallow as one meter.

Forty-seven stations throughout the estuary (Fig. 2–7) were sampled over a 4-day period on 26 February and 6, 7, and 13 March 1980. Measurements of salinity, temperature, depth, and turbidity of the water column were taken at each station (see Thompson et al. 1981). Shipboard equipment used to measure these parameters is described by Thompson et al. (1981).

Thompson et al. (1981) used a gravity corer to collect simultaneously ten replicate samples of undisturbed surface sediment at each station in polycarbonate core barrels having a 9.6 mm inner diameter. One of the cores was analyzed for diatoms. The others were analyzed for chlorophyll-a, phaeopigments, and grain size (Thompson et al. 1981). Four additional stations were sampled by hand at low tide, using the same core barrels in the Albany salt marsh and mud flats (Fig. 5) on 18 January 1981. Fifty-one stations were sampled for surface sediment.

The upper 1 cm (0.72 cc) of each surface sediment core sample was extruded and washed according to the procedures modified after Setty (1966) and Schrader and Gersonde (1978) (see Laws 1983*b*). Strewn slides of the washed material were prepared and diatom species enumerated according to the techniques discussed in Laws (1983*a*). The number of valves counted per sample varies from 265 to 888 (see Table 1) with a mean of 558 valves per sample. Ninety-two percent of the samples comprise 450 or more valves. Sample size of 400–500 valves is commonly used in similar studies of benthic diatoms or diatoms in sediment samples (e.g., McIntire and Overton 1971; Main and McIntire 1974; Amspoker and McIntire 1978; McIntire 1978; Schrader 1978; Schrader and Gersonde 1978; Schuette and Schrader 1979, 1981; Colijn and Dijkema 1981; Sullivan 1982) and was justified by McIntire and Overton (1971), Schrader and Gersonde (1978), and Laws (1983*a*).

Additional subsurface samples from a late Pleistocene (Sangamon) unit, here informally designated the Yerba Buena mud, were examined. The Yerba Buena mud occurs in the subsurface beneath southern San Francisco Bay (Sloan 1981). Data from the Yerba Buena mud are included in the floral list for comparative taxonomic purposes and completeness. Those samples come from boreholes along the proposed Southern Crossing (Fig. 1) which were drilled in 1969 by the California Department of Transportation Division of Bay Toll Crossings

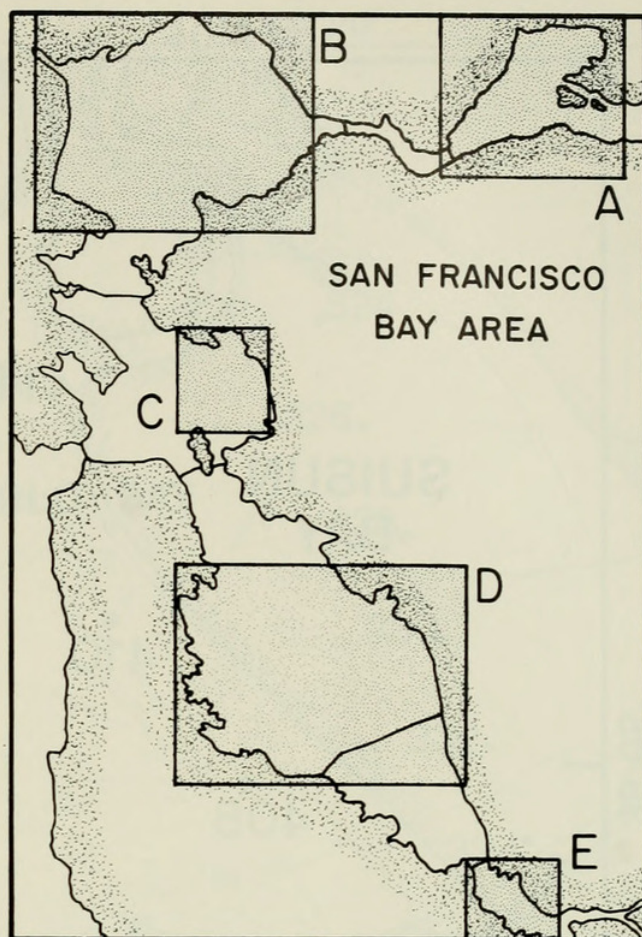


FIGURE 2. Index for Figures 3–7 and 9–13. A = Figures 3 and 9, B = Figures 4 and 10, C = Figures 5 and 11, D = Figures 6 and 12, E = Figures 7 and 13.

under contract TC 82-032. Samples retained from those boreholes are archived at the U.S. Geological Survey which kindly provided the samples for this study. The original borehole samples, each approximately 1 m long, are divided into three parts and stored in jars. The jar samples, each 5 cm in diameter and up to 15 cm in length, were split lengthwise along the diameter and sampled using the same polycarbonate core barrels as above. Sloan (1981) and Laws (1983*b*) discussed the microfauna, microflora, and stratigraphy of the Yerba Buena muds in detail.

Data Analysis

Raw data consist of species enumerations (frequencies) from each of the 51 surface-sediment samples. These raw data were standardized by percent transformations to relative frequency data and subjected to Q-mode cluster and R-mode principal components analyses. Throughout the discussion of these analyses diatom species constitute the mathematical “variables” from each

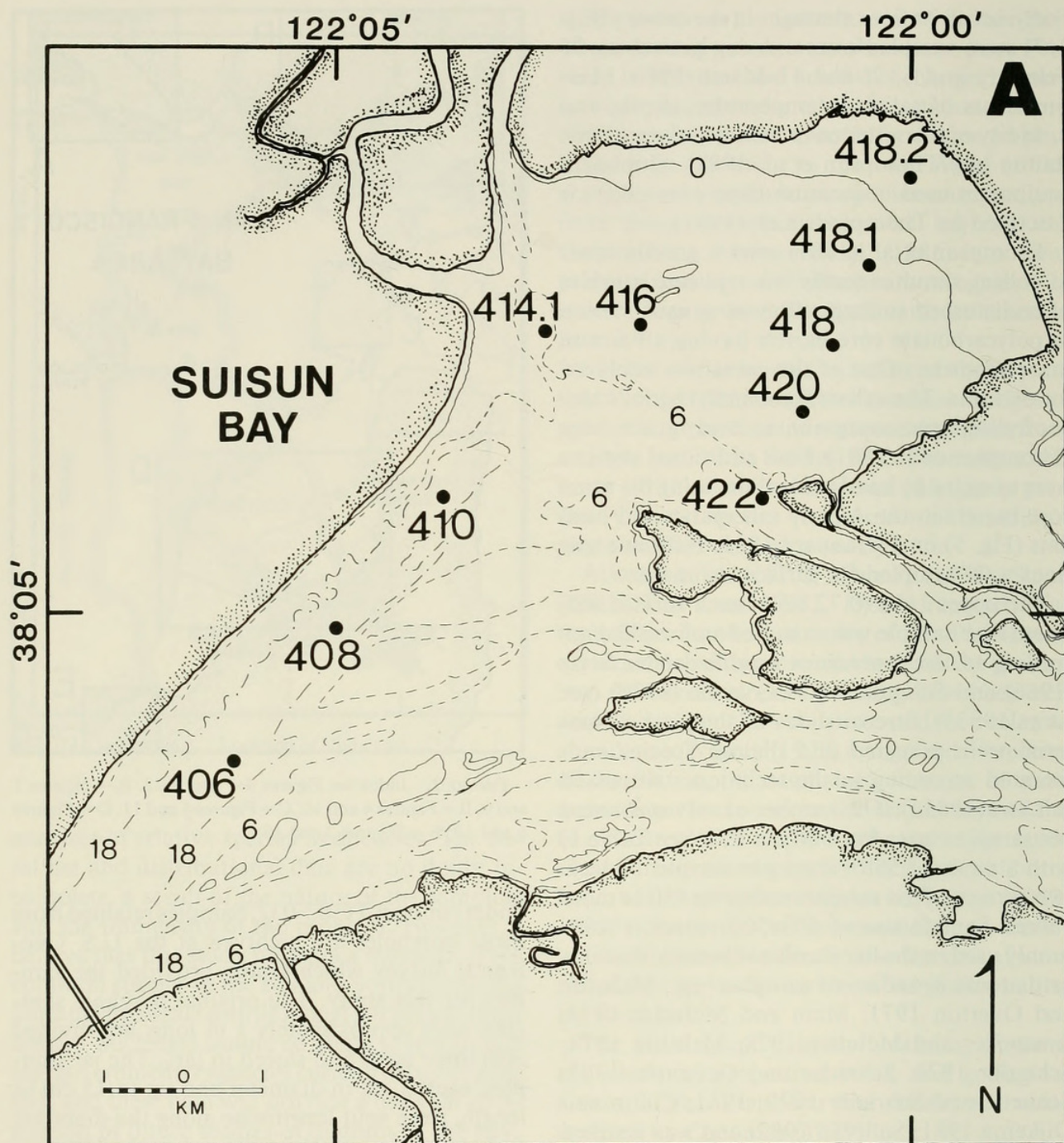


FIGURE 3. Location of sampling stations in Suisun Bay. Bathymetry in feet at mean lower low water.

sampling station. Therefore, the terms “species” and “variables” are used interchangeably.

Those two multivariate statistical analyses require the basic assumption that the data represent random samples of the original populations. The validity of that assumption hinges on consideration of taphonomic bias, sampling and preparation techniques, and counting techniques. The methods used in this study, discussed in Laws (1983a, b), were carefully designed to minimize those biases.

The Q-mode cluster and R-mode Principal components analyses are mathematically independent and were performed separately. However, each yields similar types of results that can be used to test the results of the other procedure, a method not unlike reciprocal illumination. Both analyses were performed on a matrix consisting of the 50 most abundant species distributed over the 51 sampling stations (i.e., a 50×51 data matrix).

The analyses were performed by the Biomed-

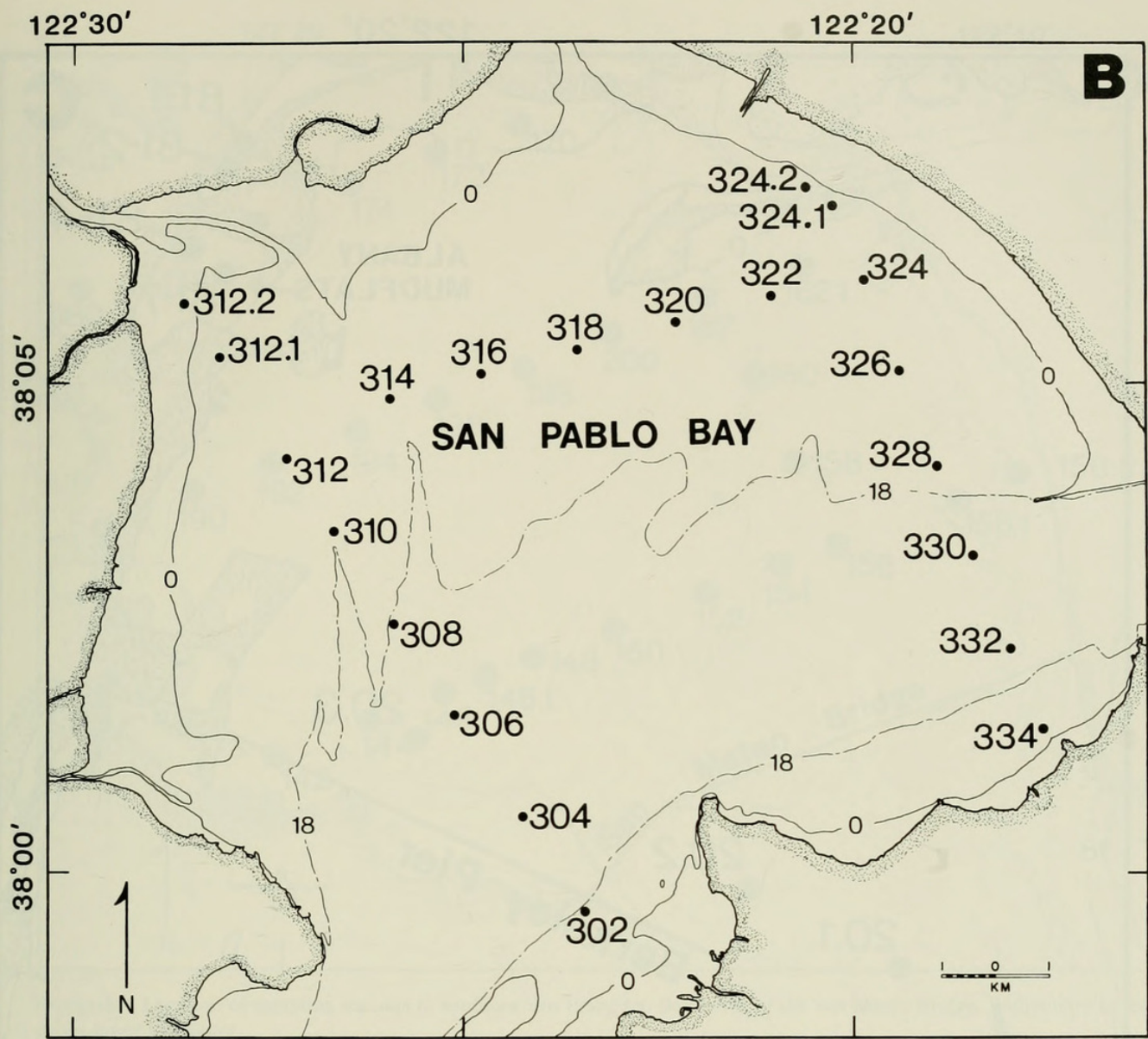


FIGURE 4. Location of sampling stations in San Pablo Bay. Bathymetry in feet at mean lower low water.

ical Computer Programs P-series (BMDP), programs P2M, Q-mode cluster analysis (revised 7/7/75), and P4M, principal components analysis (revised 7/7/75) (Dixon 1981). These programs were developed by the University of California at Los Angeles, Biomedical Computer Facility with the aid of a grant from the National Institutes of Health.

Q-mode cluster analysis groups localities on the basis of similarity of species content using a chi-square measure of similarity (or distance) between samples. The distance coefficient, d (or chi-square value) for the i variables in the j th and l th samples is written

$$d_{jl} = \left\{ \sum_i [(x_{ij} - e_{ij})^2 / e_{ij}] \right.$$

$$\left. + (x_{il} - e_{il})^2 / e_{il} \right\}^{1/2}$$

where

$$e_{ij} = (x_{ij} + x_{il}) \sum_i x_{ij} / N_{jl}$$

and

$$N_{jl} = \sum_i (x_{ij} + x_{il}).$$

Simply stated, this distance measure is the chi-square value comparing the two samples j and l for each variable summed over all variables. The parameters e_{ij} and e_{il} serve as estimates for the mean (or expected) value of each variable based on the total for all variables in the two samples.

Once these distance measures are calculated,

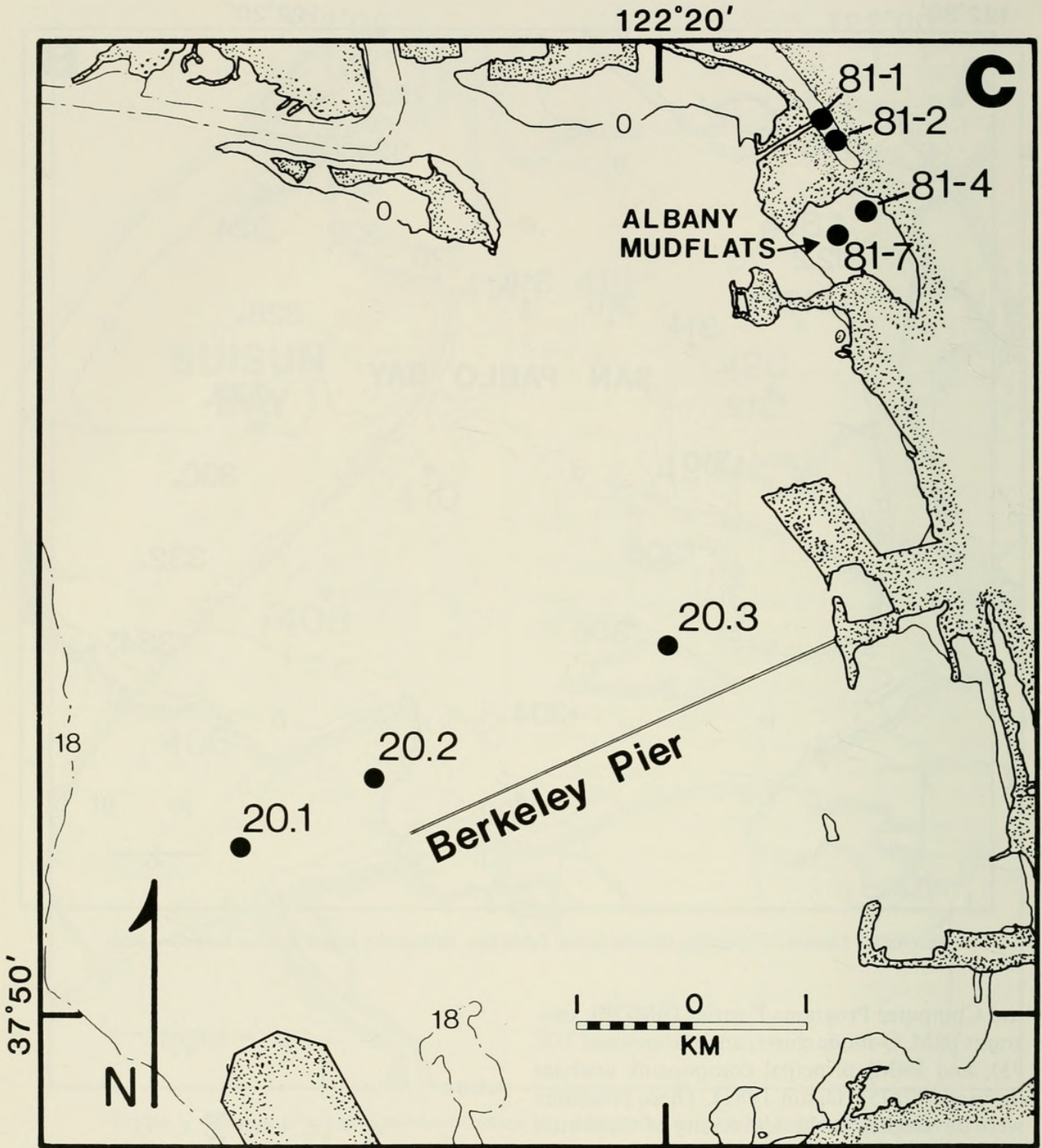


FIGURE 5. Location of sampling stations in northern San Francisco Bay and Albany mud flats. Bathymetry in feet at mean lower low water.

the samples are clustered (amalgamated) by the weighted average linkage method which calculates an arithmetic average distance between clusters and a potential new member. Sneath and Sokal (1973) gave a detailed discussion of this procedure.

Placement of boundaries between clusters (i.e., choice of a discrete value of the distance coefficient

between clusters) is subjective but is based on two criteria: (1) the clusters should be logically consistent with other independent data (e.g., geography, environment), and (2) by comparing the real data clusters to clusters of random numbers for a similar-sized matrix. The second method gives an upper limit for an amalgamation distance coefficient that is as likely due to random

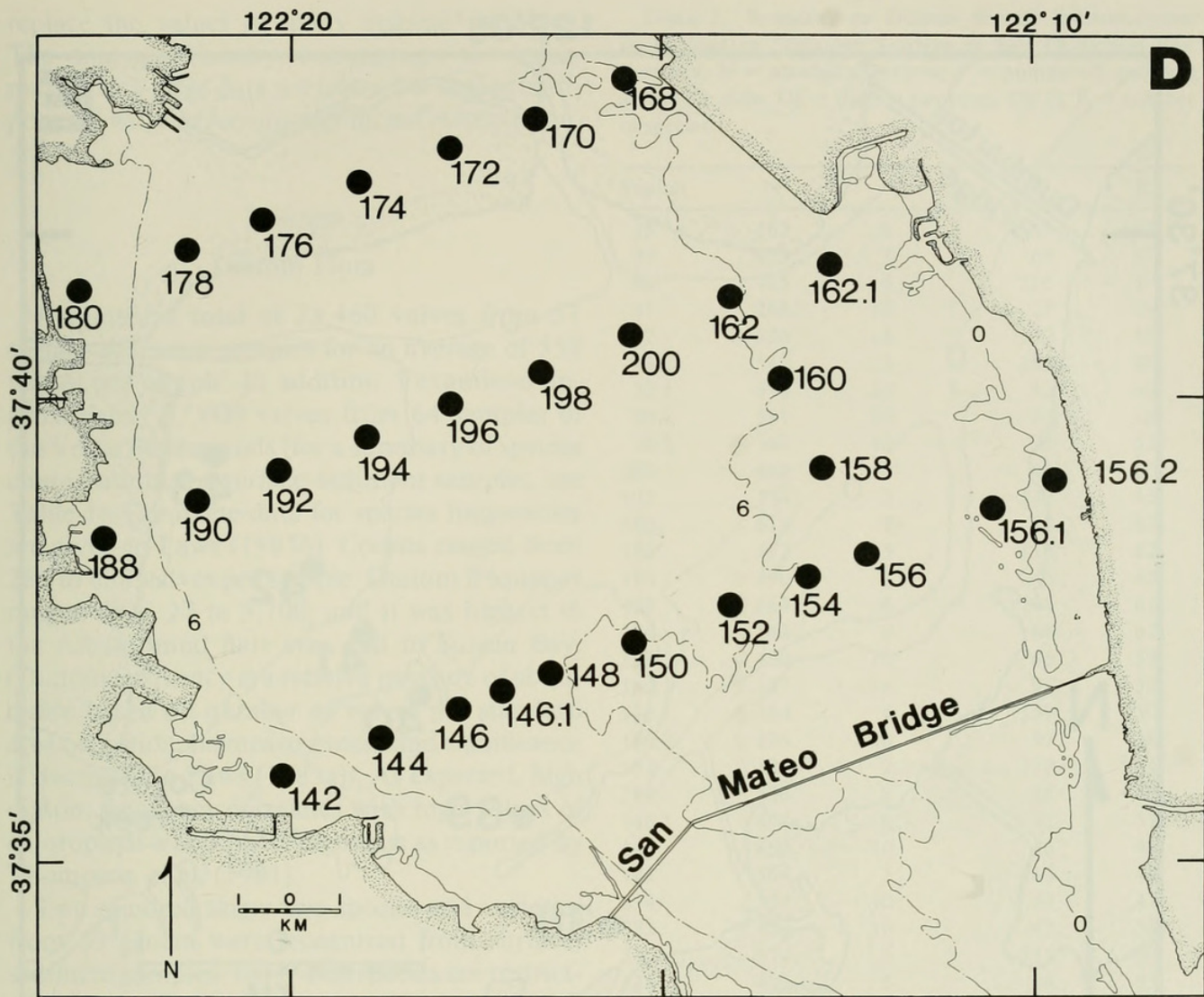


FIGURE 6. Location of sampling stations in southern San Francisco Bay north of the San Mateo Bridge. Bathymetry in feet at mean lower low water.

effects as to real correlation (see Harper 1978). Once cluster boundaries have been established, clusters are plotted against the original pattern of sample distribution.

R-mode principal components analysis with a Varimax rotation was performed on the matrix of species frequencies. Details of the methods of data analysis and interpretation used in this study are given in Frane and Hill (1976), Morrison (1976), Neff and Marcus (1980), and Laws (1983a). Briefly, principal components analysis evaluates the correlations among variables in large data sets by projecting the variables onto components (axes) drawn through variable hyperspace so that the dominant variables in each component are highly correlated with each other, but not with variables in other components. The interpretation of each component is based on the proportionate correlation (loading) of each vari-

able to each component. Each sample then receives a score for each component. The scores represent the proportionate contribution of each component to the variance in each sample. In other words, the analysis extracts groups of highly correlated species and determines the proportionate contribution of each species group to the total species assemblage in each sample. In this way, the analysis identifies recurrent groups of dominant species and enables one to map the distribution of these species associations relative to the original sample locations.

A successful analysis requires the proviso that each variable be rather highly correlated with some other variables but not all others. Principal components analysis, as used here, is an exploratory and descriptive method and is not used for hypothesis testing. As such it requires no other computational or statistical assumptions.

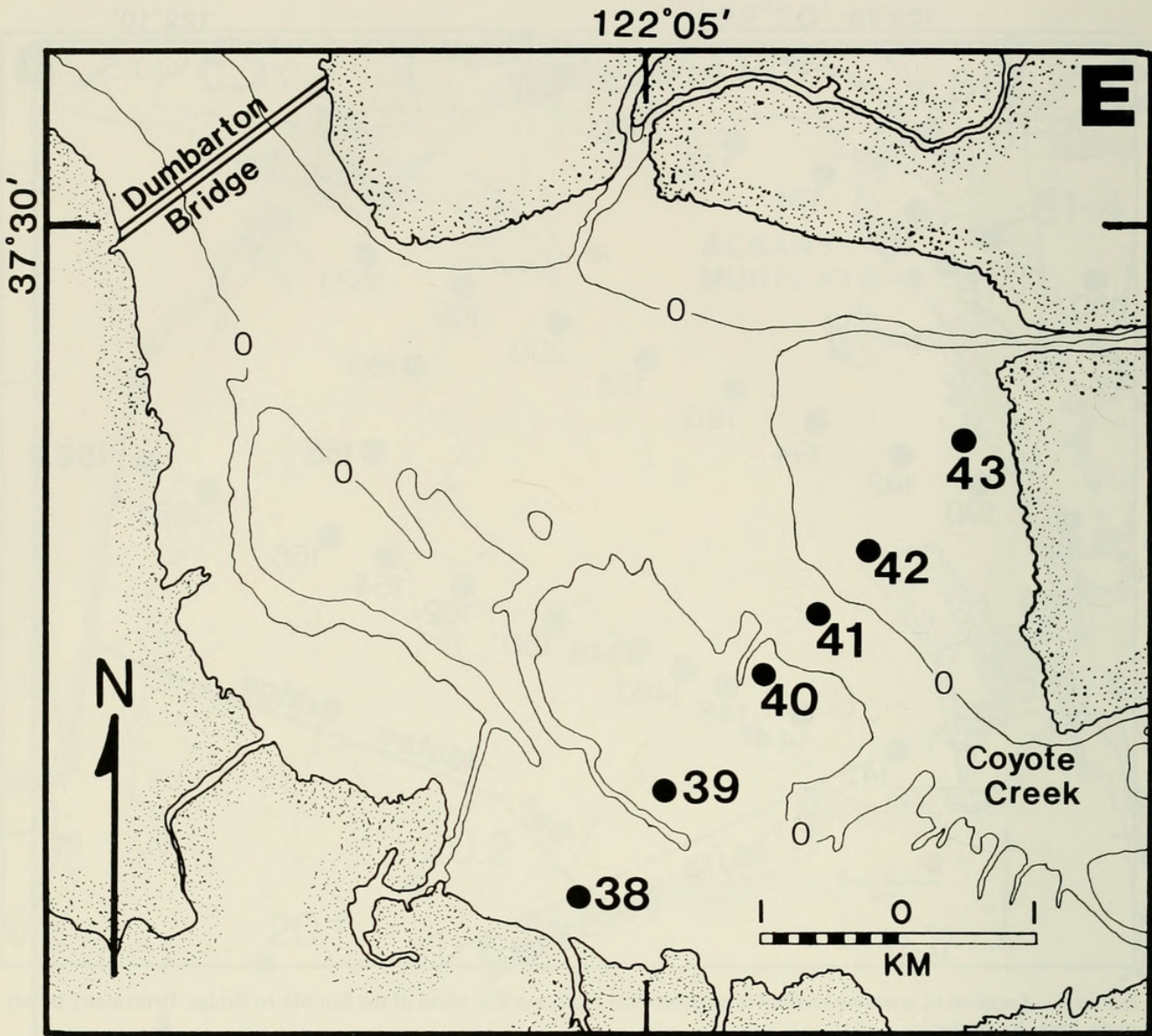


FIGURE 7. Location of sampling stations in southern San Francisco Bay south of the Dumbarton Bridge. Bathymetry in feet at mean lower low water.

Principal components were extracted from the covariance matrix because it more precisely expresses the variation in the data set when variables are correlated. The initial components extracted from the data set are orthogonal and by definition are independent or uncorrelated. The initial components are rotated using the so-called Varimax rotation to yield a more interesting configuration; that is, so that each variable is highly correlated with a small number of components. That rotation maintains the orthogonality of the components and seems appropriate because one objective is to find independent clusters of variables and samples so that distributional patterns are more easily interpreted.

It is possible to generate as many initial components as variables, but a successful analysis

must yield some number of major (principal) components that is considerably less. Major components were identified as those components that explained 90% of the total variance in the data set, were consistent with other independent data, and did not duplicate information in other major components. The major components are interpreted according to their constituent species. This is accomplished by plotting the loadings for a selected set of species for each major component (see Fig. 15). The selected species are those that have a relatively high loading on at least one of the major components. The major components are typically considered as summary variables and may be interpreted as indicators of some underlying environmental parameters. Therefore, a few large scores for each sample

replace the values of many original variables. The analysis, thereby, summarizes the information in a large data set into a few major components without losing significant information.

RESULTS

Diatom Flora

I counted a total of 28,460 valves from 51 surface-sediment samples for an average of 558 valves per sample. In addition, I examined approximately 37,000 valves from 64 samples of the Yerba Buena muds (for a summary of species enumerations for surface-sediment samples, see Table 1). Complete data for species frequencies are given in Laws (1983b). Counts ranged from 265 to 888 valves per sample. Diatom frequency ranged from 27 to 3,700, and it was highest in the Albany mud flats area and in Suisun Bay. (Diatom frequency is a relative measure of abundance based on number of valves per standard area on a slide. Its measurement and significance is discussed in Laws [1983a]). As expected, high diatom frequency correlates with high values of chlorophyll-a and phaeopigments as reported by Thompson et al. (1981).

Two hundred thirty-two species and varieties from 59 genera were recognized from surface-sediment samples. Forty-one species are restricted to the Yerba Buena muds. The complete floral list appears below. The five most abundant species are *Thalassiosira decipiens*, *Paralia sulcata*, *Nitzschia acuminata*, *Ditylum brightwellii*, and *Cyclotella striata*, whereas the five most speciose genera are *Navicula* (26 species), *Nitzschia* (25), *Fragilaria* (13), *Achnanthes* (11), and *Cocconeis* (9). The number of species per sample ranged from 24 to 73. High diversity (i.e., species richness; R, Table 1) occurs in San Pablo Bay and southern San Francisco Bay (compare Table 1 and Fig. 2-7).

The abundance and diversity data suggest several patterns. Areas of high abundance typically occur in nearshore intertidal marshes and mud flats protected from the direct effects of strong winds and currents. These areas of high abundance are not necessarily areas of high species richness. Samples with high abundance (diatom frequency) are typically dominated by a single species and often show low species richness. Colijn and Dijkema (1981) described similar patterns from intertidal areas of the Wadden Sea.

TABLE 1. SUMMARY OF DIATOM SPECIES ENUMERATIONS FROM SURFACE SEDIMENT SAMPLES IN SAN FRANCISCO BAY ESTUARY. N = number of valves; T = number of transects across the slide; DF = diatom frequency (N/T); R = number of species.

Station	N	T	DF	R
38	462	8	58	55
39	470	7	67	47
40	465	4	116	37
41	265	10	27	29
42	526	4	132	39
43	547	3	182	47
20.1	518	10	52	60
20.2	581	10	58	58
20.3	367	10	37	53
200	489	10	49	50
192	754	2	377	42
190	614	7	88	67
188	572	5	114	62
180	490	2	245	45
178	564	6	94	61
174	544	8	68	62
172	450	10	45	59
162.1	557	6	93	52
156.1	554	4	139	50
156.2	556	10	57	56
152	524	2.5	210	41
148	526	6	88	49
146.1	491	6	82	51
144	462	10	46	48
142	564	5	113	48
334	354	10	35	47
332	424	10	42	56
330	574	5	115	60
328	490	5	98	53
326	567	6	95	67
324	505	6	84	61
324.1	573	9	64	61
318	485	8	61	58
312	571	10	57	68
312.1	554	10	55	73
312.2	628	8.5	74	71
310	533	8	67	61
308	568	7	81	63
306	620	4	155	59
406	651	0.36	1,808	49
410	643	1	643	49
414.1	876	0.80	1,095	43
416	473	1	473	41
418	670	0.42	1,595	43
418.1	682	0.44	1,550	33
418.2	687	0.24	2,863	24
422	888	1	888	55
81-1	588	0.16	3,675	30
81-2	701	0.71	987	44
81-4	575	1.50	383	38
81-7	668	1	668	44

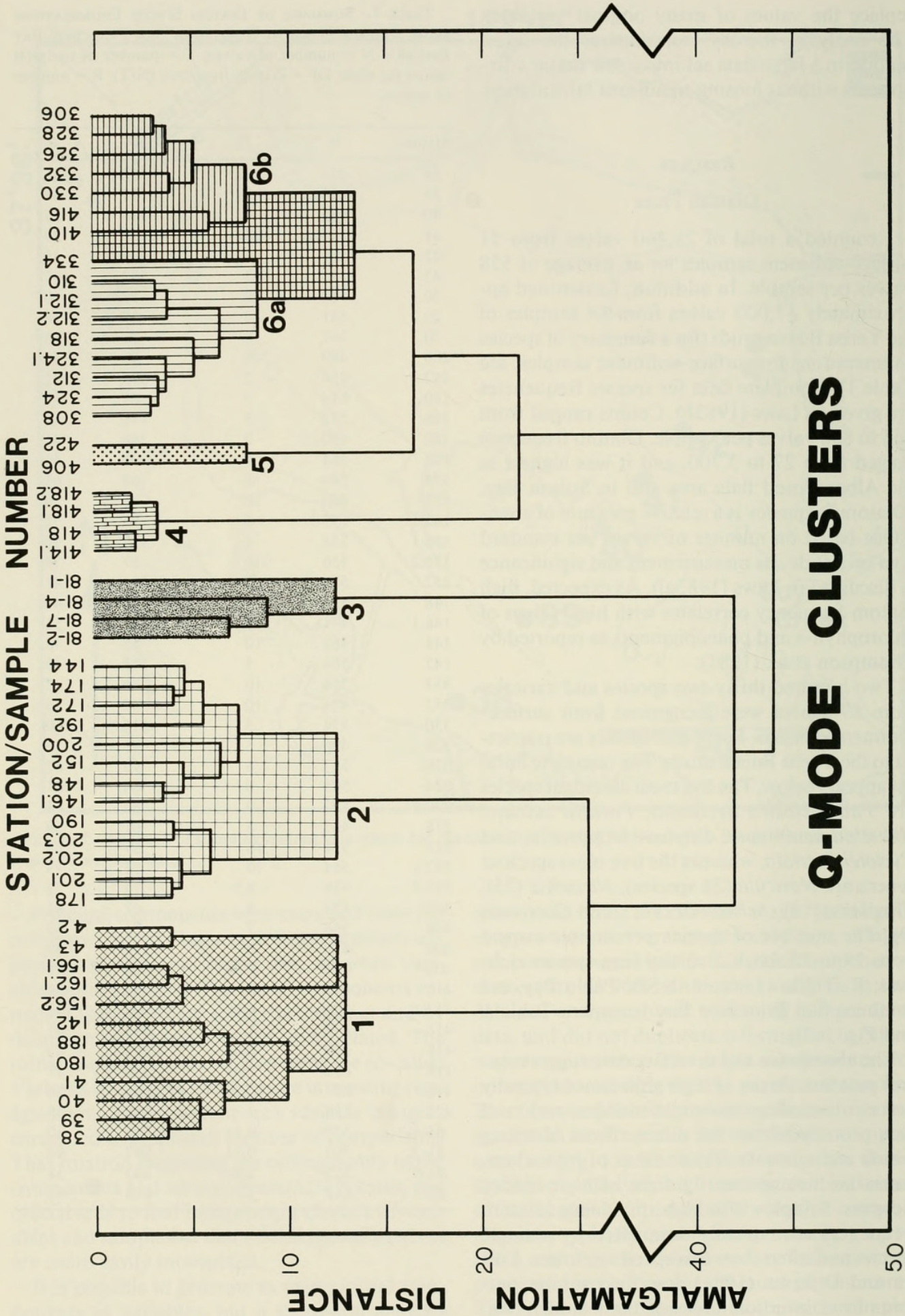


FIGURE 8. Q-mode clusters of 51 of the stations shown in Figures 3-7.

They correlated these patterns with immersion time, photoperiod, and sediment type.

High abundance in Suisun Bay is attributable to its location within the null or entrapment zone of the estuarine circulation (Arthur and Ball 1979; Cloern 1979; Wong and Cloern 1981). The dominance of a single species, *Thalassiosira decipiens*, in that area is unexplained, but it is probably related to its particular tolerance for the conditions in that area.

The cause for high abundance in the Albany salt-marsh and mud-flat samples is not so obvious and may be related more to biotic interactions than to physical constraints. Diversity is low in these samples relative to the data set as a whole, but no one species dominates as in Suisun Bay. Protected salt marshes and mud flats such as in Albany are areas where large quantities of fine-grained sediment and organic debris accumulate (Atwater et al. 1977; Atwater 1979). High nutrient levels might be maintained by accelerated bacterial activity in such areas. Furthermore, a variety of epiphytic and epipelagic habitats distributed along gradients of salinity, exposure time, insolation, and sediment size may contribute to high productivity.

Q-mode Cluster Analysis

Q-mode cluster analysis based on frequency data for the 50 most abundant taxa defined seven clusters of samples (Fig. 8). Those clusters form discrete, geographically coherent units when plotted against station locations (Fig. 9–14). That distributional pattern follows closely the distribution of salinity and depth in the Bay system (compare Fig. 3–7 and 9–14). Cluster 1 is restricted to the margin and shallow areas of southern San Francisco Bay. Cluster 2 plots in the deeper central portions of San Francisco Bay. The boundary between clusters 1 and 2 follows closely the 6-ft (1.83 m) isobath throughout southern San Francisco Bay. Cluster 3 includes the four stations in the Albany mud flats and salt marshes. Cluster 4 is restricted to the northern parts of Suisun Bay at depths shallower than 6 ft (1.83 m). Cluster 5 includes only two stations that are in the deeper channels of Suisun Bay. Cluster 6a groups those stations in the northwestern and southeastern parts of San Pablo Bay in water shallower than 6 ft (1.83 m). Cluster 6b represents stations in the deeper channels (6 ft [1.83 m] or more) of San Pablo and Suisun Bays.

Clusters 6a and 6b are labeled to reflect their similar species content but are treated separately because of their discrete distributional patterns.

Epipelagic and epiphytic taxa including *Nitzschia acuminata*, *N. pusilla*, *Cocconeis vitrea*, *Gyrosigma fasciola*, and *Navicula tripunctata* dominate stations in cluster 1. These species are typical of brackish and marine coastal environments. Stations in cluster 2 have high frequencies of the marine-to-brackish-water planktonic species *Paralia sulcata*, *Ditylum brightwellii*, *Actinocyclus senarius*, and *Cyclotella striata/stylorum*. Numerous epiphytic and epipelagic species are present at stations in cluster 3, but *Nitzschia sigmaformis* and *Achnanthes haukiana* are dominant. Other common species include *Navicula tripunctata*, *N. spp.*, *Gyrosigma fasciola*, *Melosira moniliformis*, *M. numuloides*, and *Nitzschia spp.* *Thalassiosira decipiens* overwhelmingly dominates cluster 4. Some confusion exists over the life habits of this species, which is probably benthic in fresh to moderately brackish water (G. Fryxell, pers. commu. 1982). Its dominance in the intertidal and shallow subtidal area of Suisun Bay is consistent with that opinion. Cluster 5 groups two stations (406 and 422), which have little in common with each other except for an abundance of *T. decipiens* but have less in common with other samples in the data set. They are distinguished from cluster 4, which is dominated by *T. decipiens*, because of high frequencies of a single species, rare or absent in other samples. *Cyclotella menegheniana* abounds at station 406 and *Diploneis decipiens* at station 422. Cluster 5 probably represents variation within the composite floral assemblage characterizing the deeper portions of Suisun Bay.

Stations in clusters 6a and 6b in San Pablo Bay show the highest number of species per sample (R, Table 1) in the data set reflecting the wide variety of species in the assemblages for those clusters. The dominant species are *Paralia sulcata* and *Thalassiosira decipiens*, and the ratio of these species distinguishes those two clusters. Stations in cluster 6b show high ratios of *Paralia sulcata* to *Thalassiosira decipiens*, and stations in cluster 6a exhibit lower ratios of *P. sulcata* (PS) to *T. decipiens* (TD). The PS/TD ratio decreases away from the margins, towards the channels, and upstream. This trend continues into Suisun Bay, where *P. sulcata* is almost nonexistent, and into San Francisco Bay, where *T. decipiens* is exceedingly rare. That distributional

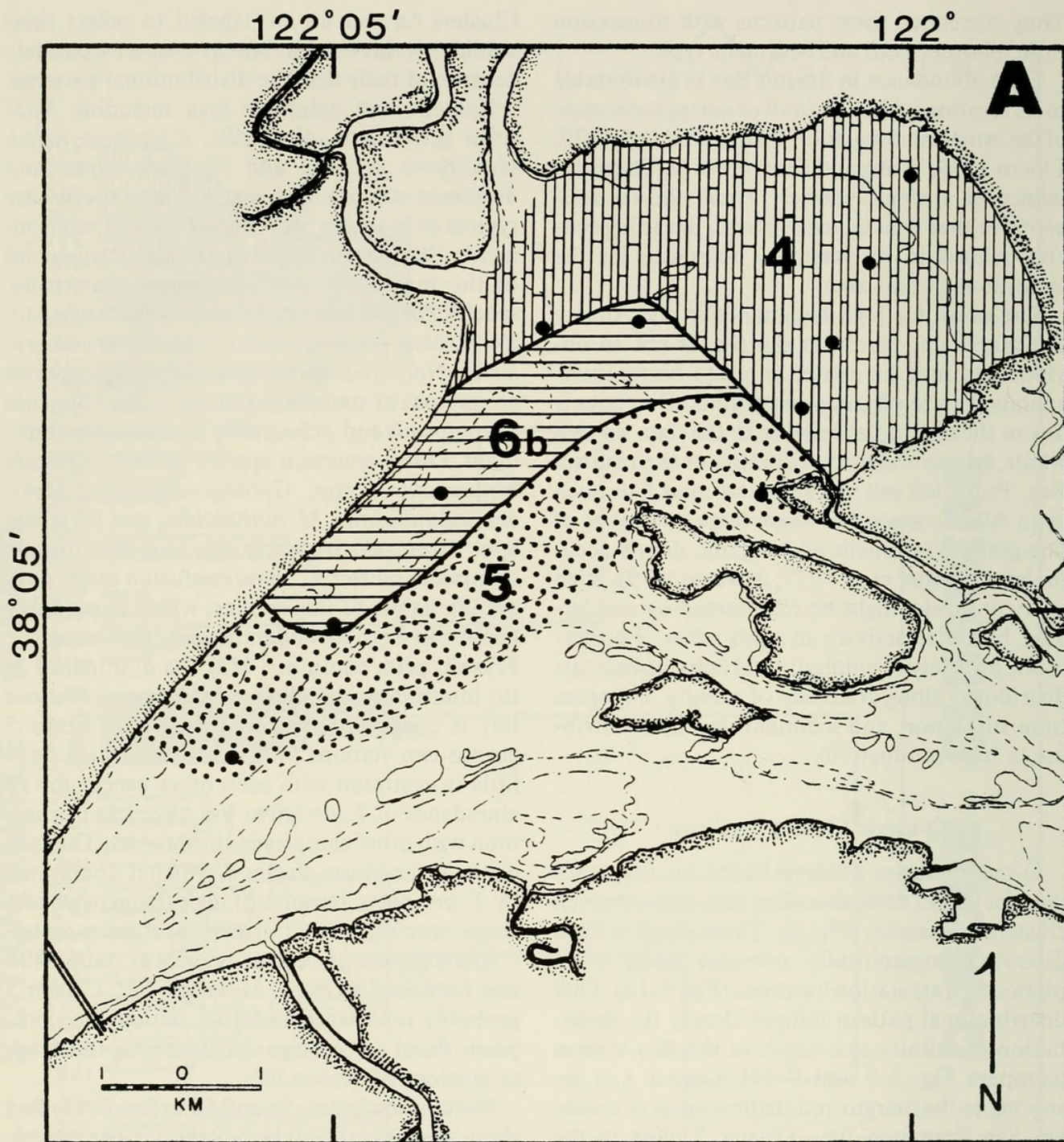


FIGURE 9. Distribution of Q-mode clusters in Suisun Bay.

pattern and the distinction between clusters 6a and 6b is also reflected in analysis of principal component scores (Fig. 16) as discussed below. The PS/TD ratio apparently varies directly with increasing salinity, and may serve as a salinity index in ancient nearshore deposits.

Principal Components

R-mode principal components analysis of the species frequency data extracted five compo-

nents that account for 91.5% of the variance in the data. I examined those five components further because their interpretation corresponds well with the results of the Q-mode cluster analysis. However, no particularly large difference in eigenvalues between components 5 and 6 especially delimits the first five components. Components 6–32 account for the remaining 8.5% of the variance, and components 33–49 have near zero eigenvalues. Figure 15 shows the loadings for the first 5 principal components for 14 se-

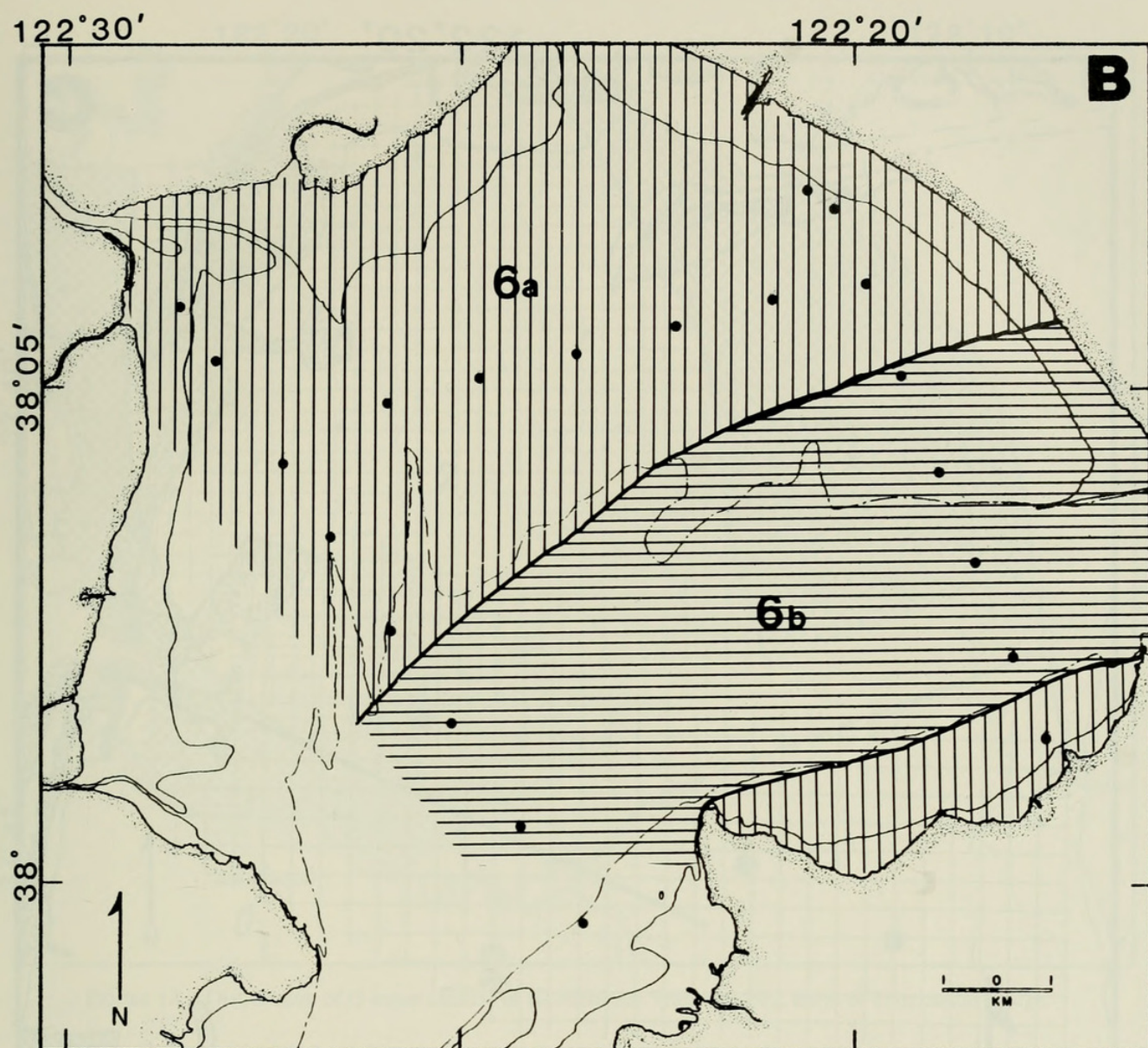


FIGURE 10. Distribution of Q-mode clusters in San Pablo Bay.

lected taxa. Figure 16 shows principal component (PC) scores for each station plotted for PC1 versus PC2 and PC4 versus PC5. Each station is coded according to the Q-mode cluster in which it belongs. Plots over other combinations of principal components show similar patterns, in particular with respect to the relationship between Q-mode clusters and principal components.

Principal component 1 accounts for 61.7% of the variance, and is characterized by *Thalassiosira decipiens* and *Fragilaria construens* (Fig. 15). Stations in clusters 4 and 6b show positive scores for PC1 (Fig. 16). PC1 represents a low-salinity component as evidenced by high scores for stations in Suisun Bay (Fig. 16). This component shows positive scores for stations in the main channel and deeper parts of San Pablo Bay; these

scores probably result from intrusion of low-salinity water into San Pablo Bay through the main channel and the concomitant downstream transport of *T. decipiens*. A comparison of diatom frequency (abundance) suggests that this component characterizes areas of high diatom productivity (see Table 1).

PC2 explains 17.2% of the variance and has positive loadings for *Paralia sulcata*, *Ditylum brightwellii*, *Actinopteryx senarius*, and *Cyclotella striata/stylorum* (Fig. 15). This component has high positive scores for stations in the central part of southern San Francisco Bay (cluster 2, Fig. 16). This is a high salinity, deeper water component characterized by brackish-water and neritic marine, planktonic species.

PC3 explains 5.6% of the variance and is char-

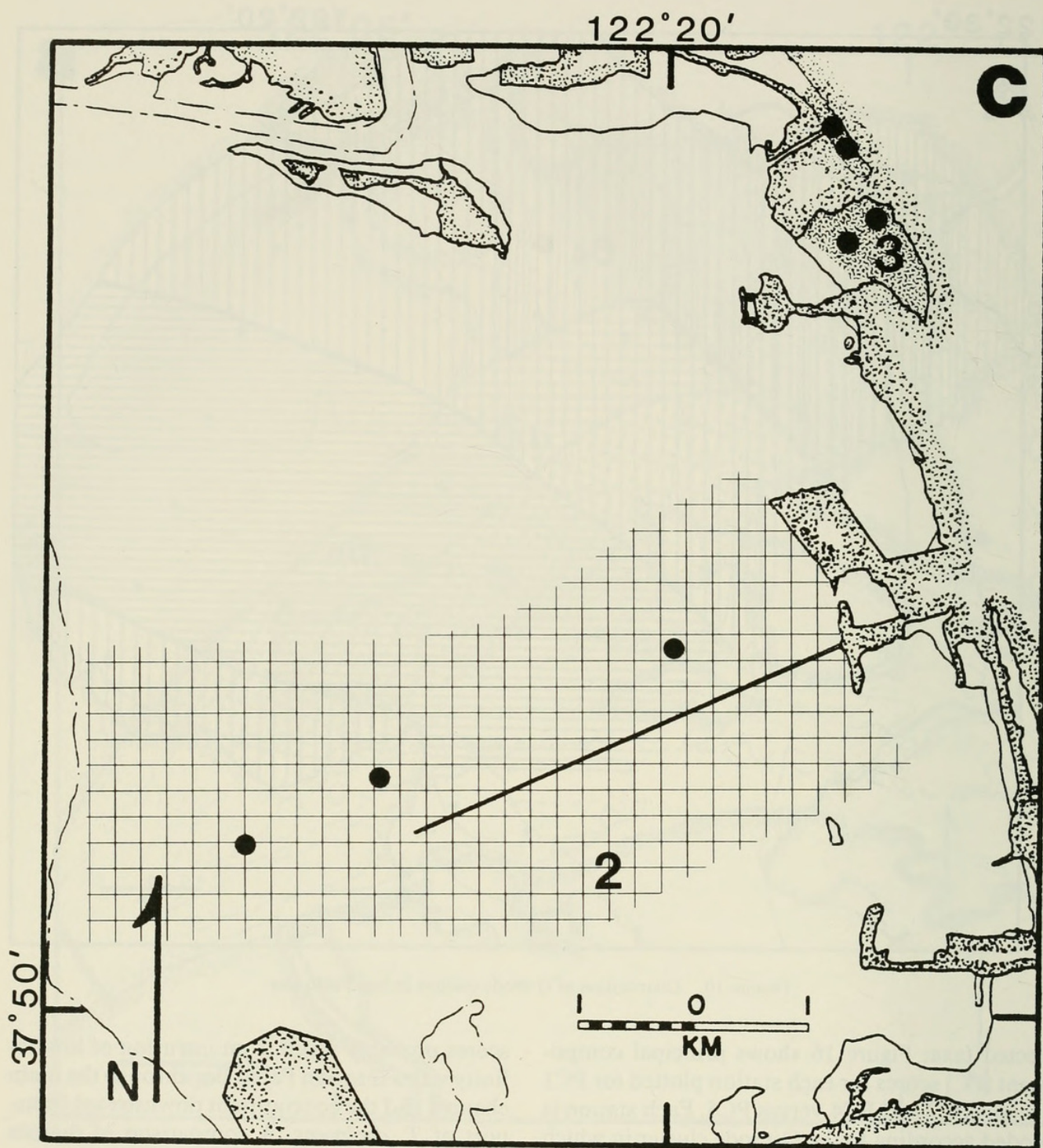


FIGURE 11. Distribution of Q-mode clusters in northern San Francisco Bay and Albany mud flats.

acterized by *Gyrosigma fasciola*, *Navicula tri-punctata*, and *Nitzschia acuminata* (Fig. 15). Those marine-to-brackish-water epipelagic species define an intertidal to shallow subtidal, mud-flat component. Stations in cluster 1 in the shallow and marginal area of southern San Francisco Bay have high scores for this component. That pattern is very similar to the distribution of positive scores for PC4 (Fig. 16). PC4, characterized by *Nitzschia acuminata*, *N. pusilla*, *Ba-*

cillaria paxillifer, and several other species (Fig. 15), accounts for 3.9% of the variance. These are marine-to-brackish-water epipelagic species typical of intertidal to subtidal mud flats in many coastal areas (Round 1971). PC4 is similar to PC3 in that they both represent intertidal to shallow subtidal, benthic components, and both show high scores for stations in southern San Francisco Bay (cluster 1, Fig. 16). However, PC4 shows higher scores for stations north of the San Mateo

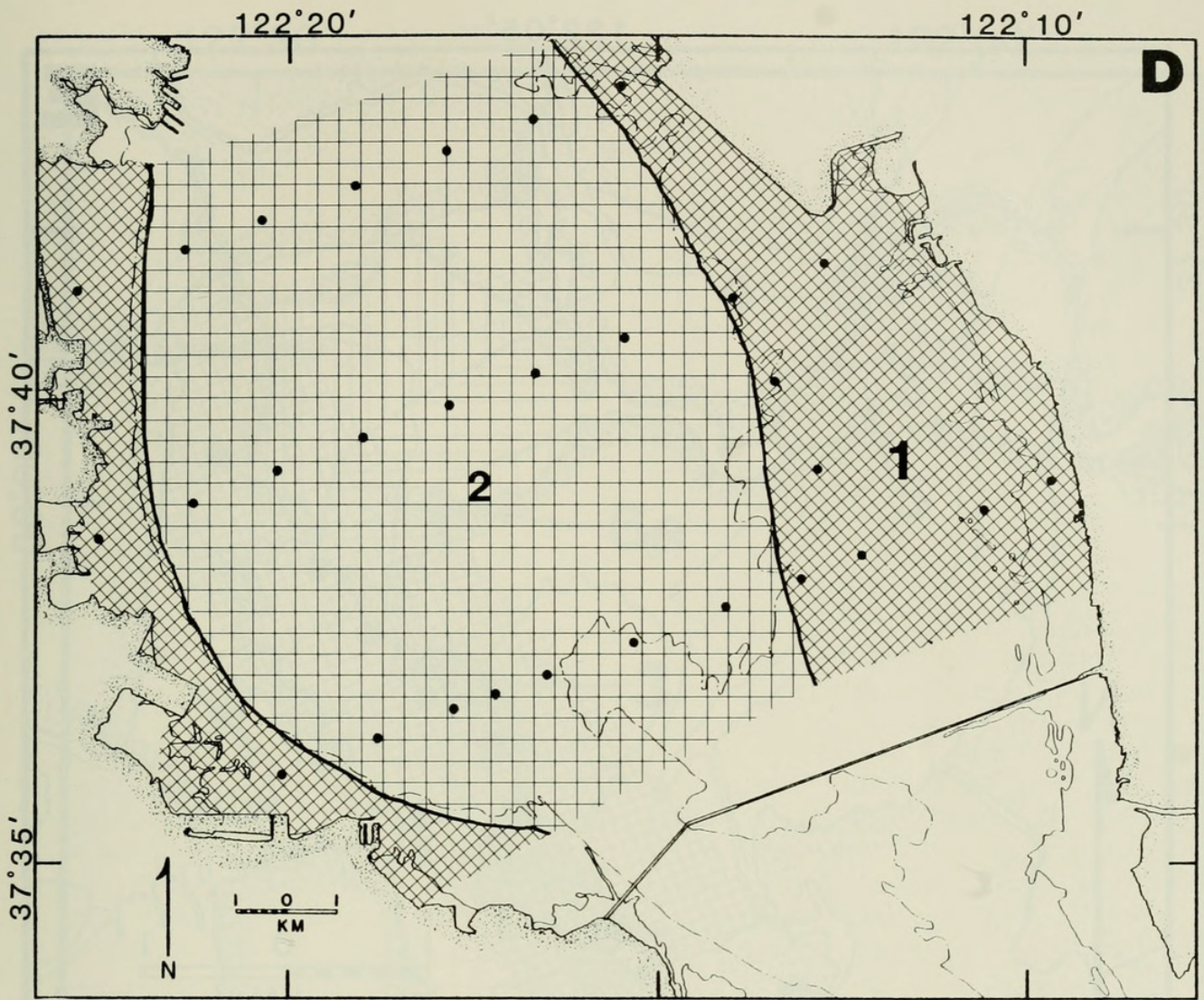


FIGURE 12. Distribution of Q-mode clusters in southern San Francisco Bay, north of Dumbarton Bridge.

Bridge, whereas PC3 prevails at stations in the areas south of the Dumbarton Bridge, reflecting the subtle differences in floral assemblages north and south of Dumbarton Bridge (Fig. 1, 14).

PC5 accounts for 3.1% of the variance and includes *Nitzschia sigmaformis*, and *Achnanthes haukiana* (Fig. 15). These are brackish-water-to-fresh-water benthic species. *Achnanthes haukiana* is very common and widespread in fresh to slightly brackish water (Patrick and Reimer 1966). *Nitzschia sigmaformis* has previously only been reported by Hustedt (1955) in mud samples from coastal areas of North Carolina. This component shows high scores for samples in cluster 3 (Fig. 16) which includes the Albany mud-flat and salt-marsh samples. This rather protected area in the intertidal zone is cut by several small fresh-water streams, which accounts for the low-salinity character. PC5 represents a low-salinity, high-intertidal-to-supratidal component. This

component also appears to characterize areas of high diatom productivity based on comparisons of diatom frequency (Table 1).

DISCUSSION

A comparison of studies of diatoms in surface sediments from coastal areas in Oregon, the German Wadden Sea, Louisiana, South Africa, North Carolina, Sweden, and West Africa shows a range of 112 to 390 species (Hustedt 1955; Hendey 1958; Miller 1964; Giffen 1971, 1973, 1975; Amspoker and McIntire 1978; Colijn and Nienhuis 1978; Cook and Whipple 1982). The wide disparity in these figures reflects to a large degree, the range of habitats sampled in each study. Nevertheless, they provide estimated minimum and maximum values for numbers of species in coastal and estuarine sediments. The number of species (232) reported from surface

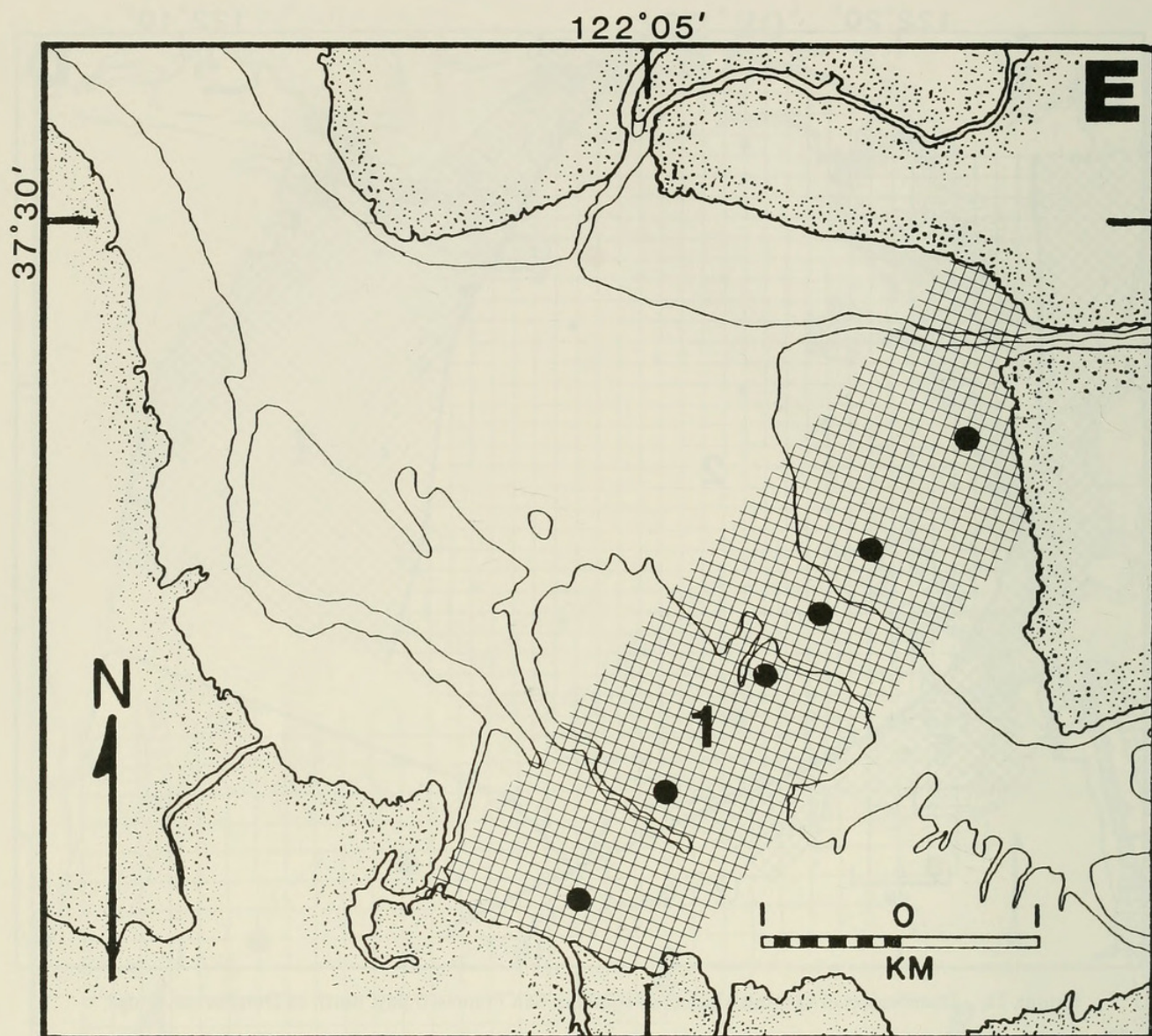


FIGURE 13. Distribution of Q-mode clusters in southern San Francisco Bay, south of Dumbarton Bridge.

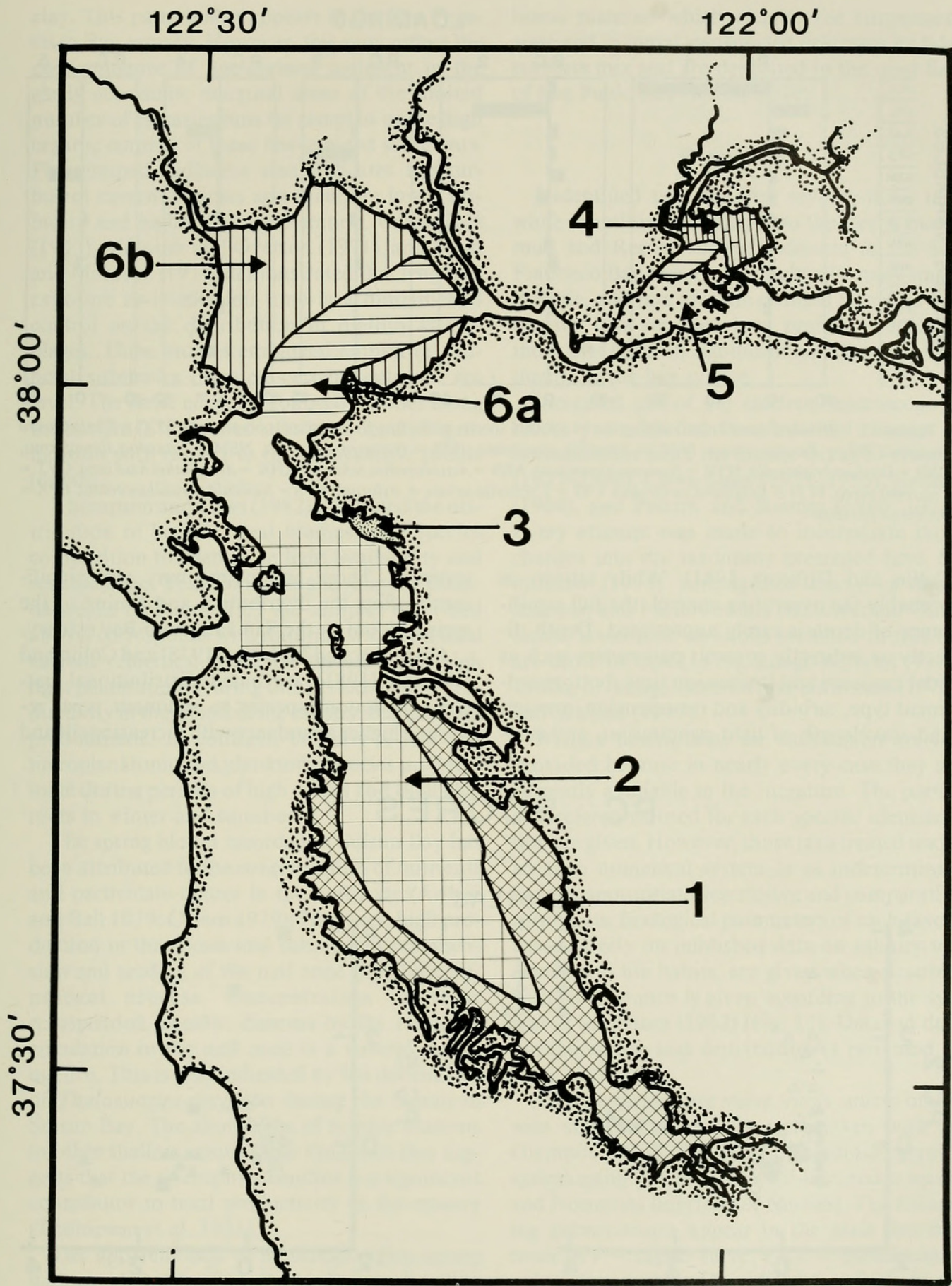
sediments in San Francisco Bay falls within that range and seems reasonable.

Significant patterns of diatom abundance and distribution in sediments of San Francisco Bay estuary include the following: (1) Highest diatom abundance is found in shallow subtidal to intertidal areas, especially in Suisun Bay and northern San Francisco Bay (Albany mud flats). (2) Areas of high species diversity (richness) in San Pablo Bay and southern San Francisco Bay do not correspond to areas of high abundance. (3) The distribution of species assemblages as determined by Q-mode cluster and R-mode principal components analysis follows gradients of salinity and

depth. (4) Based on sediment analysis, the dominant (most abundant) species in the estuary are benthic or meroplanktonic and include *Thalassiosira decipiens*, *Paralia sulcata*, *Nitzschia acuminata*, *Melosira moniliformis*, and *Achnanthes haukiana*. (5) These results are consistent with distributional patterns of benthic microalgal biomass measured as chlorophyll-a and phaeophytin.

The distribution of diatoms along gradients of salinity and depth has been documented by numerous workers (e.g., Castenholz 1963, 1964, 1967; Round 1971; Amspoker and McIntire 1978; Colijn and Nienhuis 1978; McIntire 1978;

FIGURE 14. Distribution of Q-mode clusters throughout the San Francisco Bay Estuary system. Dominant or characteristic taxa are as follows: Cluster 1—*Nitzschia acuminata*, *Nitzschia pusilla*; Cluster 2—*Paralia sulcata*, *Ditylum brightwellii*; Cluster



3—*Nitzschia sigmaformis*, *Achnanthes haukiana*; Cluster 4—*Thalassiosira decipiens*; Cluster 5—*Thalassiosira decipiens*, *Cyclotella menegheniana*; Cluster 6a—*Thalassiosira decipiens*, *Paralia sulcata* (1:1); Cluster 6b—*Thalassiosira decipiens*, *Paralia sulcata* (6:1).

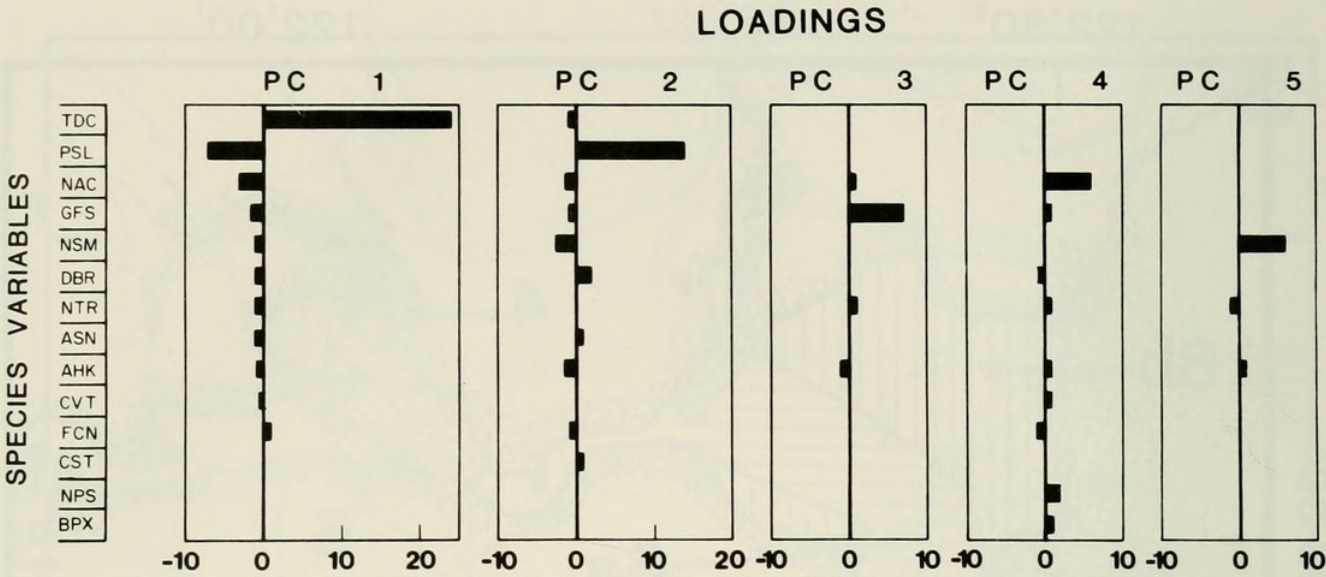


FIGURE 15. Principal component loadings for 14 selected species of the first five principal components. TDC = *Thalassiosira decipiens*, PSL = *Paralia sulcata*, NAC = *Nitzschia acuminata*, GFS = *Gyrosigma fasciola*, NSM = *Nitzschia sigmaformis*, DBR = *Ditylum brightwellii*, NTR = *Navicula tripunctata*, ASN = *Actinoptychus senarius*, AHK = *Achnanthes haukiana*, CVT = *Cocconeis vitrea*, FCN = *Fragilaria construens*, CST = *Cyclotella striata* ≠ *stylorum*, NPS = *Navicula pseudolanceolata*, BPX = *Bacillaria paxillifer*.

Colijn and Dijkema 1981). While salinity is probably the overriding control, the full significance of depth is rarely appreciated. Depth directly or indirectly controls parameters such as tidal exposure and immersion time, bottom sediment type, turbidity and resuspension, amount and wavelength of light penetration, and pho-

toperiod. These parameters may also significantly affect the distribution and timing of the spring bloom in the San Francisco Bay estuary. Amspoker and McIntire (1978) and Colijn and Dijkema (1981) attributed distributional patterns of diatom species to sediment type, reporting higher abundance with increasing silt and

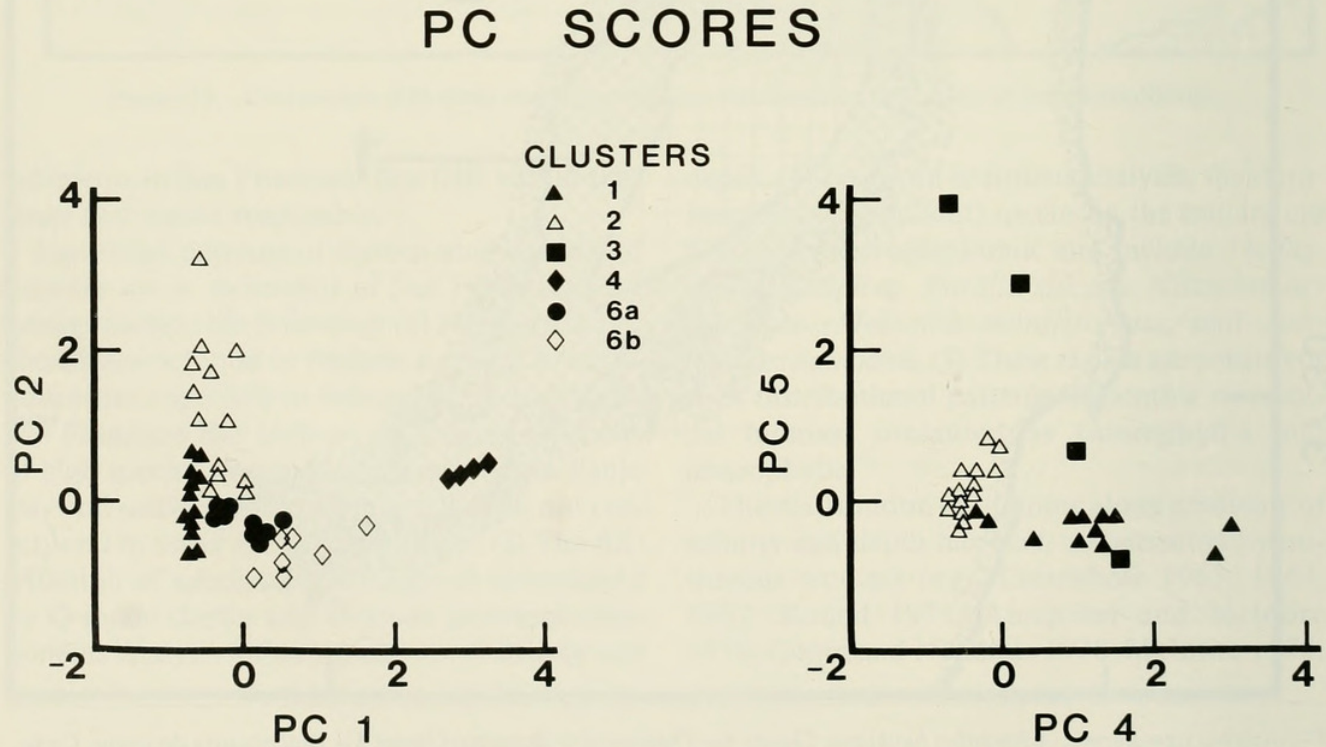


FIGURE 16. Principal component score scatter diagrams for components 1 versus 2 and components 4 versus 5. Each point represents a sampling station and is coded according to the Q-mode cluster with which it belongs.

clay. This pattern also appears in the San Francisco Bay estuary. However, this may reflect the predominance of fine-grained sediment in the easily accessible, marginal areas of the limited number of estuaries thus far sampled or the high organic content of these fine-grained sediments. Fine-grained sediment also indicates less-turbulent current regimes and therefore lower turbidity and higher light penetration. Castenholz (1963), McIntire and Overton (1971), and Main and McIntire (1974) demonstrated that length of exposure or immersion time is a fundamental control on the distribution of diatom assemblages. These studies employed natural or artificial substrates oriented perpendicular to sea level. The same effect is produced by tides along the bottom (a horizontal substrate) depending on location with respect to the bathymetric profile (depth).

Thompson and Laws (1982) attributed the distribution of benthic algal biomass and species composition to changes in light availability and resuspension. Peak biomass and diatom abundance, as represented by the samples described above, corresponds with minimal wind and tidal current velocities, hence low turbidity and high light penetration. During this period of high productivity in the shoals of the estuary, benthic taxa predominate. In contrast, biomass is low and meroplanktonic and planktonic species predominate during periods of high winds and tidal currents in winter and summer.

The spring bloom recorded in Suisun Bay has been attributed to the concentration of nutrients and particulate matter in the null zone (Arthur and Ball 1979; Cloern 1979). However, high production in the shoals and subsequent resuspension and seeding of the null zone may be a significant process. Concentration of these resuspended, benthic diatoms by the estuarine circulation in the null zone is a natural consequence. This is also indicated by the dominance of *Thalassiosira decipiens* during the bloom in Suisun Bay. The abundance of benthic diatoms in other shallow areas of San Francisco Bay suggests that the microphytobenthos is a significant contributor to total productivity in the estuary (Thompson et al. 1981).

The apparent lack of a corresponding spring diatom bloom in San Pablo Bay is puzzling (Thompson and Laws 1982). The high diversity results from the mixture of fresh and brackish-water species in that area. Fine-grained, river-

borne material which escapes the entrapment zone and material transported upstream by tidal currents mix and are deposited in the mud flats of San Pablo Bay (Krone 1979).

FLORAL LIST

I identified two hundred seventy-three taxa while examining samples from the Yerba Buena mud and Recent surface sediment in the San Francisco Bay estuary. Undoubtedly many small, delicate, and rare taxa are omitted from this list, but the taxa reported here probably represent those that occur in significant abundance in sediments of the bay system.

Increased use of the electron microscope in recent years has led to substantial changes in nomenclature since the classic works of Hustedt (1927–1966), Cleve-Euler (1951–1955), Hendey (1964), and Patrick and Reimer (1966, 1975). Every attempt was made to incorporate those changes into the taxonomy presented here. Simonsen (1979) summarized many of those changes, and I followed his classification. Other recent taxonomic revisions included in this list are those of Cox (1979), Lange-Bertalot (1977, 1980a, b), Lange-Bertalot and Simonsen (1978), and Schmid (1977).

Written descriptions for each taxon are not provided because in nearly every case they are currently available in the literature. The particular references used for each specific identification are given. However, those taxa treated under an open numerical system or as indeterminate include appropriate descriptive and comparative comments. Ecological parameters of each taxon, based largely on published data on salinity tolerance and life habits, are given when possible. Salinity tolerance is given according to the system of Simonsen (1962) (Fig. 17). Detailed data on abundance and distribution is provided in Laws (1983b).

All illustrations are valve views unless otherwise stated. Photographs were taken with an Olympus BH-2, PM-10AD photomicrography system using 50 $\times$ and 100 $\times$ oil-immersion lenses and Nomarski interference contrast. The following abbreviations appear in the plate descriptions: RV = raphe valve, PRV = pseudoraphe valve, L = length, D = diameter. Each figure number refers to a different specimen. Lowercase letters refer to different views (focal planes or magnifications) of the same specimen.

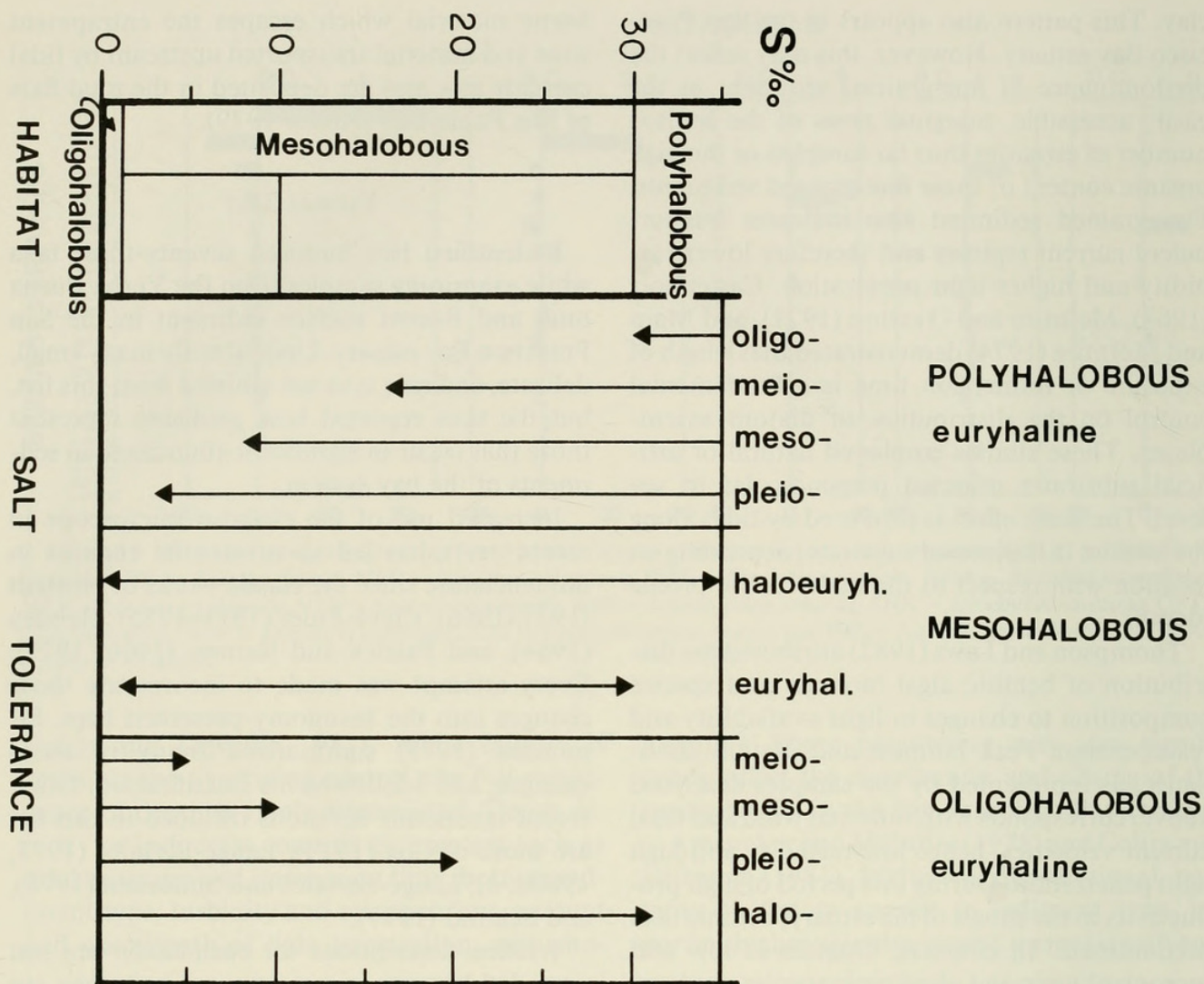


FIGURE 17. Salinity tolerance and habitat classification according to the "halobien" spectra of Simonsen (1962).

Bulk material and representative strewn mounts of each sample examined in this study are archived at the Museum of Paleontology, University of California, Berkeley.

Achnanthes Bory, 1822

Achnanthes brevipes Agardh, 1824

(Pl. 17, Fig. 22)

DESCRIPTION.—Hustedt 1933b:424–426, fig. 877.

ECOLOGY.—Mesohalobous, euryhaline (Pankow 1976; Schrader 1978); benthic.

DISTRIBUTION.—On intertidal mud flats and salt marsh of Central Bay, Sangamon, and Recent.

Achnanthes brevipes var. *intermedia* (Kutzing) Cleve, 1895

(Pl. 17, Fig. 17–19)

DESCRIPTION.—McIntire and Reimer 1974:171; pl. 2, fig. 8; pl. 3, fig. 2.

ECOLOGY.—Brackish water, benthic.

DISTRIBUTION.—Present in Sangamon and Recent sediments, not abundant.

Achnanthes conspicua var. *brevistriata* Hustedt, 1930b

(Pl. 17, Fig. 9)

DESCRIPTION.—Hustedt 1933:387, fig. 833e–f.

ECOLOGY.—A freshwater species (Hustedt 1933).

DISTRIBUTION.—Rare in San Pablo Bay; Recent.

REMARKS.—The specimens from San Francisco Bay have somewhat coarser striae (8 in 10 μm) than described by Hustedt for *A. conspicua* (13–14 in 10 μm).

Achnanthes groenlandica var. *phinneyi* McIntire and Reimer, 1974

(Pl. 17, Fig. 16)

DESCRIPTION.—McIntire and Reimer 1974:172, pl. 2, fig. 3a–c; pl. 3, fig. 3a, b.

ECOLOGY.—Brackish water, benthic.

DISTRIBUTION.—Rare in Sangamon and Recent sediments.

Achnanthes haukiana Grunow, 1880

(Pl. 17, Fig. 14)

DESCRIPTION.—Patrick and Reimer 1966:267–269, pl. 17, fig. 25–32.

ECOLOGY.—Mesohalobous, euryhaline (Pankow 1976); fresh to moderately brackish water (Patrick and Reimer 1966).

DISTRIBUTION.—Intertidal mud flats near areas where creeks enter the Bay. Recent.

Achnanthes haukiana var. *rostrata*

Schulz, 1926

(Pl. 17, Fig. 11–13, 15)

DESCRIPTION.—Patrick and Reimer 1966:269, pl. 17, fig. 33, 34.

ECOLOGY.—Same as species.

DISTRIBUTION.—Same as species.

Achnanthes lanceolata Brébisson

in Kutzing, 1846

(Pl. 17, Fig. 20, 21; Pl. 25, Fig. 8, 9)

DESCRIPTION.—Patrick and Reimer 1966:269–270, pl. 18, fig. 1–10.

ECOLOGY.—Widespread in fresh and brackish water. Fresh water (Hustedt 1933), brackish water (Hendey 1964).

DISTRIBUTION.—On intertidal mud flats throughout the Bay; Sangamon and Recent.

Achnanthes longipes Agardh, 1824

(Pl. 17, Fig. 23a, b)

DESCRIPTION.—Hendey 1964:174, pl. 28, fig. 1–6; pl. 42, fig. 2.

ECOLOGY.—Benthic, littoral marine, prefers salinities of 32–34‰ (Hendey 1964).

DISTRIBUTION.—Rare in Recent sediments.

Achnanthes parvula Kutzing, 1844

(Pl. 18, Fig. 2)

DESCRIPTION.—McIntire and Reimer 1974:174, pl. 2, fig. 4a, b; pl. 4, fig. 3a–d.

ECOLOGY.—Brackish water, neritic, benthic.

DISTRIBUTION.—Intertidal mud flat, Central Bay; Recent sediments.

Achnanthes wellsiae Reimer

in Patrick and Reimer, 1966

(Pl. 17, Fig. 10; Pl. 18, Fig. 3)

DESCRIPTION.—Patrick and Reimer (1966):255, pl. 16, fig. 14–17.

ECOLOGY.—Poorly known, only reported from brackish water.

DISTRIBUTION.—In one intertidal salt-marsh sample. Recent sediments.

Achnanthes yaquinensis McIntire and Reimer, 1974

(Pl. 18, Fig. 1)

DESCRIPTION.—McIntire and Reimer 1974:174; pl. 2, fig. 1a, b; pl. 3, fig. 1a, b.

ECOLOGY.—Brackish water, benthic.

DISTRIBUTION.—Intertidal mud flat, Recent sediments.

Actinocyclus Ehrenberg, 1837*Actinocyclus normanii* (Gregory) Hustedt, 1957

(Pl. 8, Fig. 1–3, 7, 9, 11, 12)

DESCRIPTION.—Hustedt 1957:218, fig. 5, 6.

ECOLOGY.—Planktonic, mesohalobous (Schrader 1978); polyhalobous, mesoeuryhaline (Pankow 1976); marine to brackish (Hasle 1977).

DISTRIBUTION.—Abundant in Yerba Buena mud; present but rare in Recent sediments.

Actinocyclus normanii f. *subsalsa*

(Juhlin.-Dannt.) Hustedt, 1957

(Pl. 8, Fig. 4–6, 8, 10)

DESCRIPTION.—Hasle 1977:321–328, fig. 1, 3–10, 18, 19, 22, 23.

ECOLOGY.—Fresh to moderately brackish water, indicative of high eutrophication and pollution (Hasle 1977; Stoermer and Yang 1969).

DISTRIBUTION.—Rare in Sangamon and Recent sediments.

Actinocyclus octanarius Ehrenberg, 1838

(Pl. 9, Fig. 1, 5)

DESCRIPTION.—Hendey 1964:83, pl. 24, fig. 3.

ECOLOGY.—Planktonic, polyhalobous (meso- to meioeuryhaline (Pankow 1976).

DISTRIBUTION.—Rare in Sangamon and Recent sediments.

Actinocyclus? sp. 1

(Pl. 9, Fig. 2)

DESCRIPTION.—Valve circular, strongly convex, central area large, about ½ the diameter with irregularly scattered punctae; remaining portion of valve covered with widely spaced, coarsely punctate striae, 6 in 10 µm, diameter is 31 µm.

DISTRIBUTION.—A single specimen from the Yerba Buena mud.

Actinoptychus Ehrenberg, 1841*Actinoptychus senarius* Ehrenberg, 1838

(Pl. 13, Fig. 1–4, 7)

DESCRIPTION.—Hendey 1964:95, pl. 23, fig. 1, 2.

ECOLOGY.—Planktonic, polyhalobous, meioeuryhaline (Pankow 1976); cosmopolitan in neritic plankton (Hendey 1964); meroplanktonic (Schuette and Schrader 1979).

DISTRIBUTION.—Common in Sangamon sediment and present in Recent sediment.

REMARKS.—This species is abundant in samples from the upper part of the Yerba Buena muds and commonly occurs with *Thalassionema nitzschoides* in the Yerba Buena muds. Hendey (1964) states that *A. senarius* is always present, but never abundant, in neritic plankton

samples worldwide. It is curious, therefore, to find it as the dominant species in some samples.

Actinoptychus splendens (Shadbolt) Ralfs
in Pritchard, 1861

(Pl. 13, Fig. 5, 6)

DESCRIPTION.—Hendey 1964:95, pl. 22, fig. 1.

ECOLOGY.—Same as *A. senarius*.

DISTRIBUTION.—Rare in Sangamon and Recent sediment.

Amphipleura Kutzing, 1844

Amphipleura rutilans (Trent.) Cleve, 1894

(Pl. 19, Fig. 4, 7)

DESCRIPTION.—Patrick and Reimer 1966:304, pl. 21, fig. 3.

ECOLOGY.—Lives in gelatinous tubes attached to bottom.

DISTRIBUTION.—Intertidal mud flats and salt-marsh sediments of Recent bay.

Amphora (Ehrenberg) Kutzing, 1844

Amphora ovalis (Kutzing) Kutzing, 1844

(Pl. 27, Fig. 4)

DESCRIPTION.—Patrick and Reimer 1966, pl. 13, fig. 1, 2.

ECOLOGY.—Benthic, oligohalobous mesoeuryhaline (Pankow 1976); alkaliphilous (Patrick and Reimer 1966).

DISTRIBUTION.—Rare in Sangamon and Recent sediments.

Amphora granulata Gregory, 1857

(Pl. 27, Fig. 5, 7, 8)

DESCRIPTION.—Cleve-Euler 1953:100. Hustedt 1955:40, pl. 14, fig. 8–10, 26, 27.

ECOLOGY.—Benthic, marine (Hendey 1964).

DISTRIBUTION.—Recent sediment, rare.

Amphora sublaevis Hustedt, 1955

(Pl. 27, Fig. 10)

DESCRIPTION.—Hustedt 1955:41, pl. 13, fig. 3, 12–15.

DISTRIBUTION.—Intertidal mud flats and salt marsh, epiphytic; from Recent sediment, abundant in some samples.

Amphora ventricosa (Gregory) Hendey, 1951

(Pl. 27, Fig. 9)

DESCRIPTION.—Hendey 1951:70, pl. 9, fig. 6. Hendey 1964:269, pl. 38, fig. 12.

ECOLOGY.—Marine to brackish water, littoral, benthic (Hendey 1964).

DISTRIBUTION.—Frequent and widespread in Recent sediments, especially from intertidal mud flats and salt marshes in central and southern San Francisco Bay.

Amphora sp. 1

(Pl. 27, Fig. 6)

DESCRIPTION.—Valves semi-lanceolate, ends rounded and directed slightly ventrally, ventral margin straight, slightly in-

flated in the middle of the valve, dorsal margin convex, raphe arcuate, central area very narrow, central nodule small, valve striate, striae parallel becoming slightly convergent near the end, very fine 25–30 in 10 μ m, length is 30–45 μ m, breadth is 5–8 μ m.

DISTRIBUTION.—Intertidal mud flats, Recent sediment.

Anomoeoneis Pfitzer, 1871

Anomoeoneis sphaerophora f. *costata*
(Kutzing) Schmid, 1977

(Pl. 22, Fig. 3)

DESCRIPTION.—Patrick and Reimer 1966:376, pl. 32, fig. 3. Schmid 1977:320, pl. 3, fig. 13–20.

ECOLOGY.—Benthic, mesohalobous (Pankow 1976); in waters of moderate to high salt concentration (Patrick and Reimer 1966).

DISTRIBUTION.—Rare, Sangamon sediment.

Arachnoidiscus Bailey, 1849

Arachnoidiscus ehrenbergi Bailey, 1849

(Pl. 14, Fig. 5)

DESCRIPTION.—Hustedt 1929:471, fig. 262.

ECOLOGY.—A coastal marine species, commonly found in association with *Isthmia* spp. (Hustedt 1929). Epiphytic, rarely found in plankton (Gran and Angst 1931).

DISTRIBUTION.—Present in Sangamon and Recent sediment, commonly associated with *Isthmia nervosa*.

Asteromphalus Ehrenberg, 1844

Only one poorly preserved specimen was recorded from Recent and Sangamon sediments and was not treated taxonomically.

Aulacosira Thwaites, 1848

Aulacosira ambigua (Grunow) Simonsen, 1979

(Pl. 1, Fig. 8)

DESCRIPTION.—Hustedt 1927:256, fig. 108.

ECOLOGY.—Oligohalobous, meioeuryhaline (Pankow 1976).

DISTRIBUTION.—Rare in Sangamon sediment.

Aulacosira granulata (Ehr.) Simonsen, 1979

(Pl. 1, Fig. 11–15)

DESCRIPTION.—Hustedt 1927:248, fig. 104.

ECOLOGY.—Oligohalobous, meioeuryhaline (Pankow 1976); plankton in eutrophic fresh water (Hustedt 1927).

DISTRIBUTION.—Recent and Sangamon sediment, rare.

Aulacosira islandica (O. Muller) Simonsen, 1979

(Pl. 2, Fig. 2–4)

DESCRIPTION.—Hustedt 1927:252, fig. 106, 107.

ECOLOGY.—Oligohalobous, meioeuryhaline (Pankow 1976), "very abundant and widespread in eutrophic fresh water. . . ." (Hustedt 1927).

DISTRIBUTION.—Recent and Sangamon sediments.

Aulacosira italica (Ehrenberg) Simonsen, 1979

(Pl. 1, Fig. 9, 10)

DESCRIPTION.—Hustedt 1927:257, fig. 109.

ECOLOGY.—Littoral of freshwater streams and lakes (Hustedt 1927).

DISTRIBUTION.—Rare in Recent and Sangamon sediments.

Auricula Castracane, 1875*Auricula complexa* Gregory, 1857

(Pl. 29, Fig. 14)

DESCRIPTION.—Pankow 1976:145, fig. 295.

ECOLOGY.—Polyhalobous, meioeuryhaline, subtropical, benthic (Pankow 1976).

DISTRIBUTION.—A single specimen in Recent sediments from Albany mud flats.

Bacillaria Gmelin, 1788*Bacillaria paxillifer* (O. F. Müller) Hendey, 1951

(Pl. 31, Fig. 2)

DESCRIPTION.—Hendey 1951:74. Hustedt 1930b:396, fig. 755.

ECOLOGY.—Mesohalobous, holoeuryhaline (Pankow 1976).

DISTRIBUTION.—Present in Sangamon and Recent sediments.

Biddulphia Gray, 1821*Biddulphia alterans* (Bailey)

Van Heurck, 1880–1885

(Pl. 14, Fig. 2)

DESCRIPTION.—Hendey 1964:102, pl. 25, fig. 5.

ECOLOGY.—Neritic marine, benthic.

DISTRIBUTION.—Rare in Sangamon and Recent sediments.

Biddulphia aurita (Lyngbye) Brébisson, 1838

(Pl. 13, Fig. 8–10)

DESCRIPTION.—Hustedt 1930a:846, fig. 501, 502. Schmidt 1874, pl. 120, fig. 7–10; pl. 122, fig. 1–9.

ECOLOGY.—Polyhalobous, meioeuryhaline (Pankow 1976); neritic plankton (Hendey 1951).

DISTRIBUTION.—Frequent in Sangamon and Recent sediment.

Biddulphia laevis Ehrenberg, 1843

(Pl. 14, Fig. 1)

DESCRIPTION.—Hustedt 1930a:852, fig. 506, 507.

ECOLOGY.—Poorly known, mesohalobous(?) (Pankow 1976). It appears to be a coastal species that prefers moderately high salt concentrations.

DISTRIBUTION.—Rare in Sangamon and Recent sediments.

Caloneis Cleve, 1894*Caloneis alpestris* (Grunow) Cleve, 1894

(Pl. 22, Fig. 8)

DESCRIPTION.—Patrick and Reimer 1966:587, pl. 54, fig. 9.

ECOLOGY.—Prefers cool, fresh, mesotrophic waters (Patrick and Reimer 1966), oligohalobous.

DISTRIBUTION.—Rare in Recent sediments.

Caloneis amphisbaena (Bory) Cleve, 1894

(Pl. 22, Fig. 10)

DESCRIPTION.—Patrick and Reimer 1966:579, pl. 53, fig. 2.

ECOLOGY.—Oligohalobous (indifferent), meioeuryhaline, in brackish and fresh water, benthic (Pankow 1976); fresh to slightly brackish water (Patrick and Reimer 1966).

DISTRIBUTION.—Rare in Recent sediment.

Caloneis bacillum (Grunow) Cleve, 1894

(Pl. 22, Fig. 6, 11)

DESCRIPTION.—Patrick and Reimer 1966:586, pl. 54, fig. 8.

ECOLOGY.—Oligohalobous, mesoeuryhaline, benthic, widely distributed in fresh waters (Pankow 1976).

DISTRIBUTION.—Rare in Sangamon and Recent sediment.

Caloneis ventricosa (Ehrenberg) Meister, 1912

(Pl. 22, Fig. 14)

DESCRIPTION.—Patrick and Reimer 1966:583, pl. 54, fig. 3.

ECOLOGY.—Fresh water, benthic.

DISTRIBUTION.—A single specimen from Sangamon sediments.

Caloneis westii (Smith) Hendey, 1964

(Pl. 22, Fig. 4, 5, 9)

DESCRIPTION.—Hendey 1964:230, pl. 44, fig. 5–10; pl. 45, fig. 1–13.

ECOLOGY.—Mesohalobous, euryhaline (Pankow 1976); a brackish-water species, common in the littoral zone (Hendey 1964); benthic.

DISTRIBUTION.—Common in Sangamon sediments and intertidal mud flats and salt marshes of present bay.

REMARKS.—This species is frequent in many Sangamon sediment samples. It is commonly found in association with *Nitzschia granulata* in Recent and Sangamon sediments.*Campylodiscus* Ehrenberg, 1840*Campylodiscus clypeus* Ehrenberg, 1840

(Pl. 35, Fig. 2)

DESCRIPTION.—Pankow 1976:319. Cleve-Euler 1952:128, fig. 1579.

ECOLOGY.—Mesohalobous (Pankow 1976), benthic.

DISTRIBUTION.—Rare in Recent sediments.

Campylodiscus echeneis Ehrenberg, 1840

(Pl. 35, Fig. 1, 3)

DESCRIPTION.—Hendey 1964:291, pl. 40, fig. 14.

ECOLOGY.—Mesohalobous (Pankow 1976); a common marine and brackish water species (Hendey 1964); a coastal marine species sometimes found in inland salt waters (Cholnoky 1968), benthic.

DISTRIBUTION.—Present in Sangamon and Recent sediment, not abundant.

REMARKS.—Sloan (1981) reports abundant *C. echeneis* in some Sangamon sediments from San Francisco Bay. The high density of *C. echeneis* observed by Sloan (1981) may be an artifact of sieving and sample concentration.

Campylodiscus incertus Schmidt, 1874

(Pl. 33, Fig. 19)

DESCRIPTION.—Schmidt 1874, Pl. 15, fig. 13–15, 19, 20; pl. 207, fig. 14. Giffen 1971:4, fig. 60.

DISTRIBUTION.—Rare in Recent sediments from intertidal mud flats and salt marshes, Albany mud flats.

Campylodiscus ralfsii Smith, 1853

(Pl. 33, Fig. 12)

DESCRIPTION.—Hendey 1964:291. Cleve-Euler 1952:127, fig. 1576.

ECOLOGY.—Mesohalobous, benthic.

DISTRIBUTION.—Rare in intertidal salt-marsh and mud flat sediments, Recent.

Cerataulus Ehr. 1843

Cerataulus turgidus (Ehrenberg) Ehrenberg, 1843

(Pl. 14, Fig. 10)

DESCRIPTION.—Hendey 1964:106, pl. 20, fig. 4.

ECOLOGY.—Polyhalobous, meioeuryhaline, planktonic and benthic (Pankow 1976).

DISTRIBUTION.—In Recent and Sangamon sediment, rare.

Chaetoceros Ehrenberg, 1844

Chaetoceros cinctus Gran, 1897

(Pl. 15, Fig. 1)

DESCRIPTION.—Cupp 1943:142, fig. 98.

ECOLOGY.—Polyhalobous, meioeuryhaline (Pankow 1976).

DISTRIBUTION.—Rare in Recent and Sangamon sediment.

REMARKS.—Hendey (1964) distinguishes this species from *C. radicans* by the lack of spines on the setae, whereas Cupp (1943) shows smooth setae in both species.

Chaetoceros mitra (Bailey) Cleve, 1896

(Pl. 15, Fig. 4)

DESCRIPTION.—Hendey 1964:124, pl. 16, fig. 2.

ECOLOGY.—Polyhalobous, meioeuryhaline.

DISTRIBUTION.—A single specimen from the Yerba Buena mud.

REMARKS.—Hendey (1964) distinguished resting spores of this species from the similar *C. lorenzianus* (Grunow) by its short conical protuberances. Hendey (1964:124, pl. 16, fig. 1) de-

scribed *C. lorenzianus* as possessing elongate, curved protuberances on the resting spores. Gran and Angst (1931:471, fig. 53b, c) identified both forms as *C. lorenzianus*. Cupp (1943:118, fig. 71e, f) described *C. lorenzianus* resting spores with short protuberances. Evidently Gran and Angst (1931) and Cupp (1943) combined the two forms using the earlier epithet. Hendey (1964) recognized Cleve's (1896) distinction between *C. mitra* and *C. lorenzianus*.

Chaetoceros sp. 1

(Pl. 15, Fig. 2)

DESCRIPTION.—Resting spore, semispherical with numerous short spines scattered on convex surface. Diameter is 17 μ m. This specimen is very similar to one illustrated by Schrader (1973, pl. 17, fig. 9–11).

DISTRIBUTION.—A single specimen in the Yerba Buena mud.

REMARKS.—No positive identification could be made from this specimen. Many species of *Chaetoceros* show similar resting spores.

Chaetoceros? sp. 2

(Pl. 15, Fig. 3)

DESCRIPTION.—Valve roughly semi-ovoid, somewhat expanded at the base; three large, hollow spines protrude from the rounded top; valve surface covered with longitudinal rows of coarse punctae; length is 17 μ m; breadth is 15 μ m.

REMARKS.—This specimen is questionably assigned to *Chaetoceros*. Valves of *Chaetoceros* only have two setae and the spines of resting spores are rarely as long as those of this specimen.

Cocconeis Ehrenberg, 1837

Cocconeis californica (Grunow) Cleve, 1895

(Pl. 18, Fig. 13, 14)

DESCRIPTION.—Hustedt 1933:343, fig. 796.

ECOLOGY.—Littoral, marine species, benthic (Hustedt 1933).

DISTRIBUTION.—Rare in Sangamon and Recent sediments.

Cocconeis decipiens Cleve, 1873

(Pl. 18, Fig. 15)

DESCRIPTION.—Hustedt 1933:353, fig. 808.

ECOLOGY.—Coastal marine species, benthic (Hustedt 1933).

DISTRIBUTION.—A single specimen from the Yerba Buena mud.

Cocconeis diminuta Pantocsek, 1902

(Pl. 18, Fig. 10–12)

DESCRIPTION.—Hustedt 1933:346, fig. 800.

ECOLOGY.—Poorly known, probably fresh water, benthic.

DISTRIBUTION.—Rare in Recent and Sangamon sediments.

Cocconeis fasciolata Ehrenberg, 1844

(Pl. 19, Fig. 1, 2)

DESCRIPTION.—Brown 1920:232.

ECOLOGY.—Unknown.

DISTRIBUTION.—Rare but widely distributed in Sangamon and Recent sediments.

Cocconeis placentula Ehrenberg, 1838

(Pl. 18, Fig. 5, 6)

DESCRIPTION.—Patrick and Reimer 1966:240, pl. 15, fig. 7.

ECOLOGY.—Oligohalobous, holo- to pleioeuryhaline, a freshwater species (Pankow 1976); a widespread, epiphytic species, apparently salt indifferent (Patrick and Reimer 1966).

DISTRIBUTION.—Widespread but not abundant in Recent and Sangamon sediments.

Cocconeis scutellum Ehrenberg, 1837

(Pl. 18, Fig. 4; Pl. 19, Fig. 5)

DESCRIPTION.—Hustedt 1933:337, fig. 790.

ECOLOGY.—Polyhalobous, meio- to pleioeuryhaline, benthic (Pankow 1976).

DISTRIBUTION.—Present in Recent and Sangamon sediment, not abundant.

Cocconeis vitrea Brun, 1891

(Pl. 18, Fig. 7–9)

DESCRIPTION.—Brun 1891:19, pl. 18, fig. 2.

ECOLOGY.—Poorly known.

DISTRIBUTION.—Common in intertidal mud flats of present bay, rare in the Yerba Buena mud.

Cocconeis sp. 1

(Pl. 18, Fig. 16)

DESCRIPTION.—Pseudoraphe valve elliptical, saddle shaped. Axial area narrow and straight; valve surface striate, striae radial and moniliform; broadly spaced punctae form irregular longitudinal lines. Length is 19 μm ; width is 16 μm ; striae 16 in 10 μm .

DISTRIBUTION.—Rare in recent sediments from San Pablo Bay.

Cocconeis sp. 2

(Pl. 19, Fig. 3)

DESCRIPTION.—Pseudoraphe valve elliptical, flat. Axial area narrow, lanceolate. Valve surface striate, striae radial, punctate. Longitudinal line present parallel to the valve margin about $\frac{1}{3}$ the width from the margin on each side of the valve. Length is 15 μm , width is 10 μm , striae 14 in 10 μm .

DISTRIBUTION.—A single specimen from Recent sediment of Albany mud flats.

Coscinodiscus Ehrenberg, 1838*Coscinodiscus curvatulus* Grunow, 1878

(Pl. 9, Fig. 3, 4)

DESCRIPTION.—Hendey 1964:81. Hustedt 1928:406, fig. 214.

ECOLOGY.—Marine neritic, boreal, planktonic.

DISTRIBUTION.—Rare in Recent and Sangamon sediment.

Coscinodiscus decrescens Grunow
in Schmidt, 1878

(Pl. 5, Fig. 3, 5)

DESCRIPTION.—Hustedt 1928:430, fig. 233.

ECOLOGY.—Coastal, marine plankton (Hustedt 1928).

DISTRIBUTION.—Rare in Yerba Buena mud.

Coscinodiscus jonesianus (Greville)
Ostenfeld, 1915

(Pl. 5, Fig. 1, 2)

DESCRIPTION.—Hustedt 1928:438, fig. 239, 240.

ECOLOGY.—Polyhalobous, meioeuryhaline, subtropical to tropical seas (Pankow 1976); planktonic.

DISTRIBUTION.—Widespread in Sangamon and Recent sediments, not abundant. More common in Recent sediments from the entrapment zone in Suisun Bay.

REMARKS.—Several valves, which are identical to *C. jonesianus* in all respects except lacking the two prominent marginal processes, have been assigned to this species. They may represent a variety or one valve of a heterovalvar cell in which the other valve possesses those processes.*Coscinodiscus marginatus* Ehrenberg, 1841

(Pl. 6, Fig. 6; Pl. 35, Fig. 4)

DESCRIPTION.—Hendey 1964:78, pl. 22, fig. 2.

ECOLOGY.—Oceanic plankton (Hendey 1964).

DISTRIBUTION.—Rare in Recent sediment.

Coscinodiscus nitidus Gregory, 1857

(Pl. 7, Fig. 3)

DESCRIPTION.—Hendey 1964:76, pl. 23, fig. 12.

ECOLOGY.—Polyhalobous, planktonic, meioeuryhaline (Pankow 1976).

DISTRIBUTION.—A single specimen from Recent sediment. Wong (1975) reported this species from plankton of central San Francisco Bay.

Coscinodiscus obscurus Schmidt, 1878

(Pl. 5, Fig. 6, 8–9; Pl. 6, Fig. 1)

DESCRIPTION.—Hustedt 1928:418, fig. 224.

ECOLOGY.—Planktonic, marine; pelagic in North Atlantic (Hustedt 1928).

DISTRIBUTION.—Widespread but not abundant in Sangamon and Recent sediment.

Coscinodiscus oculus-iridis Ehrenberg, 1839

(Pl. 5, Fig. 4)

DESCRIPTION.—Hendey 1964:78, pl. 24, fig. 1.

ECOLOGY.—Oceanic, planktonic (Hendey 1964).

DISTRIBUTION.—Present in Recent and Sangamon sediments.

REMARKS.—This species is similar to *C. asteromphalus* but is distinguished by fewer large areolae in the central rosette. *Coscinodiscus oculus-iridis* has five or fewer areolae in the central rosette (Hendey 1964), whereas *C. asteromphalus* has seven to nine (Brooks 1975). However, Brooks (1975:19) indicates that the central area of some specimens “have no large central rosette, the most central cribra being very little larger than the others.” Therefore, the distinction between these two species may be tenuous.

Coscinodiscus radiatus Ehrenberg, 1839

(Pl. 5, Fig. 7; Pl. 6, Fig. 2–4)

DESCRIPTION.—Hustedt 1928:420, fig. 225.

ECOLOGY.—Polyhalobous, pleioeuryhaline (Pankow 1976), planktonic.

DISTRIBUTION.—Present in Recent and Sangamon sediment, rare.

Cyclotella Kutzing, 1833

Cyclotella comta (Ehrenberg) Kutzing, 1849

(Pl. 3, Fig. 3; Pl. 7, Fig. 7)

DESCRIPTION.—Hustedt 1928:354, fig. 183.

ECOLOGY.—Oligohalobous, meioeuryhaline (Pankow 1976).

DISTRIBUTION.—Rare in Recent and Sangamon sediments.

Cyclotella menegheniana Kutzing, 1844

(Pl. 3, Fig. 5)

DESCRIPTION.—Hustedt 1928:341, fig. 174.

ECOLOGY.—Oligohalobous, pleioeuryhaline, planktonic and benthic (Pankow 1976).

DISTRIBUTION.—Present in Recent sediments, most common in samples from Suisun and San Pablo bays.

Cyclotella pygmaea Pantocsek, 1892

(Pl. 3, Fig. 2; Pl. 7, Fig. 4)

DESCRIPTION.—Pantocsek 1892:37, 38, pl. 2, fig. 22; pl. 4, fig. 59.

ECOLOGY.—Fresh water (Schrader 1978).

DISTRIBUTION.—A single specimen from the Yerba Buena mud.

REMARKS.—This species has been reported only from fossil, freshwater material and this specimen is probably contamination from Plio-Pleistocene freshwater diatomites in northern California.

Cyclotella stelligera Cleve, 1881

(Pl. 3, Fig. 1)

DESCRIPTION.—Hustedt 1928:339, fig. 172.

ECOLOGY.—Fresh water.

DISTRIBUTION.—A single specimen from Recent sediments in San Pablo Bay.

Cyclotella striata (Kutzing) Grunow
in Cleve and Grunow, 1880

(Pl. 3, Fig. 4, 6; Pl. 7, Fig. 5, 6)

DESCRIPTION.—Hustedt 1928:344, fig. 176.

ECOLOGY.—Marine to brackish water (Hendey 1964); a marine littoral species common in estuaries and inland salt water, a typical brackish-water diatom (Cholnoky 1968); meroplanktonic.

DISTRIBUTION.—Present but not abundant in Recent and Sangamon sediment.

Cyclotella stylorum Brightwell, 1860

(Pl. 3, Fig. 7–9)

DESCRIPTION.—Planktonic, marine (Hustedt 1928), meroplanktonic (Schuette and Schrader 1979).

DISTRIBUTION.—Abundant in Sangamon sediments, rare in Recent sediments.

REMARKS.—This is the most abundant species in the Yerba Buena mud. However its taxonomic status and ecology are unclear. Hustedt (1928) states that most authors would synonymize this species with *C. striata*. Hustedt retained *C. stylorum* based on the presence of marginal chambers on this species and their absence in *C. striata*. These species are very similar morphologically and are no doubt closely related. Schuette and Schrader (1979) considered *C. stylorum* and *C. striata* as a single taxonomic entity (their “*C. striata/stylorum*”) for ecological purposes in a study of diatom taphocoenoses. Hasegawa (1975) reported *C. stylorum* from Pleistocene sediment on the west coast of Japan.

Cymatosira Grunow, 1862

Cymatosira belgica Grunow
in Van Heurck, 1880–1885

(Pl. 15, Fig. 7–9, 13)

DESCRIPTION.—Hendey 1964:160. Hustedt 1931:127, fig. 649.

ECOLOGY.—Polyhalobous, meioeuryhaline, benthic (Pankow 1976); a common littoral species (Hendey 1964); probably tychoipelagic.

DISTRIBUTION.—Abundant in Yerba Buena mud; present but not common in Recent sediments.

REMARKS.—This species is very abundant in Sangamon sediments from San Francisco Bay. From the work of Fryxell and Miller (1978) on *C. lorenziana*, it is inferred that *C. belgica* is a coastal marine species that forms chains attached to the substrate at one end. These chains are

occasionally torn from the substrate by currents or waves and live in the plankton.

***Cymbella* Agardh, 1830**

***Cymbella cistula* (Ehrenberg in Hemprich and Ehrenberg, Kirchner in Cohn, 1878**

(Pl. 28, Fig. 7)

DESCRIPTION.—Patrick and Reimer 1975:62, pl. 11, fig. 3, 4.

ECOLOGY.—Alkaliphilous, "indifferent" oligohalobous; eurytopic epiphyte (Patrick and Reimer 1966).

DISTRIBUTION.—Rare in Sangamon and Recent sediments.

***Cymbella meulleri* var. *ventricosa* (Temperé and Peragallo) Reimer in Patrick and Reimer, 1975**

(Pl. 28, Fig. 2)

DESCRIPTION.—Patrick and Reimer 1975:44, pl. 7, fig. 3a, 4.

ECOLOGY.—Poorly known.

DISTRIBUTION.—A single specimen from Recent sediment.

***Cymbella mexicana* (Ehrenberg) Cleve, 1894**

(Pl. 28, Fig. 3–5)

DESCRIPTION.—Patrick and Reimer 1975:59, pl. 12, fig. 1, 2.

ECOLOGY.—Poorly known, fresh water.

DISTRIBUTION.—Rare in Sangamon and Recent sediments.

***Cymbella mexicana* var. *janischii* (Schmidt) Reimer in Patrick and Reimer 1975**

(Pl. 28, Fig. 6)

DESCRIPTION.—Patrick and Reimer 1975:60, pl. 12, fig. 3a, b.

ECOLOGY.—Not known, probably fresh water.

DISTRIBUTION.—A single specimen from sediment in Suisun Bay.

***Cymbella minuta* Hilse in Rabenhorst, 1861–1879**

(Pl. 27, Fig. 14)

DESCRIPTION.—Patrick and Reimer 1975:47, pl. 8, fig. 1–4b.

ECOLOGY.—Eurytopic, oligohalobous (Patrick and Reimer 1975).

DISTRIBUTION.—Rare in Sangamon sediment.

***Cymbella prostrata* (Berk.) Cleve, 1894**

(Pl. 27, Fig. 12)

DESCRIPTION.—Patrick and Reimer 1975:40, pl. 6, fig. 4.

ECOLOGY.—Alkaliphilous, indifferent oligohalobous (Pan-kow 1976).

DISTRIBUTION.—Rare in Recent and Sangamon sediment.

***Cymbella prostrata* var. *auerswaldii* (Rabenhorst) Reimer**

in Patrick and Reimer, 1975

(Pl. 27, Fig. 15)

DESCRIPTION.—Patrick and Reimer 1975:41, pl. 6, fig. 5, 6.

ECOLOGY.—Insufficiently known.

DISTRIBUTION.—A single specimen from Sangamon sediments.

***Cymbella sinuata* Gregory, 1856**

(Pl. 27, Fig. 13)

DESCRIPTION.—Patrick and Reimer 1975:51, pl. 9, fig. 3, 4.

ECOLOGY.—Oligohalobous (Patrick and Reimer 1975).

DISTRIBUTION.—Rare in Recent sediment.

***Cymbella triangulum* (Ehrenberg) Cleve, 1894**

(Pl. 27, Fig. 12; Pl. 28, Fig. 1)

DESCRIPTION.—Patrick and Reimer 1975:45, pl. 7, fig. 7–10.

ECOLOGY.—A fresh-water species, alkaliphilous.

DISTRIBUTION.—Rare in Recent and Sangamon sediments.

***Cymbella tumidula* Grunow in Schmidt, 1875**

(No illustration)

DESCRIPTION.—Patrick and Reimer 1975:56, pl. 10, fig. 6.

ECOLOGY.—Fresh water, alkaliphilous (Patrick and Reimer 1975).

DISTRIBUTION.—Rare in sediment from San Pablo and Suisun Bays.

***Denticula* Kutzing, 1844**

***Denticula subtilis* Grunow, 1862**

(Pl. 30, Fig. 12, 13)

DESCRIPTION.—Patrick and Reimer 1975:172, pl. 22, fig. 10, 11.

ECOLOGY.—A brackish-water, estuarine species (Patrick and Reimer 1975).

DISTRIBUTION.—Rare in Sangamon and Recent sediments.

***Denticula thermalis* Kutzing, 1844**

(No illustration)

DESCRIPTION.—Patrick and Reimer 1975:174, pl. 22, fig. 18, 19.

ECOLOGY.—A fresh-water species.

DISTRIBUTION.—A single specimen from Sangamon sediment.

***Diatoma* Bory, 1824**

***Diatoma anceps* (Ehrenberg in Hemprich and Ehrenberg) Kirchner in Cohn, 1878**

(Pl. 15, Fig. 12)

DESCRIPTION.—Patrick and Reimer 1966:106, pl. 2, fig. 1–3.

ECOLOGY.—Fresh water.

DISTRIBUTION.—A single specimen from the Yerba Buena mud.

***Diatoma vulgare* var. *breve* Grunow, 1862**

(Pl. 15, Fig. 11)

DESCRIPTION.—Patrick and Reimer 1966:110, pl. 2, fig. 10,

11.

ECOLOGY.—Prefers cool, fresh water (Patrick and Reimer 1966).

DISTRIBUTION.—A single specimen from Recent sediments.

Dimeregramma Ralfs in Pritchard, 1861

Dimeregramma minor (Gregory) Ralfs in Pritchard, 1861

(Pl. 15, Fig. 15, 16)

DESCRIPTION.—Hendey 1964:156, Pl. 27, Fig. 12.

ECOLOGY.—Polyhalobous, mesoeuryhaline, epiphytic on macroalgae (Pankow 1976).

DISTRIBUTION.—Rare in Sangamon and Recent sediments.

Diploneis Ehrenberg, 1844

Diploneis bombus Ehrenberg, 1844

(Pl. 23, Fig. 3)

DESCRIPTION.—Hendey 1964:227, pl. 32, fig. 2. Hustedt 1937:704, fig. 1086.

ECOLOGY.—Polyhalobous, meio- to mesoeuryhaline (Pankow 1976); brackish-water species, benthic (Hendey 1964).

DISTRIBUTION.—Rare but widespread in Sangamon and Recent sediments.

Diploneis decipiens Cleve-Euler, 1915

(Pl. 23, Fig. 5)

DESCRIPTION.—Cleve-Euler 1953:77, fig. 645.

ECOLOGY.—Marine and brackish water.

DISTRIBUTION.—Abundant in sediments from Suisun Bay.

REMARKS.—The identification of this species is uncertain. The specimens from this study are smaller (length is 9–20 μm , width is 5–11 μm) than the description given by Cleve-Euler. However, the number of striae (9–12 in 10 μm) agrees with Cleve-Euler's description as do the other aspects of morphology. The specimens in this study are similar to *D. puella* (Schum.) Cl. described by Patrick and Reimer (1966) and Germain (1979), but the striae are coarser.

Diploneis interrupta (Kutzing) Cleve, 1894

(Pl. 23, Fig. 1, 2)

DESCRIPTION.—Hustedt 1937:602, fig. 1019. Patrick and Reimer 1966:416, pl. 38, fig. 12.

ECOLOGY.—Mesohalobous (Pankow 1976), brackish water, benthic.

DISTRIBUTION.—Rare in Sangamon and Recent sediment.

Diploneis oblongella (Naeg. in Kutzing) Ross, 1947

(Pl. 22, Fig. 15, 16)

DESCRIPTION.—Patrick and Reimer 1966:413, pl. 38, fig. 8.

ECOLOGY.—Oligohalobous, mesoeuryhaline, benthic (Pan-

kow 1976); fresh to slightly brackish water (Patrick and Reimer 1966).

DISTRIBUTION.—Widespread but rare in San Pablo and Suisun Bay samples, Recent.

REMARKS.—Patrick and Reimer (1966) consider *D. ovalis*, a more commonly known species, synonymous with *D. oblongella*. The epithet *oblongella* has priority. Hustedt (1937) considered *D. oblongella* a variety of *D. ovalis*.

Diploneis papula var. *constricta* Hustedt, 1937

(Pl. 23, Fig. 6)

DESCRIPTION.—Hustedt 1937:679, 680, fig. 1071d.

ECOLOGY.—Benthic, warm, coastal marine waters.

DISTRIBUTION.—Rare in Sangamon sediments.

Diploneis smithii (Brébisson in Smith) Cleve, 1894

(Pl. 22, Fig. 7, 12, 13)

DESCRIPTION.—Hustedt 1937:647, fig. 1051, 1052. Patrick and Reimer 1966:410, pl. 38, fig. 2–4.

ECOLOGY.—Polyhalobous, plioeuryhaline, benthic (Pankow 1976); in slightly brackish to brackish water (Patrick and Reimer 1966).

DISTRIBUTION.—Present in Sangamon and Recent sediments.

REMARKS.—This is the most abundant species of *Diploneis* and no doubt several of the commonly recognized varieties are present (see Pl. 22). No attempt was made to consistently distinguish the varieties because they are not sufficiently common.

Diploneis sp. 6

(Pl. 23, Fig. 4)

DESCRIPTION.—Valve linear-elliptical. Longitudinal canal indistinct. Axial area lanceolate, central area rectangular, wider than long. Costae and striae moderately radiate, punctae indistinct. Striae, 15–17 μm ; length, 25 μm ; breadth, 12 μm .

DISTRIBUTION.—A single specimen from Sangamon sediments.

REMARKS.—This specimen is similar to *D. oculata* (Brébisson) Cleve except that the striae are coarser and more radiate.

Ditylum Bailey, 1861

Ditylum brightwellii (West) Grunow in Van Heurck, 1880–1885

(Pl. 15, Fig. 5, 6)

DESCRIPTION.—Hendey 1964:111, pl. 5, fig. 1.

ECOLOGY.—Polyhalobous, meioeuryhaline (Pankow 1976); planktonic, neritic species (Hendey 1964).

DISTRIBUTION.—A common and widespread species in San-

gamon and Recent sediment. Typically the corona and central spine are preserved; rarely is the entire valve present.

Entomoneis Ehrenberg, 1845

Entomoneis alata (Ehrenberg) Ehrenberg, 1845
(Pl. 27, Fig. 1)

DESCRIPTION.—Patrick and Reimer 1975:3, pl. 1, fig. 2.

ECOLOGY.—Benthic, mesohalobous (Pankow 1976), marine (Cholnoky 1968), marine to brackish.

DISTRIBUTION.—Intertidal mud flats, Recent sediments, not common.

Entomoneis paludosa (Smith) Reimer
in Patrick and Reimer, 1975
(Pl. 26, Fig. 10)

DESCRIPTION.—Patrick and Reimer 1975:4, pl. 1, fig. 1.

ECOLOGY.—Mesohalobous euryhaline (Pankow 1976); fresh to moderately brackish water, benthic.

DISTRIBUTION.—Intertidal areas of Recent bay.

Entomoneis sp. 1
(Pl. 26, Fig. 11)

DESCRIPTION.—Valve aspect lanceolate to linear-lanceolate with acute apices. Valve surface with transverse striae, striae doubly punctate. Raphe canal sigmoid, crossed by costae which form a fibulate appearance like that in the genus *Nitzschia*. Length is 105 μm , width is 10 μm , striae 7–8 in 10 μm .

DISTRIBUTION.—A single specimen from Recent intertidal salt marsh sediments, Albany mud flats.

REMARKS.—This species is very similar to *E. conspicua* Greville and *E. pulchra* (Bailey) Reimer (see Hustedt 1955:37; Patrick and Reimer 1975:5). The girdle aspect was not observed therefore this specimen could not be positively assigned to either of those closely related species.

Epithemia Brébisson, 1838

Epithemia adnata var. *porcellus* (Kutzing)
Patrick in Patrick and Reimer, 1975
(Pl. 30, Fig. 5)

DESCRIPTION.—Patrick and Reimer 1975:180, pl. 24, fig. 6.

ECOLOGY.—Oligohalobous (indifferent), mesoeuryhaline, benthic (Pankow 1976).

DISTRIBUTION.—A single specimen from Sangamon sediments.

Epithemia argus (Ehrenberg) Kutzing, 1844
(Pl. 30, Fig. 3)

DESCRIPTION.—Patrick and Reimer 1975:175, pl. 23, fig. 1. Hustedt 1930b:384, fig. 727b.

ECOLOGY.—Oligohalobous (indifferent), meioeuryhaline, benthic (Pankow 1976).

DISTRIBUTION.—A single specimen from Sangmon sediments.

Epithemia sorex Kutzing, 1844
(Pl. 30, Fig. 4)

DESCRIPTION.—Patrick and Reimer 1975:188, pl. 27, fig. 4.

ECOLOGY.—Oligohalobous (indifferent), pleioeuryhaline, benthic (Pankow 1976).

DISTRIBUTION.—Rare in Sangamon and Recent sediments.

Epithemia turgida (Ehrenberg) Kutzing, 1844
(Pl. 30, Fig. 1)

DESCRIPTION.—Patrick and Reimer 1975:182, pl. 25, fig. 1a, b.

ECOLOGY.—Oligohalobous (indifferent), pleioeuryhaline, upper limit 17% (Pankow 1976).

DISTRIBUTION.—Frequent and widespread in Sangamon and Recent sediments.

Epithemia turgida var. *westermanii*
(Ehrenberg) Grunow, 1862
(Pl. 30, Fig. 2)

DESCRIPTION.—Patrick and Reimer 1975:184, pl. 25, fig. 2. Cleve-Euler 1952:40, fig. 1410n, o.

ECOLOGY.—Fresh water (Patrick and Reimer 1966).

DISTRIBUTION.—Rare in Sangamon and Recent sediment.

Eunotia Ehrenberg, 1837

Eunotia arcus Ehrenberg, 1837
(Pl. 17, Fig. 4)

DESCRIPTION.—Patrick and Reimer 1966:212, pl. 13, fig. 11.

ECOLOGY.—Fresh water (Patrick and Reimer 1966).

DISTRIBUTION.—A single specimen from Sangamon sediment.

Eunotia arcus var. *bidens* (Ehrenberg)
Grunow, 1881
(Pl. 17, Fig. 6)

DESCRIPTION.—Patrick and Reimer 1966:213, pl. 13, fig. 12.

ECOLOGY.—Fresh, slightly acid water.

DISTRIBUTION.—A single specimen from Sangamon sediments.

Eunotia eruca Ehrenberg, 1854
(Pl. 17, Fig. 1–3)

DESCRIPTION.—Patrick and Reimer 1966:161, pl. 9, fig. 8, 9, as “*Amphicampa mirabilis*” (Reaside 1970:537).

ECOLOGY.—Fresh water, benthic, tolerates slightly brackish water (Reaside 1970).

DISTRIBUTION.—Rare in the Yerba Buena mud.

Eunotia monodon Ehrenberg, 1843
(Pl. 17, Fig. 5, 7)

DESCRIPTION.—Patrick and Reimer 1966:198, pl. 11, fig. 6.

ECOLOGY.—Fresh water, in cool- to cold-water swamps (Patrick and Reimer 1966).

DISTRIBUTION.—Rare but widespread in Sangamon and Recent sediment.

Eunotia triodon Ehrenberg, 1837

(Pl. 17, Fig. 8)

DESCRIPTION.—Patrick and Reimer 1966:200, pl. 12, fig. 1.

ECOLOGY.—Oligotrophic, slightly acid water.

DISTRIBUTION.—A single specimen from Sangamon sediments.

Eunotogramma Weisse, 1854*Eunotogramma marinum* (Smith)

Peragallo and Peragallo, 1897–1908

(Pl. 15, Fig. 10)

DESCRIPTION.—Hustedt 1955:10, pl. 4, fig. 10–17.

ECOLOGY.—A marine and brackish-water species.

DISTRIBUTION.—Rare in Sangamon and Recent sediments.

Fragilaria Lyngbye, 1819*Fragilaria brevistriata* Grunow

in Van Heurck, 1880–1885

(Pl. 16, Fig. 23)

DESCRIPTION.—Patrick and Reimer 1966:128, pl. 4, fig. 14.

ECOLOGY.—Oligohalobous, mesoeuryhaline, benthic (Pankow 1976).

DISTRIBUTION.—Rare in sediments from San Pablo and Suisun Bays.

Fragilaria capucina Desmazieres, 1825

(Pl. 16, Fig. 14)

DESCRIPTION.—Patrick and Reimer 1966:118, pl. 13, fig. 5. Lange-Bertalot 1980*b*, fig. 39–81, 239–242.

ECOLOGY.—“Indifferent” oligohalobous.

DISTRIBUTION.—Rare in Recent sediments.

Fragilaria capucina var. *vaucheriae* (Kutzing)Lange-Bertalot, 1980*b*

(Pl. 16, Fig. 25)

DESCRIPTION.—Patrick and Reimer 1966:120, pl. 3, as *F. vaucheriae*. Lange-Bertalot 1980*b*, fig. 26–38, 216–235.

ECOLOGY.—A fresh-water species.

DISTRIBUTION.—Rare in Recent sediments.

Fragilaria construens (Ehrenberg) Grunow, 1862

(Pl. 16, Fig. 20)

DESCRIPTION.—Patrick and Reimer 1966:125, pl. 4, fig. 4.

ECOLOGY.—Oligohalobous, meio- to mesoeuryhaline, benthic? (Pankow 1976).

DISTRIBUTION.—Rare but widespread in Recent and Sangamon sediments.

Fragilaria construens var. *binodis*

(Ehrenberg) Grunow, 1862

(Pl. 16, Fig. 18)

DESCRIPTION.—Patrick and Reimer 1966:125, pl. 4, fig. 7.

ECOLOGY.—Same as species.

DISTRIBUTION.—Same as species.

Fragilaria construens var. *pumila* Grunow, 1881

(Pl. 16, Fig. 22)

DESCRIPTION.—Patrick and Reimer 1966:126, pl. 4, fig. 5, 6.

ECOLOGY.—Same as species.

DISTRIBUTION.—Frequent in San Pablo and Suisun Bays.

Fragilaria construens var. *venter*

(Ehrenberg) Grunow, 1881

(Pl. 16, Fig. 12)

DESCRIPTION.—Patrick and Reimer 1966:126, pl. 4, fig. 8, 9.

ECOLOGY.—Same as species.

DISTRIBUTION.—Widespread and frequent in Sangamon and Recent sediments.

Fragilaria crotonensis Kitton, 1869

(Pl. 16, Fig. 15)

DESCRIPTION.—Patrick and Reimer 1966:121, pl. 3, fig. 11, 12.

ECOLOGY.—Oligohalobous, meioeuryhaline (Pankow 1976).

DISTRIBUTION.—A single specimen from Sangamon sediments.

Fragilaria lapponica Grunow, 1881

(Pl. 16, Fig. 21)

DESCRIPTION.—Patrick and Reimer 1966:130, pl. 4, fig. 17.

ECOLOGY.—Fresh water, tolerates low salt concentrations (Patrick and Reimer 1966).

DISTRIBUTION.—Rare in Sangamon sediments.

Fragilaria leptostauron (Ehrenberg)

Hustedt, 1931

(Pl. 16, Fig. 24)

DESCRIPTION.—Patrick and Reimer 1966:124, pl. 4, fig. 2.

ECOLOGY.—“Indifferent” oligohalobous, mesoeuryhaline (Pankow 1976).

DISTRIBUTION.—Rare in Sangamon and Recent sediments.

Fragilaria tabulata (Agardh)Lange-Bertalot, 1980*b*

(Pl. 16, Fig. 13)

DESCRIPTION.—Patrick and Reimer 1966:141, pl. 5, fig. 17, 18. Lange-Bertalot 1980*b*, fig. 155–173, 268–278.

ECOLOGY.—Mesohalobous, euryhaline, benthic (Pankow 1976).

DISTRIBUTION.—Frequent and widely distributed in Sangamon and Recent sediment.

REMARKS.—Patrick and Reimer (1966:141) indicate that the correct epithet for this taxon is *fasciculata* (*Synedra fasciculata*). Lange-Bertalot (1980*b*:749) noted this priority, but maintained the epithet *tabulata* because of its widespread usage in the modern literature.

Fragilaria ulna (Nitzsch) Lange-Bertalot, 1980b
(Pl. 16, Fig. 16, 17)

DESCRIPTION.—Patrick and Reimer 1966:148, pl. 7, fig. 1, 2. Lange-Bertalot 1980b, fig. 174–197, 258–267.

ECOLOGY.—Oligohalobous, mesoeuryhaline (Pankow 1976).

DISTRIBUTION.—Widespread in Sangamon and Recent sediments.

Fragilaria virescens var. *elliptica* Hustedt, 1914
(Pl. 16, Fig. 19)

DESCRIPTION.—Hustedt 1931:163, fig. 672a, c.

ECOLOGY.—Fresh water (Hustedt 1931).

DISTRIBUTION.—A single specimen from San Pablo Bay.

Frustulia Rabenborst, 1853

Frustulia asymmetrica (Cl.) Hustedt, 1954
(Pl. 19, Fig. 13)

DESCRIPTION.—Patrick and Reimer 1966:305, pl. 22, fig. 4.

ECOLOGY.—Mesohalobous (Patrick and Reimer 1966).

DISTRIBUTION.—Intertidal mud-flat and salt-marsh sediments of present bay.

Frustulia interposita (Lewis) Cleve, 1894b
(Pl. 19, Fig. 14)

DESCRIPTION.—Patrick and Reimer 1966:305, pl. 22, fig. 5.

ECOLOGY.—Fresh water (Patrick and Reimer 1966).

DISTRIBUTION.—A single specimen from Sangamon sediments.

Gomphoneis Cleve, 1894

Gomphoneis erienne (Grunow) Skvortzow and Meyer, 1928
(Pl. 29, Fig. 11)

DESCRIPTION.—Patrick and Reimer 1975:148, pl. 20, fig. 3.

ECOLOGY.—A cool, fresh-water species.

DISTRIBUTION.—A single specimen from Sangamon sediments.

Gomphoneis herculeana (Ehrenberg) Cleve, 1894
(Pl. 29, Fig. 12)

DESCRIPTION.—Patrick and Reimer 1975:149, pl. 21, fig. 1.

ECOLOGY.—Prefers fresh, cool water (Patrick and Reimer 1975).

DISTRIBUTION.—Rare in Sangamon and Recent sediment, most abundant in Suisun Bay sediments.

Gomphonema Ehrenberg, 1832
nom. cons. non Agardh

Gomphonema affine Kutzing, 1844
(Pl. 29, Fig. 10)

DESCRIPTION.—Patrick and Reimer 1975:133, pl. 17, fig. 5.

ECOLOGY.—Fresh water.

DISTRIBUTION.—Rare in Sangamon and Recent sediments.

Gomphonema angustatum var. *sarcophagus*
(Gregory) Grunow, 1880
(Pl. 29, Fig. 5, 6)

DESCRIPTION.—Patrick and Reimer 1975:128, pl. 17, fig. 23.

ECOLOGY.—In fresh, mesotrophic water (Patrick and Reimer 1966).

DISTRIBUTION.—Rare in Recent sediments from San Pablo Bay.

REMARKS.—Patrick and Reimer (1975) give measurements of 7–11 striae in 10 μ m. The specimen figured here has 6 striae in 10 μ m.

Gomphonema apicatum Ehrenberg, 1854
(No illustration)

DESCRIPTION.—Patrick and Reimer 1975:110, pl. 15, fig. 1.

ECOLOGY.—Poorly known.

DISTRIBUTION.—A single specimen from Sangamon sediment.

Gomphonema gracile (Ehrenberg)
emend. Van Heurck, 1885
(Pl. 29, Fig. 4)

DESCRIPTION.—Patrick and Reimer 1975:131, pl. 17, fig. 1–3.

ECOLOGY.—“Indifferent” oligohalobous, benthic and planktonic (Patrick and Reimer 1975).

DISTRIBUTION.—Rare in Sangamon sediment.

Gomphonema grovei Schmidt, 1899
(Pl. 29, Fig. 3)

DESCRIPTION.—Patrick and Reimer 1975:142, pl. 18, fig. 24a, b.

ECOLOGY.—Oligohalobous (Patrick and Reimer 1975).

DISTRIBUTION.—Rare in Sangamon and Recent sediments.

Gomphonema parvulum (Kutzing) Kutzing, 1849
(Pl. 29, Fig. 7)

DESCRIPTION.—Patrick and Reimer 1975:122, pl. 17, fig. 7–12.

ECOLOGY.—Fresh water.

DISTRIBUTION.—A single specimen from Recent sediment in San Pablo Bay.

Gomphonema rhombicum Fricke, 1904
(Pl. 29, Fig. 8)

DESCRIPTION.—Carter 1970:616, pl. 4, fig. 6.

ECOLOGY.—Fresh water, benthic.

DISTRIBUTION.—A single specimen from Recent sediment.

Gomphonema septum Moghadam, 1969
(Pl. 29, Fig. 9)

DESCRIPTION.—Patrick and Reimer 1975:136, pl. 19, fig. 1.

ECOLOGY.—Cool, circumneutral fresh water (Patrick and Reimer 1975).

DISTRIBUTION.—A single specimen from the Yerba Buena mud.

Gomphonema ventricosum Gregory, 1856

(Pl. 29, Fig. 1, 2)

DESCRIPTION.—Patrick and Reimer 1975:137, pl. 19, fig. 2.

ECOLOGY.—Cool, fresh water (Patrick and Reimer 1975).

DISTRIBUTION.—Rare in Sangamon sediment.

Grammatophora Ehrenberg, 1840

Grammatophora marina (Lyngbye)

Kutzing, 1844

(Pl. 15, Fig. 14, 17, 18)

DESCRIPTION.—Hendey 1964:170. Hustedt 1931:43, fig. 569, 570.

ECOLOGY.—Polyhalobous, meso- to meioeuryhaline, benthic (Pankow 1976).

DISTRIBUTION.—Widespread but not abundant in Sangamon and Recent sediments; common in a few samples from Yerba Buena mud.

Gyrosigma Hassall, 1845

Gyrosigma acuminatum (Kutzing)

Rabenhorst, 1853

(Pl. 20, Fig. 3, 4)

DESCRIPTION.—Patrick and Reimer 1966:314, pl. 23, fig. 1–3.

ECOLOGY.—“Indifferent” oligohalobous, mesoeuryhaline, in inland salt waters (Pankow 1976); can withstand slightly salty waters.

DISTRIBUTION.—Common in intertidal salt-marsh and mud-flat samples near stream mouth.

REMARKS.—These specimens show the dimensions and shape of *G. acuminatum* but have a pattern of striae similar to *G. attenuatum*.

Gyrosigma balticum (Ehrenberg)

Rabenhorst, 1853

(Pl. 20, Fig. 5)

DESCRIPTION.—Patrick and Reimer 1966:324, pl. 25, fig. 1.

ECOLOGY.—Mesohalobous, euryhaline benthic (Pankow 1976); a marine littoral species often in brackish, estuarine waters (Hendey 1964).

DISTRIBUTION.—Frequent and widespread in Sangamon and Recent sediments; most abundant on intertidal mud flats and salt marshes in present bay.

Gyrosigma exile (Grunow) Reimer

in Patrick and Reimer, 1966

(Pl. 19, Fig. 12; Pl. 20, Fig. 1)

DESCRIPTION.—Patrick and Reimer 1966:322, pl. 24, fig. 4.

ECOLOGY.—Fresh to slightly brackish water, “indifferent” oligohalobous (Patrick and Reimer 1966).

DISTRIBUTION.—Intertidal mud flats and marshes in present bay.

Gyrosigma eximium (Thwaites) Boyer, 1927

(Pl. 19, Fig. 10, 11)

DESCRIPTION.—Patrick and Reimer 1966:317, pl. 23, fig. 6.

ECOLOGY.—Characteristic of brackish water, but also in fresh water (Patrick and Reimer 1966).

DISTRIBUTION.—Intertidal mud flats and marshes in present bay.

Gyrosigma fasciola (Ehrenberg)

Griffith and Henfrey, 1856

(Pl. 20, Fig. 2)

DESCRIPTION.—Patrick and Reimer 1966:328, pl. 26, fig. 4.

ECOLOGY.—Mesohalobous, benthic (Pankow 1976); brackish to marine salinities 1–20‰ (Patrick and Reimer 1966).

DISTRIBUTION.—Common and widespread in Recent sediment from central and southern San Francisco Bay.

Hantzschia Grunow

in Cleve and Grunow, 1880

Hantzschia amphioxys (Ehrenberg)

Grunow, 1880

(Pl. 31, Fig. 3)

DESCRIPTION.—Hustedt 1930b:394, fig. 747–750. Cleve-Euler 1952:46, fig. 1419–1421.

ECOLOGY.—In fresh to slightly brackish water, aerophilic (Cleve-Euler 1952).

DISTRIBUTION.—Rare but widespread in Sangamon and Recent sediment.

Hyalodiscus Ehrenberg, 1845

Hyalodiscus scoticus (Kutzing) Grunow, 1879

(Pl. 12, Fig. 10, 11)

DESCRIPTION.—Hendey 1964:90. Hustedt 1928:293, fig. 133.

ECOLOGY.—Mesohalobous (Pankow 1976).

DISTRIBUTION.—Rare in Sangamon and Recent sediment.

Hydrosera Wallich, 1858

Hydrosera triquetra Wallich, 1858

(Pl. 14, Fig. 3)

DESCRIPTION.—Frenguelli 1953:73–75, pl. 3, fig. 4.

ECOLOGY.—A brackish-water species from Recent sediments.

DISTRIBUTION.—A single specimen from Recent sediments.

Isthmia Agardh, 1832

Isthmia nervosa Kutzing, 1844

(Pl. 14, Fig. 4)

DESCRIPTION.—Hustedt 1930a:865, fig. 515.

ECOLOGY.—A littoral, marine species; epiphytic (Hustedt 1930b).

DISTRIBUTION.—Rare in Sangamon and Recent sediments.

REMARKS.—This large species is common along the northern California coast. Sloan (1981) reported abundant *I. nervosa* in some samples from the Yerba Buena mud. That data was taken from sieved samples and is difficult to compare with the occurrence found in whole sample mounts.

Mastogloia Thwaites in Smith, 1856

***Mastogloia exigua* Lewis, 1862**

(Pl. 19, Fig. 8, 9)

DESCRIPTION.—Hustedt 1933:569, fig. 1003.

ECOLOGY.—Mesohalobous; widespread in coastal waters (Pankow 1976).

DISTRIBUTION.—Intertidal mud flat and marshes of present bay.

Melosira Agardh, 1824

***Melosira arenaria* Moore, 1843**

(Pl. 2, Fig. 1)

DESCRIPTION.—Hustedt 1927:269, fig. 114.

ECOLOGY.—A littoral marine species (Hustedt 1927).

DISTRIBUTION.—A single specimen from Sangamon sediment.

***Melosira moniliformis* (O. F. Muller) Agardh, 1824**

(Pl. 1, Fig. 1-6)

DESCRIPTION.—Crawford 1977:277-285.

ECOLOGY.—Polyhalobous, pleioeuryhaline, benthic, and planktonic (Pankow 1976).

DISTRIBUTION.—Widely distributed in Sangamon and Recent sediments, abundant in samples from Albany mud flats.

***Melosira nummuloides* (Dillw.) Agardh, 1824**

(Pl. 1, Fig. 7)

DESCRIPTION.—Crawford 1975:323-338.

ECOLOGY.—Mesohalobous (Pankow 1976).

DISTRIBUTION.—Widespread in Recent sediment, abundant in Albany mud flats.

Meridion Agardh, 1824

***Meridion circulare* var. *constrictum* (Ralfs) Van Heurck, 1885**

(Pl. 16, Fig. 4)

DESCRIPTION.—Patrick and Reimer 1966:114, pl. 2, fig. 16.

ECOLOGY.—Fresh to slightly brackish water.

DISTRIBUTION.—A single specimen from the Yerba Buena mud.

Navicula Bory, 1824

***Navicula abunda* Hustedt, 1955**

(Pl. 23, Fig. 13)

DESCRIPTION.—Hustedt 1955:27, pl. 9, fig. 10-12.

ECOLOGY.—Marine to brackish water? (Hustedt 1955).

DISTRIBUTION.—A single specimen in Recent sediments from Albany mud flats.

***Navicula auriculata* Hustedt, 1944**

(Pl. 25, Fig. 7)

DESCRIPTION.—Patrick and Reimer 1966:441, pl. 39, fig. 1.

ECOLOGY.—Poorly known.

DISTRIBUTION.—Recent intertidal mud-flat and salt-marsh sediments, not common.

***Navicula aurora* Sovereign, 1958**

(Pl. 23, Fig. 10)

DESCRIPTION.—Patrick and Reimer 1966:532, pl. 51, fig. 3, 4.

ECOLOGY.—Fresh water.

DISTRIBUTION.—A single specimen from the Yerba Buena mud.

***Navicula circumtexta* Meister in Hustedt, 1934**

(Pl. 23, Fig. 7, 8)

DESCRIPTION.—Patrick and Reimer 1966:442, pl. 39, fig. 3.

ECOLOGY.—Prefers fresh, hard water (Patrick and Reimer 1966).

DISTRIBUTION.—Frequent in Recent sediments from Albany mud flats and salt marsh; epiphytic on microalgae.

***Navicula cryptocephala* Kutzing, 1844**

(Pl. 23, Fig. 9)

DESCRIPTION.—Patrick and Reimer 1966:503, pl. 48, fig. 3.

ECOLOGY.—Fresh to slightly brackish water; oligohalobous "indifferent," pleio- or more likely holoeuryhaline (Pankow 1976).

DISTRIBUTION.—Common only in intertidal mud flats and marsh sediments of present bay, Albany mud flats.

REMARKS.—This assignment is somewhat doubtful. The shape, dimensions, and striae of these specimens agree well with published descriptions of *N. cryptocephala*, but the central area of these specimens is indistinct and uncharacteristic of *N. cryptocephala*.

***Navicula cuspidata* (Kutzing) Kutzing, 1844**

(Pl. 23, Fig. 11, 12)

DESCRIPTION.—Patrick and Reimer 1966:464, pl. 43, fig. 9, 10.

ECOLOGY.—"Indifferent," oligohalobous (Pankow 1976).

DISTRIBUTION.—Rare in Recent sediments.

Navicula digito-radiata (Gregory) Ralfs
in Pritchard, 1861

(Pl. 23, Fig. 16)

DESCRIPTION.—Hendey 1964:202, pl. 29, fig. 8, 9.

ECOLOGY.—Mesohalobous (Pankow 1976), common on muddy shores (Hendey 1964).

DISTRIBUTION.—Frequent in Recent sediments from intertidal mud flats and marshes.

Navicula distans (Smith) Ralfs
in Pritchard, 1861

(Pl. 23, Fig. 17)

DESCRIPTION.—Hendey 1964:203, pl. 27, fig. 13.

ECOLOGY.—Marine to brackish water, benthic (Hendey 1964).

DISTRIBUTION.—Rare, but widespread in Sangamon and Recent sediments.

Navicula elegans Smith, 1853

(No illustration)

DESCRIPTION.—Patrick and Reimer 1966:540, pl. 52, fig. 8, 9.

ECOLOGY.—Fresh to brackish water, benthic.

DISTRIBUTION.—Intertidal mud flats and salt marshes of present bay.

Navicula elginensis (Gregory) Ralfs
in Pritchard, 1861

(Pl. 24, Fig. 3)

DESCRIPTION.—Patrick and Reimer 1966:524, pl. 50, fig. 3.

ECOLOGY.—Fresh to slightly brackish water; oligohalobous "indifferent," mesoeuryhaline, benthic (Pankow 1976).

DISTRIBUTION.—Rare in Recent sediments from San Pablo Bay.

Navicula expansa Hagelstein, 1939

(Pl. 25, Fig. 2)

DESCRIPTION.—Patrick and Reimer 1966:459, pl. 43, fig. 1–3.

ECOLOGY.—Brackish water; common in tropical swamps (Hendey 1964).

DISTRIBUTION.—A single specimen from the Recent sediments of Albany mud flats.

Navicula granulata Bailey, 1853

(Pl. 24, Fig. 2)

DESCRIPTION.—Hendey 1964:208, pl. 31, fig. 6

ECOLOGY.—Polyhalobous, meioeuryhaline, littoral, benthic (Pankow 1976).

DISTRIBUTION.—Rare in Sangamon and Recent sediments.

REMARKS.—Despite the work of Hendey (1953), much disagreement still remains as to the status of *N. granulata* Bailey, *N. brasiliensis* Grunow, *N. marina* Ralfs, and *N. punctulata* Smith (compare Hendey 1951, 1953, 1958, 1964, 1970; Hustedt 1955, 1961; and Patrick and Rei-

mer 1966). Most workers agree that these species are closely related and in some cases synonymous. It appears from inspection of the literature that each species has a restricted geographical and ecological distribution (see Hendey 1970). The "species" may represent geographical and ecological variants of a single taxon. Culture studies might shed light on this problem. I distinguish the various morphs as separate species to be consistent with previous work, although some intergradation is apparent (see *N. punctulata*).

Navicula gregaria Donkin, 1861

(Pl. 24, Fig. 4, 5, 9–11)

DESCRIPTION.—Patrick and Reimer 1966:467, pl. 44, fig. 6.

ECOLOGY.—Mesohalobous, benthic, "prefers brackish water and fresh water with high mineral content." (Patrick and Reimer 1966:468).

DISTRIBUTION.—Intertidal salt-marsh sediments of present bay, Albany mud flats.

Navicula humii Hustedt, 1955

(Pl. 24, Fig. 12)

DESCRIPTION.—Hustedt 1955:23, pl. 8, fig. 8–10, 24.

ECOLOGY.—Poorly known, previously only reported from the type area.

DISTRIBUTION.—A single specimen from Sangamon sediment.

Navicula mutica Kutzing, 1844

(Pl. 24, Fig. 13, 14)

DESCRIPTION.—Patrick and Reimer 1966:454, pl. 42, fig. 2.

ECOLOGY.—Oligohalobous "indifferent," meso- to pleioeuryhaline, benthic (Pankow 1976).

DISTRIBUTION.—Rare but widespread in Sangamon and Recent sediments.

Navicula peregrina (Ehrenberg) Kutzing, 1844

(Pl. 24, Fig. 19, 20)

DESCRIPTION.—Patrick and Reimer 1966:533, pl. 51, fig. 5. Hendey 1964:201, pl. 30, fig. 12, 13.

ECOLOGY.—Prefers brackish water; mesohalobous, euryhaline, benthic (Pankow 1976).

DISTRIBUTION.—Common in sediments from Recent intertidal mud flats and salt marshes.

Navicula pseudolanceolata Lange-Bertalot, 1980a

(Pl. 25, Fig. 6)

DESCRIPTION.—Lange-Bertalot 1980a:32, pl. 2, fig. 1–8.

ECOLOGY.—Probably mesohalobous, widely distributed.

DISTRIBUTION.—Rare in Recent and Sangamon sediments.

REMARKS.—Lange-Bertalot (1980a) recently revised the "*Navicula lineolatae*" Cl. which includes *N. lanceolata*, *N. trivialis*, *N. pseudolan-*

ceolata, and several other species. The subtle distinctions between the species are difficult to evaluate without comparative material. The specimens from San Francisco Bay best fit the description of *N. pseudolanceolata*, but this assignment is questionable.

Navicula punctulata Smith, 1853

(Pl. 24, Fig. 1)

DESCRIPTION.—Patrick and Reimer 1966:499, pl. 41, fig. 1.

ECOLOGY.—Polyhalobous, meioeuryhaline, benthic (Pankow 1976 for *N. marina*); a brackish-water species (Patrick and Reimer 1966).

DISTRIBUTION.—Rare in Sangamon sediments.

REMARKS.—Patrick and Reimer (1966) synonymized *N. marina* Ralfs (1861) with *N. punctulata* based on their morphological similarity and the priority of Wm. Smith's epithet. In contrast, Hustedt (1966) and Hendey (1964) took *N. marina* Ralfs (1861) as the correct epithet and synonymized *punctulata*. The two taxa are apparently conspecific and *punctulata* is the valid epithet based on the rules of priority.

Navicula pusilla Smith, 1853

(Pl. 24, Fig. 16)

DESCRIPTION.—Patrick and Reimer 1966:452, pl. 41, fig. 7.

ECOLOGY.—Fresh to slightly brackish water; oligohalobous "indifferent," mesoeuryhaline, benthic (Pankow 1976).

DISTRIBUTION.—A single specimen in Sangamon sediment.

Navicula pusilla var. 1

(Pl. 24, Fig. 15, 17)

DESCRIPTION.—This taxon is similar to the nominate variety in all respects except size. These specimens are consistently 14–17 μm long and 5–7 μm wide, substantially smaller than the nominate variety according to Patrick and Reimer (1966:452).

ECOLOGY.—Unknown.

DISTRIBUTION.—Frequent in sediments from Albany mud-flat samples.

Navicula pygmaea Kützing, 1849

(Pl. 24, Fig. 18; Pl. 25, Fig. 3, 4)

DESCRIPTION.—Patrick and Reimer 1966:442, pl. 39, fig. 4.

ECOLOGY.—Mesohalobous, benthic (Pankow 1976).

DISTRIBUTION.—Frequent in sediments from intertidal mud flats and salt marshes of present bay.

Navicula reichardtii var. *tschuktschorum*
Cleve, 1895

(Pl. 25, Fig. 12)

DESCRIPTION.—Cleve (1895).

ECOLOGY.—Unknown, probably brackish water.

DISTRIBUTION.—Intertidal mud flats of present bay.

REMARKS.—Hustedt (1964:367) states that he doubts that this taxon belongs in *N. reichardtii*. Using the figures of Cleve (1895) he was unable to make a positive decision, but he indicated that the taxon may be a small species of *Diploneis*. For that reason Cleve's name is conserved in this study until further examination indicates otherwise. Van Landingham (1971) also places this taxon in *Diploneis*.

Navicula salinarum Grunow, 1880

(Pl. 24, Fig. 6–8)

DESCRIPTION.—Patrick and Reimer 1966:502, pl. 48, fig. 1. Hustedt 1930b:295, fig. 498.

ECOLOGY.—Brackish water, benthic, littoral (Patrick and Reimer 1966).

DISTRIBUTION.—Common in intertidal salt-marsh and mud-flat sediments of present bay.

Navicula scopulorum Brébisson in Kützing, 1849

(Pl. 25, Fig. 11)

DESCRIPTION.—Hendey 1964:193, pl. 30, fig. 6; pl. 41, fig. 1. Hustedt 1961:25, fig. 1186.

ECOLOGY.—Polyhalobous, meioeuryhaline, benthic (Pankow 1976).

DISTRIBUTION.—Rare, but widely distributed in Recent sediment from central and southern San Francisco Bay.

Navicula secreta var. *apiculata* Patrick, 1959

(Pl. 25, Fig. 10)

DESCRIPTION.—Patrick 1959:107, pl. 8, fig. 6.

ECOLOGY.—Fresh water, probably to slightly brackish, benthic.

DISTRIBUTION.—Two specimens from intertidal salt-marsh sediments.

Navicula spicula (Hickie) Cleve, 1894

(Pl. 25, Fig. 13)

DESCRIPTION.—Patrick and Reimer 1966:469, pl. 44, fig. 9.

ECOLOGY.—Marine to brackish water (Patrick and Reimer 1966).

DISTRIBUTION.—A single specimen from Recent sediment.

Navicula subforcipata Hustedt, 1964

(Pl. 25, Fig. 5)

DESCRIPTION.—Hustedt 1964:533, fig. 1569.

ECOLOGY.—Coastal marine, benthic (Hustedt 1966).

DISTRIBUTION.—Rare in Recent sediments from central San Francisco Bay.

Navicula tripunctata (O. F. Müller) Bory, 1824

(Pl. 25, Fig. 15–18)

DESCRIPTION.—Patrick and Reimer 1966:513, pl. 49, fig. 3, 4.

ECOLOGY.—Fresh to slightly brackish water (Patrick and Reimer 1966).

DISTRIBUTION.—Frequent in intertidal mud-flat sediments from the Albany mud flats and south of the Dumbarton Bridge; most abundant in a sample scraped off of a cobble from a stream bed in the mud flats. The sample was collected at low tide with fresh water flowing through the stream. At high tide the area is covered with brackish water reaching salinities 25‰.

Nitzschia Hassall, 1845

Nitzschia acuminata (Smith) Grunow, 1880

(Pl. 31, Fig. 7, 8)

DESCRIPTION.—Hendey 1964:280, pl. 39, fig. 10.

ECOLOGY.—Polyhalobous, meioeuryhaline, benthic (Pankow 1976); brackish water.

DISTRIBUTION.—Common and widespread in Sangamon and Recent sediments.

Nitzschia angularis Smith, 1853

(Pl. 33, Fig. 10)

DESCRIPTION.—Hendey 1964:281, pl. 39, fig. 6.

ECOLOGY.—Polyhalobous, meio- to mesoeuryhaline, benthic (Pankow 1976).

DISTRIBUTION.—Frequent in Recent sediment from intertidal mud-flat areas.

Nitzschia circumsuta (Bailey) Grunow, 1880

(Pl. 31, Fig. 9)

DESCRIPTION.—Hendey 1964:280, pl. 44, fig. 1.

ECOLOGY.—Mesohalobous, euryhaline, benthic (Pankow 1976).

DISTRIBUTION.—Rare in Sangamon and Recent sediments.

Nitzschia closterium (Ehrenberg) Smith, 1853

(Pl. 33, Fig. 11)

DESCRIPTION.—Hendey 1964:283, pl. 21, fig. 8.

ECOLOGY.—Neritic plankton; marine to brackish water (Hendey 1964).

DISTRIBUTION.—Rare in Sangamon and Recent sediments.

Nitzschia dissipata (Kutzing) Grunow, 1880

(Pl. 32, Fig. 11)

DESCRIPTION.—Hustedt 1930b:412, fig. 789.

ECOLOGY.—Oligohalobous "indifferent," mesoeuryhaline (Pankow 1976).

DISTRIBUTION.—A single specimen from Yerba Buena mud.

Nitzschia fasciculata Grunow in Van Heurck, 1880–1885

(Pl. 33, Fig. 14, 15)

DESCRIPTION.—Hustedt 1930b:421, fig. 815.

ECOLOGY.—Marine to brackish water, littoral, benthic (Hustedt 1930b).

DISTRIBUTION.—Frequent from intertidal mud-flat and salt-marsh samples, Recent sediments, Albany mud flats.

Nitzschia frustulum (Kutzing) Grunow, 1880

(Pl. 33, Fig. 1)

DESCRIPTION.—Lange-Bertalot and Simonsen 1978:23, fig. 1–39, 292, 293.

ECOLOGY.—An estuarine, brackish-water species.

DISTRIBUTION.—Rare, but widespread in Sangamon and Recent sediments.

Nitzschia gandersheimiensis Krasske, 1927

(Pl. 33, Fig. 2–4)

DESCRIPTION.—Lange-Bertalot and Simonsen 1978:28, fig. 40–53, 60–112, 289.

ECOLOGY.—Fresh to brackish water, seems to be typical of waters affected by industrial wastewater.

DISTRIBUTION.—Intertidal mud flats of present bay, common on Albany mud flats.

Nitzschia granulata Grunow, 1880

(Pl. 32, Fig. 2)

DESCRIPTION.—Hendey 1964:278. Schrader 1973, pl. 25, fig. 22.

ECOLOGY.—Marine to brackish, benthic, possibly epiphytic.

DISTRIBUTION.—Common and widely distributed in Sangamon and Recent sediments.

Nitzschia granulata var. 1

(Pl. 32, Fig. 3–5)

DESCRIPTION.—Valve elliptic to elliptic-lanceolate. Both margins furnished with short double rows of small punctae, one or two coarse punctae present at the end of each row. Axial area broad, lanceolate and hyaline, rarely interrupted by a few coarse punctae. Length, width, and striae as in nominate variety.

DISTRIBUTION.—Abundant in Sangamon and Recent sediments. Commonly in association with the nominate variety.

REMARKS.—This variety is distinguished from the nominate variety by the hyaline axial area. It is easily distinguished from *Nitzschia navicularis* by smaller size, coarser punctae, and the absence of an axial fold. In *Nitzschia navicularis*, both margins cannot be focused at the same time, whereas in this variety it is possible (see Pl. 32, Fig. 3–5 versus Fig. 1).

Nitzschia hummii Hustedt, 1955

(Pl. 33, Fig. 13)

DESCRIPTION.—Hustedt 1955:47, pl. 15, fig. 6.

ECOLOGY.—Brackish water, epipelagic (Hustedt 1955).

DISTRIBUTION.—A single specimen from the Yerba Buena mud.

REMARKS.—The reticulate pattern of striae on this species is very distinctive. However, this identification is quite doubtful because it is based on a single fragmentary specimen.

Nitzschia levidensis (Smith)

Van Heurck, 1880–1885

(Pl. 31, Fig. 10)

DESCRIPTION.—Hendey 1964:277, pl. 44, fig. 4.

ECOLOGY.—Brackish water, benthic (Hendey 1964).

DISTRIBUTION.—Rare in Recent sediments.

Nitzschia longa Grunow, 1880

(Pl. 33, Fig. 9)

DESCRIPTION.—Hustedt 1955:46, pl. 16, fig. 1.

ECOLOGY.—Brackish water? (Hustedt 1955).

DISTRIBUTION.—A single specimen from Recent sediments.

Nitzschia navicularis (Brébisson) Grunow, 1880

(Pl. 32, Fig. 1)

DESCRIPTION.—Hendey 1964:276, pl. 39, fig. 3–5.

ECOLOGY.—A brackish-water species, benthic (Hendey 1964).

DISTRIBUTION.—Rare in Recent sediment.

Nitzschia obtusa var. *scalpeliformis*
Grunow, 1878

(Pl. 33, Fig. 6)

DESCRIPTION.—Hustedt 1930b:422, fig. 817d.

ECOLOGY.—Marine to brackish water, littoral, benthic.

DISTRIBUTION.—Frequent in Recent sediment from intertidal mud flats, Albany mud flats.

Nitzschia panduriformis Gregory, 1857

(Pl. 32, Fig. 7)

DESCRIPTION.—Hendey 1964:279, Miller 1964:50, pl. 6, fig. 7.

ECOLOGY.—Polyhalobous, mesoeuryhaline, benthic (Pankow 1976).

DISTRIBUTION.—Sangamon and Recent sediment, most abundant from intertidal mud flats of present bay.

Nitzschia plana Smith, 1853

(Pl. 32, Fig. 12)

DESCRIPTION.—Hendey 1964:278, pl. 39, fig. 7.

ECOLOGY.—Brackish water, benthic.

DISTRIBUTION.—Rare in Recent sediment.

Nitzschia pseudohybrida Hustedt, 1955

(Pl. 32, Fig. 9, 10)

DESCRIPTION.—Hustedt 1955:45, pl. 15, fig. 3, 4.

ECOLOGY.—Benthic, probably brackish water.

DISTRIBUTION.—Frequent in intertidal mud flats of present southern San Francisco Bay.

Nitzschia punctata (Smith) Grunow, 1880

(Pl. 31, Fig. 11–14)

DESCRIPTION.—Hendey 1964:278, pl. 39, fig. 11, Giffen 1970a:292, fig. 80, Cleve-Euler 1952:56, 57, fig. 1429.

ECOLOGY.—Polyhalobous, mesoeuryhaline, benthic (Pankow 1976).

DISTRIBUTION.—Common and widespread in Sangamon and Recent sediment.

REMARKS.—This is one of the most common species of *Nitzschia* in the Sangamon and Recent flora. The specimens from San Francisco Bay show a wide range of sizes and shapes but seem clearly to belong to this species.*Nitzschia punctata* var. *coarcta* (Grunow)
Hustedt, 1921

(Pl. 32, Fig. 6)

DESCRIPTION.—Hendey 1964:278, Hasegawa 1975, pl. 10, fig. 8.

ECOLOGY.—Polyhalobous, meioeuryhaline, benthic (Pankow 1976).

DISTRIBUTION.—Sangamon and Recent sediment, rare.

Nitzschia pusilla (Kutzing) Grunow, 1880

(Pl. 32, Fig. 13–15)

DESCRIPTION.—Lange-Bertalot and Simonsen 1978, pl. 11, fig. 198–202, Lange-Bertalot 1977:273, pl. 7, fig. 1–10.

DISTRIBUTION.—Intertidal mud flats and salt marshes of present bay.

Nitzschia sigma (Kutzing) Smith, 1853

(Pl. 33, Fig. 16–18)

DESCRIPTION.—Hendey 1964:281, pl. 42, fig. 1, Hustedt 1930b:420, fig. 813.

ECOLOGY.—Marine to brackish, mesohalobous, holoeuryhaline (Pankow 1976), benthic.

DISTRIBUTION.—Widespread but not common in Recent and Sangamon sediments.

Nitzschia sigmaformis Hustedt, 1955

(Pl. 33, Fig. 7, 8)

DESCRIPTION.—Hustedt 1955:47, pl. 16, fig. 2, 3.

ECOLOGY.—Brackish water, estuarine, benthic.

DISTRIBUTION.—Frequent in Recent sediment from intertidal mud flats, Albany mud flats.

Nitzschia tryblionella Hantzsch
in Rabenhorst, 1848–1860

(Pl. 31, Fig. 4–6)

DESCRIPTION.—Hendey 1964:276, pl. 44, fig. 2, 3.

ECOLOGY.—Oligohalobous (halophile), pleio- to mesoeuryhaline, benthic (Pankow 1976).

DISTRIBUTION.—Widespread in Sangamon and Recent sediment, most abundant in sediments from intertidal mud flats of present bay.

Nitzschia tryblionella var. *victorae* Grunow, 1863
(No illustration)

DESCRIPTION.—Hustedt 1930b:399, fig. 758.

ECOLOGY.—Same as species.

DISTRIBUTION.—Rare in Recent sediments.

Nitzschia vitrea Norman, 1861

(Pl. 33, Fig. 5)

DESCRIPTION.—Hustedt 1930b:411, fig. 787.

ECOLOGY.—Mesohalobous, euryhaline, benthic (Pankow 1976).

DISTRIBUTION.—Rare in Sangamon and Recent sediments.

REMARKS.—These specimens are questionably assigned to *N. vitrea*. The keel puncta and striae are finer (10–14 in 10 μ m and 30–35 in 10 μ m, respectively) than that which Hustedt (1930b) gives for *N. vitrea* (4–7 in 10 μ m and 17–27 in 10 μ m, respectively). However, such variation in a single species is quite common (see Lange-Bertalot 1977; Lange-Bertalot and Simonsen 1978).

Nitzschia sp. 1

(Pl. 32, Fig. 8)

DESCRIPTION.—Valves elliptic-lanceolate with slightly cuneate apices, 14–16 μ m long, 6 μ m wide. Valve with transverse costae (16–18 in 10 μ m). A longitudinal line runs parallel to the margin, close to the side opposite the keel. A few scattered punctae occur along this margin.

DISTRIBUTION.—Frequent in Recent sediments from Suisun Bay.

Opephora Petit, 1888*Opephora swartzii* (Grunow) Petit
in Pelletan, 1889

(Pl. 16, Fig. 1, 2)

DESCRIPTION.—Patrick and Reimer 1966:116, pl. 3, fig. 1.

ECOLOGY.—Brackish to marine waters, benthic.

DISTRIBUTION.—Rare in Sangamon sediments.

Opephora pacifica (Grunow) Petit, 1888

(Pl. 16, Fig. 3)

DESCRIPTION.—Hustedt 1931:135, fig. 655. Hustedt 1955:13, pl. 4, fig. 47–49.

ECOLOGY.—Marine, littoral species, benthic (Hustedt 1931).

DISTRIBUTION.—Rare in Recent sediments.

Paralia Heiberg, 1863*Paralia sulcata* (Ehrenberg) Cleve, 1873

(Pl. 2, Fig. 5–17)

DESCRIPTION.—Crawford 1979:200–210, fig. 1–33.

ECOLOGY.—Polyhalobous, mesoeuryhaline (Pankow 1976).

DISTRIBUTION.—Abundant and widespread in Sangamon and Recent sediment.

REMARKS.—Two varieties, the nominate and *P. sulcata* var. *coronata* (Ehr.) Andrews, are recognized by many authors. Crawford (1979) has shown that *P. sulcata* (Ehr.) Cleve is heterovalvar with valves assignable to both varieties present

in a single cell. Both varieties occur in the material from San Francisco Bay, but I did not treat them separately. Plate 2, Figures 6 and 11 show opposite valves of a single cell illustrating both varieties and thus supporting Crawford's (1979) findings.

Pinnularia Ehrenberg, 1843*Pinnularia abaujensis* var. *rostrata* (Patrick)
Patrick in Patrick and Reimer, 1966

(Pl. 26, Fig. 7)

DESCRIPTION.—Patrick and Reimer 1966:614, pl. 58, fig. 4.

ECOLOGY.—Fresh water (Patrick and Reimer 1966).

DISTRIBUTION.—A single specimen in Sangamon sediments.

Pinnularia acuminata Smith, 1853

(Pl. 26, Fig. 6)

DESCRIPTION.—Patrick and Reimer 1966:621, pl. 59, fig. 4.

ECOLOGY.—Fresh water (Patrick and Reimer 1966).

DISTRIBUTION.—Rare in Sangamon and Recent sediments.

Pinnularia borealis Ehrenberg, 1843

(Pl. 25, Fig. 14)

DESCRIPTION.—Patrick and Reimer 1966:618, pl. 58, fig. 13.

ECOLOGY.—Fresh water, low mineral-content.

DISTRIBUTION.—Rare in Sangamon and Recent sediments.

Pinnularia borealis var. *brevicostata*
Hustedt, 1914

(Pl. 26, Fig. 2)

DESCRIPTION.—Hustedt 1930b:326, fig. 598.

ECOLOGY.—Same as species.

DISTRIBUTION.—A single specimen in the Yerba Buena mud.

Pinnularia gibba Ehrenberg, 1841

(Pl. 26, Fig. 4, 5)

DESCRIPTION.—Hustedt 1930b:327, fig. 600b.

ECOLOGY.—Fresh water (Hustedt 1930b).

DISTRIBUTION.—Rare in Sangamon and Recent sediments.

Pinnularia microstauron var. *biundulata*
O. Muller, 1893

(Pl. 26, Fig. 8)

DESCRIPTION.—Hustedt 1930b:320, fig. 583.

ECOLOGY.—Fresh water (Hustedt 1930b).

DISTRIBUTION.—A single specimen from the Yerba Buena mud.

Pinnularia subcapitata var. *paucistriata*
(Grunow) Cleve, 1895

(Pl. 26, Fig. 3)

DESCRIPTION.—Patrick and Reimer 1966:597, pl. 55, fig. 11.

ECOLOGY.—Fresh water, low mineral-content.

DISTRIBUTION.—A single specimen from Recent sediment.

Plagiogramma Greville, 1859*Plagiogramma interruptum* (Greville) Ralfs, 1861
(No illustration)

DESCRIPTION.—Hustedt 1931:110, fig. 656.

ECOLOGY.—Marine to brackish, warm water (Hustedt 1931).

DISTRIBUTION.—Rare in Sangamon sediments.

Plagiogramma stauropharum (Gregory)
Heiberg, 1863
(No illustration)

DESCRIPTION.—Hendey 1964:166, pl. 36, fig. 1.

ECOLOGY.—Polyhalobous, meioeuryhaline, benthic (Pankow 1976).

DISTRIBUTION.—A single specimen in the Yerba Buena mud.

Plagiotropis Pfitzer, 1871*Plagiotropis vitrea* (Smith) comb. nov.
(Pl. 27, Fig. 2, 3)DESCRIPTION.—Hendey 1964:255, pl. 36, fig. 3 (as *Tropidoneis vitrea*).

ECOLOGY.—Benthic, marine and brackish water (Hendey 1964).

DISTRIBUTION.—Common in sediments from intertidal mud flats and salt marshes, present bay.

REMARKS.—Patrick and Reimer (1975) point out that Cleve (1891) placed all of *Plagiotropis* Pfitzer (1871), including the type species, in his new genus *Tropidoneis*. Therefore, according to priority and Article 57.1 of the *International Code of Botanical Nomenclature* (1978), *Plagiotropis* is the legal name for this genus. Simonsen (1979: 53) also recognizes *Plagiotropis* as the valid generic designation.

Pleurosigma Smith, 1852*Pleurosigma angulatum* (Quekett) Smith, 1852
(Pl. 20, Fig. 7; Pl. 21, Fig. 8)

DESCRIPTION.—Patrick and Reimer 1966:331, pl. 27, fig. 1a–c.

ECOLOGY.—Polyhalobous, mesoeuryhaline, benthic (Pankow 1976).

DISTRIBUTION.—Rare in intertidal mud-flat sediments, present bay.

Pleurosigma australe Grunow, 1868b
(Pl. 21, Fig. 6, 7)

DESCRIPTION.—Patrick and Reimer 1966:336, pl. 28, fig. 3a–c.

ECOLOGY.—Insufficiently known.

DISTRIBUTION.—Rare in intertidal mud-flat sediments of present bay.

Pleurosigma diverse-striatum Meister, 1935
(Pl. 20, Fig. 6)

DESCRIPTION.—Hendey 1958:58, 1970:152, pl. 6, fig. 62.

ECOLOGY.—Marine to brackish water, littoral, benthic.

DISTRIBUTION.—Frequent and widespread in the Yerba Buena mud, rare in Recent sediment.

Pleurosigma formosum Smith, 1852
(Pl. 21, Fig. 5)

DESCRIPTION.—Hendey 1951:62, pl. 11, fig. 6.

ECOLOGY.—A marine species, favors high salinity (Hendey 1964).

DISTRIBUTION.—A single specimen from Recent sediment.

Pleurosigma normanii Ralfs in Pritchard, 1861
(Pl. 20, Fig. 11, 12)

DESCRIPTION.—Hendey 1964:244. Cleve-Euler 1952:22, fig. 1371, pl. F, fig. f.

ECOLOGY.—Polyhalobous, meioeuryhaline, benthic (Pankow 1976).

DISTRIBUTION.—Common in the Yerba Buena mud, present in Recent sediments.

REMARKS.—Transverse striae on specimens from the Yerba Buena mud range from 21–25 in 10 μm , somewhat finer than is typical (19–21 in 10 μm).

Pleurosigma strigosum Smith, 1852
(Pl. 21, Fig. 1–4)

DESCRIPTION.—Patrick and Reimer 1966:335, pl. 28, fig. 2a–c. Cleve-Euler 1952:22, fig. 1369.

ECOLOGY.—Polyhalobous, meioeuryhaline, benthic (Pankow 1976).

DISTRIBUTION.—Common in intertidal mud-flat and salt-marsh samples of present bay.

Pleurosigma sp. 1
(Pl. 20, Fig. 8, 9)

DESCRIPTION.—Valves linear to linear-lanceolate, sigmoid with subacute apices. Margins parallel in middle half of valve. Raphe strongly sigmoid and eccentric towards the ends. Polar and central nodules small. Central nodule ovoid. Axial area narrow to absent. Valve striate, striae cross at 70–75° angle, transverse striae 16–18 in 10 μm . Length 220–250 μm , breadth 26–27 μm .

DISTRIBUTION.—Recent intertidal mud-flat sediments.

REMARKS.—This species superficially resembles *P. formosum* Smith and may represent small specimens of that species. *Pleurosigma formosum* is typically longer than 300 μm (Hendey 1951, 1964), whereas these specimens are less than 300 μm long. In addition, the striae are somewhat finer (16–18 in 10 μm) on this species than on *P. formosum* (14–16 in 10 μm), and the

angle between oblique striae is 70–75° versus 90° in *P. formosum*.

Pleurosigma sp. 2

(Pl. 20, Fig. 10)

DESCRIPTION.—Valve slightly sigmoid, linear-lanceolate with subacute apices. Valve surface slightly arched at ends. Raphe sigmoid, slightly eccentric at ends. Axial area narrow. Central nodule small, ovate. Transverse striae 20–24 in 10 μ m. Length 160–175 μ m, breadth 30–32 μ m.

DISTRIBUTION.—Rare in sediments from intertidal mud flats of present bay, Albany mud flats.

REMARKS.—This species most closely resembles *P. strigosum* Smith, but is more finely striate than that species. Otherwise, it is quite similar to smaller specimens of *P. strigosum*.

Pseudoeunotia Grunow, 1880

Pseudoeunotia doliolus (Wallich) Grunow
in Van Heurck, 1880

(Pl. 31, Fig. 1)

DESCRIPTION.—Schrader 1973:708, pl. 4, fig. 1–8. Hustedt 1959:258–260.

ECOLOGY.—Marine, oceanic, planktonic.

DISTRIBUTION.—Rare in Recent sediments.

Rhabdonema Kutzing, 1844

Rhabdonema arcuatum (Agardh) Kutzing, 1844

(Pl. 16, Fig. 5)

DESCRIPTION.—Hustedt 1931:20, fig. 549.

ECOLOGY.—Polyhalobous, meioeuryhaline, epiphytic (Pankow 1976).

DISTRIBUTION.—Rare in Sangamon sediments.

Rhaphoneis Ehrenberg, 1844

Rhaphoneis ampiceros (Ehrenberg)
Ehrenberg, 1844

(Pl. 16, Fig. 6)

DESCRIPTION.—Hendey 1964:154, pl. 26, fig. 1–4.

ECOLOGY.—Marine neritic, benthic (Hendey 1964).

DISTRIBUTION.—Frequent and widespread in the Yerba Buena mud but rare in Recent sediments.

Rhaphoneis margaritalimbata Mertz, 1966

(Pl. 16, Fig. 7)

DESCRIPTION.—Mertz 1966:27, pl. 6, fig. 1–3.

ECOLOGY.—Marine (Mertz 1966; Schrader 1973).

DISTRIBUTION.—Rare, but widespread in Sangamon and Recent sediment.

Rhaphoneis surirella (Ehrenberg) Grunow
in Van Heurck, 1880

(Pl. 16, Fig. 8)

DESCRIPTION.—Hendey 1964:155, pl. 26, fig. 11–13.

ECOLOGY.—Polyhalobous, meioeuryhaline, benthic (Pankow 1976).

DISTRIBUTION.—Rare in Recent and Sangamon sediments.

Rhizosolenia Brightwell, 1858

Rhizosolenia sp. 1

(Pl. 14, Fig. 9)

This species is rare in Sangamon and Recent sediment and is represented only by isolated apical spines. No effort was made to determine the species.

Rhoicosphenia Grunow, 1860

Rhoicosphenia curvata (Kutzing) Grunow
in Rabenhorst, 1864

(Pl. 19, Fig. 6)

DESCRIPTION.—Patrick and Reimer 1966:282, pl. 20, fig. 1–5.

ECOLOGY.—Oligohalobous, halo- to pleioeuryhaline, benthic (Pankow 1976); fresh to brackish water.

DISTRIBUTION.—Rare but widespread in Sangamon sediments, common in intertidal mud-flat and salt-marsh sediments of present bay.

Rhopalodia O. Muller, 1895

Rhopalodia gibba (Ehrenberg) O. Muller, 1895

(Pl. 30, Fig. 6)

DESCRIPTION.—Patrick and Reimer 1975:189, pl. 28, fig. 1.

ECOLOGY.—Oligohalobous “indifferent,” mesohalobous, benthic (Pankow 1976); epiphytic.

DISTRIBUTION.—Rare, but widespread in Sangamon and Recent sediment.

Rhopalodia gibberula (Ehrenberg)
O. Muller, 1895

(Pl. 30, Fig. 7–10)

DESCRIPTION.—Patrick and Reimer 1975:191, pl. 28, fig. 6.

ECOLOGY.—Oligohalobous (“indifferent” to halophilic), pleioeuryhaline (Pankow 1976).

DISTRIBUTION.—Rare in Recent sediment and Sangamon sediment.

Rhopalodia operculata (Agardh) Hakansson, 1979

(Pl. 30, Fig. 11)

DESCRIPTION.—Hakansson 1979:1, 66, fig. 1–5.

DISTRIBUTION.—Present in Sangamon and Recent sediments.

REMARKS.—Hakansson (1979) synonymized *R. musculus* (Kutzing) O. Muller with *R. operculata* on the basis of priority after examination of Agardh's type material of "*Frustulia operculata*" and "*Cymbella operculata*." Patrick and Reimer (1975:191–192) indicate that *R. gibberula* (Ehrenberg) O. Muller and *R. musculus* (Kutz.) Muller are very similar, closely related, and possibly synonymous. These species are distinguished by shape alone, being identical in all other characters. Pankow (1976) recognizes *R. musculus* as a variety of *R. gibberula*. Apparently, recognition of these species is more than ordinarily subjective and will undoubtedly be subject to equivocation. Therefore, only *R. operculata* is recognized in this study.

Scoliopleura Grunow, 1860

Scoliopleura tumida (Brébisson in Kutzing)
Rabenhorst, 1864

(Pl. 26, Fig. 9)

DESCRIPTION.—Hendey 1964:234, pl. 29, fig. 6, 7.

ECOLOGY.—Brackish-water, euryhaline.

DISTRIBUTION.—Rare in Recent sediments.

Scoliotropis Cleve, 1894

Scoliotropis latestriata (Brébisson in Kutzing)
Cleve, 1894

(Pl. 26, Fig. 12)

DESCRIPTION.—Hendey 1951:64, pl. 11, fig. 3, 4.

ECOLOGY.—Polyhalobous, meioeuryhaline, benthic (Pankow 1976).

DISTRIBUTION.—A single specimen from the Yerba Buena mud.

Skeletonema Greville, 1865

Skeletonema costatum (Greville) Cleve, 1878
(No illustration)

DESCRIPTION.—Hendey 1964:91, pl. 7, fig. 3.

ECOLOGY.—Polyhalobous, pleioeuryhaline (Pankow 1976); arctic, neritic plankton (Hendey 1964).

DISTRIBUTION.—Rare in Recent sediments.

REMARKS.—Although this species is abundant at times in the plankton of San Francisco Bay (Wong and Cloern 1981), it is extremely rare in the sediments. This is probably because its delicate frustule is destroyed by dissolution and bioturbation.

Stauroneis Ehrenberg, 1843

Stauroneis acuta Smith, 1853

(Pl. 22, Fig. 1)

DESCRIPTION.—Patrick and Reimer 1966, pl. 31, fig. 1.

ECOLOGY.—Alkaliphilous, oligohalobous (Patrick and Reimer 1966).

DISTRIBUTION.—Rare in Sangamon and Recent sediment.

Stauroneis amphioxys Gregory, 1856

(Pl. 22, Fig. 2)

DESCRIPTION.—Patrick and Reimer 1966, pl. 30, fig. 7. Hendey 1964:219, pl. 37, fig. 13, 14.

ECOLOGY.—Mesohalobous, euryhaline, benthic (Pankow 1976); euryhaline, brackish to marine (Patrick and Reimer 1966).

DISTRIBUTION.—Common in sediments from intertidal salt marsh and mud flats of present bay, Albany mud flats.

Stauroneis obtusa Lagerstedt, 1873

(Pl. 21, Fig. 9)

DESCRIPTION.—Patrick and Reimer 1966:363, pl. 30, fig. 8, 9.

ECOLOGY.—Oligohalobous ("indifferent" to halophobic), alkaliphilous.

DISTRIBUTION.—A single specimen from the Yerba Buena mud.

REMARKS.—Pseudosepta are not conspicuous on this specimen and may have been removed by breakage or dissolution. The specimen agrees in all other respects with the diagnosis of *S. obtusa*.

Stauroneis smithii var. *incisa* Pantocsek, 1902

(Pl. 21, Fig. 10)

DESCRIPTION.—Patrick and Reimer 1966:366, pl. 30, fig. 13.

ECOLOGY.—Fresh water (Patrick and Reimer 1966).

DISTRIBUTION.—A single specimen from the Yerba Buena mud.

Stephanodiscus Ehrenberg, 1845

Stephanodiscus astrea (Ehrenberg) Grunow, 1880
(Pl. 4, Fig. 9, 10)

DESCRIPTION.—Hustedt 1930b:368, fig. 193. Schrader 1978: 863, pl. 2, fig. 7, 11; pl. 3, fig. 11, 12; pl. 4, fig. 22, 23; pl. 13, fig. 2, 8.

ECOLOGY.—Planktonic; oligohalobous, meioeuryhaline (Pankow 1976); marine to brackish water (Hendey 1964:75 as *S. rotula*).

DISTRIBUTION.—Common in Recent sediments from intertidal mud flats of Northern San Francisco, San Pablo, and Suisun bays.

REMARKS.—Hendey (1964) synonymized *S. astrea* with *S. rotula* Kutzing. Pankow (1976)

recognized this synonymy whereas Schrader (1978) did not. According to Hustedt (1928, 1930a), Cholnoky (1968), Pankow (1976), and Schrader (1978), *S. astrea* is a freshwater species common in lakes and streams, but it can tolerate slightly brackish water. Hendey (1964:75) states that *S. rotula* is a "marine to brackish-water species widespread and common on all European coasts, particularly in estuaries and waters of lowered salinity."

Stephanodiscus carconensis Eulenstein
in Grunow, 1878

(Pl. 4, Fig. 1-4)

DESCRIPTION.—Van Landingham 1967:17, pl. 21, fig. 18. Schrader 1978:863, pl. 9, fig. 5, 8, 11-15, 18-23, 27.

ECOLOGY.—Planktonic, fresh water (Schrader 1978).

DISTRIBUTION.—Rare in Sangamon and Recent sediments.

Stephanodiscus lucens Hustedt, 1939

(No illustration)

DESCRIPTION.—Hustedt 1939:583, 584, fig. 4

ECOLOGY.—Probably fresh water.

DISTRIBUTION.—Rare in Recent sediments from Suisun Bay.

Stephanodiscus niagarae Ehrenberg, 1841

(Pl. 4, Fig. 5-8)

DESCRIPTION.—Schrader 1978:863, pl. 5, fig. 1; pl. 6, fig. 5; pl. 7, fig. 10; pl. 8, fig. 1; pl. 16, fig. 1; pl. 17, fig. 1, 2.

ECOLOGY.—Planktonic, fresh water, oligotrophic, moderate temperatures, pH-neutral (Schrader 1978).

DISTRIBUTION.—Widespread but not abundant in Sangamon and Recent sediments.

Stephanogonia Ehrenberg, 1844

Stephanogonia? sp. 1

(No illustration)

This taxon is represented by a single fragmentary specimen from Recent sediments. No diagnosis is attempted based on this specimen, which is questionably assigned to *Stephanogonia*.

Stephanopyxis Ehrenberg, 1844

Stephanopyxis turris (Greville and Arv.) Ralfs
in Pritchard, 1861

(No illustration)

DESCRIPTION.—Hendey 1964:92. Schrader 1973, pl. 15, fig. 1-7.

ECOLOGY.—Polyhalobous, pleioeuryhaline, planktonic (Pankow 1976).

DISTRIBUTION.—Rare in Sangamon sediments.

Stephanopyxis? sp. 1

(Pl. 6, Fig. 5)

DESCRIPTION.—Valve circular, flat, with coarse areolae in linear array, areolae 8 in 10 μm and uniform in size across valve face. Mantle deep with coarse areolae, 8 in 10 μm , only slightly smaller than on valve face. Diameter 26 μm .

DISTRIBUTION.—One specimen from Recent sediments.

REMARKS.—This specimen is similar in size and shape to the lower valves of several dimorphic species of *Stephanopyxis* described by Schrader (1973). However, in contrast to the specimen figured here, the areolae on those species are not uniform in size across the valve face and are arranged in tangential rows.

Surirella Turpin, 1828

Surirella crumena Brébisson in Kutzing, 1849

(Pl. 34, Fig. 6, 7)

DESCRIPTION.—Schmidt 1878-1959, pl. 24, fig. 7-9. Hendey 1964:288, pl. 40, fig. 12. Pankow 1976:316, pl. 21, fig. 4, as *S. ovalis* var. *crumena*.

ECOLOGY.—Oligohalobous (halophilic) (Pankow 1976).

DISTRIBUTION.—Rare in Sangamon sediment.

Surirella fastuosa (Ehrenberg) Kutzing, 1844

(Pl. 34, Fig. 3, 5)

DESCRIPTION.—Hendey 1964:288, pl. 40, fig. 4.

ECOLOGY.—Marine to brackish water, benthic.

DISTRIBUTION.—Recent surface sediment.

Surirella gemma (Ehrenberg) Kutzing, 1844

(Pl. 34, Fig. 8)

DESCRIPTION.—Hendey 1964:288, pl. 40, fig. 5.

ECOLOGY.—Mesohalobous, benthic (Pankow 1976).

DISTRIBUTION.—Rare in Sangamon sediment; frequent and widespread in Recent sediment; most common from intertidal mud flats.

Surirella ovata Kutzing, 1844

(Pl. 34, Fig. 2)

DESCRIPTION.—Hendey 1951:77, pl. 14, fig. 4-7.

ECOLOGY.—Oligohalobous "indifferent", mesoeuryhaline (Pankow 1976); common in brackish waters (Hendey 1964).

DISTRIBUTION.—Rare in Sangamon and Recent sediments.

Surirella peisonis Pantocsek, 1889

(Pl. 34, Fig. 9)

DESCRIPTION.—Hustedt 1930b:441, fig. 862.

ECOLOGY.—Brackish to marine water, benthic (Hustedt 1930b).

DISTRIBUTION.—A single specimen from Recent sediment in Suisun Bay.

REMARKS.—Cleve-Euler (1952) and Pankow

(1976) have synonymized *S. peisonis* with *S. ovalis* var. *pyriformis* (Pantocsek) Cleve-Euler. Hustedt (1930b) indicated that *S. pyriformis* Pantocsek is synonymous with *S. peisonis*. Van Landingham (1978, VII) synonymizes *peisonis* with *S. ovalis* var. *maxima* Grunow.

Surirella recedens Schmidt, 1874

(No illustration)

DESCRIPTION.—Hendey 1970:159, pl. 5, fig. 45. Hustedt 1955: 48, pl. 3, fig. 2.

ECOLOGY.—Marine to brackish water (Hendey 1970).

DISTRIBUTION.—Rare, but widespread in Recent and Sangamon sediments.

Surirella salina Smith, 1851

(No illustration)

DESCRIPTION.—Hendey 1964:287, pl. 40, fig. 11.

ECOLOGY.—A brackish-water species.

DISTRIBUTION.—A single specimen from the Yerba Buena mud.

REMARKS.—This specimen is fragmental and is questionably assigned to *S. salina*. Cleve-Euler (1952) considered this taxon to be a variety of *S. ovalis* Breb.

Surirella striatula Turpin, 1828

(Pl. 34, Fig. 1)

DESCRIPTION.—Hendey 1964:288, pl. 40, fig. 2, 3.

ECOLOGY.—Mesohalobous (Pankow 1976); brackish water, benthic.

DISTRIBUTION.—Widespread in Recent and Sangamon sediment.

Surirella torquata Pantocsek, 1892

(Pl. 34, Fig. 4)

DESCRIPTION.—Pantocsek 1892, pl. 41, fig. 570; 1905:102. Cleve-Euler 1952:124, fig. 1568b.

ECOLOGY.—Benthic, brackish water (Cleve-Euler 1952).

DISTRIBUTION.—Widespread and frequent in Recent sediment.

REMARKS.—This taxon is questionably assigned to *S. torquata* because a complete description is not available. Cleve-Euler's (1952) illustration shows a striate valve, whereas these valves appear punctate.

Tabellaria Ehrenberg, 1840

Tabellaria fenestra (Lyngbye) Kutzing, 1844

(Pl. 16, Fig. 10)

DESCRIPTION.—Patrick and Reimer 1966:103, pl. 1, fig. 1, 2.

ECOLOGY.—Oligohalobous, meioeuryhaline, benthic (Pankow 1976).

DISTRIBUTION.—Rare in Recent sediments.

Terpsinoe Ehrenberg, 1843

Terpsinoe americana (Bailey) Ralfs
in Pritchard, 1861

(Pl. 14, Fig. 6, 7)

DESCRIPTION.—Hustedt 1930a:900, fig. 541.

ECOLOGY.—Marine to brackish water; littoral in the subtropical coast of South Africa (Cholnoky 1968), benthic.

DISTRIBUTION.—Frequent in a single sample from the Yerba Buena mud, rare elsewhere in Sangamon sediment.

REMARKS.—This appears to be the first record of this species from the west coast of North America.

Thalassionema (Grunow) Hustedt, 1932

Thalassionema nitzschioides Hustedt, 1932

(Pl. 16, Fig. 9)

DESCRIPTION.—Hendey 1964:165. Hasle and de Mendiola 1967:111, fig. 5, 27–34, 39–44.

ECOLOGY.—Polyhalobous, meio- to mesoeuryhaline (Pankow 1976); neritic plankton common in upwelling areas.

DISTRIBUTION.—Abundant and widespread in the Yerba Buena mud, widespread but rare in Recent sediments.

Thalassiosira Cleve, 1873

Thalassiosira decipiens (Grunow)
Jorgensen, 1905

(Pl. 12, Fig. 1–4)

DESCRIPTION.—Hasle 1979:85–108, fig. 1–42.

ECOLOGY.—Marine to brackish water, littoral, probably benthic, epiphytic, living in chains attached at one end to a substrate; reported from rivers, estuaries and inland salt waters (Hasle 1979).

DISTRIBUTION.—Abundant and widespread in Recent sediments especially in Suisun Bay where it was the dominant diatom. Widespread but not abundant in Sangamon sediments.

REMARKS.—This species is quite variable with respect to convexity of the valve and the pattern and density of areolae. The areolae vary from polygonal (usually hexagonal) to circular. These features are shown also by the figures of Hasle (1979). On the basis of these characters two forms could be recognized. One morph has a slightly convex to nearly flat valve and densely spaced, polygonal areolae (Pl. 12, fig. 1–4). This form is referred to as *T. decipiens*. The other form, referred to as *T. decipiens* var. 1, has a strongly convex valve, with widely spaced, round areolae arranged in a radial pattern. Compare figures 21–

23 with figure 25 of Hasle (1979). Nevertheless, the pattern of strutted and labiate processes in that form is consistent with the nominate variety. However, features such as the number and position of strutted and labiate processes are difficult to assess for each specimen in whole-sample strewn amounts of acid-cleaned sediment. For this reason it is difficult to accurately and consistently distinguish between *T. decipiens* and closely related species such as *T. incerta*, *T. angulata*, and *T. visurgis* when examining tens of thousands of specimens. Although no specimens assignable to those species were observed, it is probably best to consider this taxon as a species group.

Thalassiosira decipiens var. 1

(Pl. 12, Fig. 5–9)

DESCRIPTION.—This variety is identical to the nominate variety regarding number and distribution of labiate and strutted processes. It is typically smaller (9–16 μm diameter) compared to the nominate variety, which reaches a maximum diameter of about 25 μm in these samples. Variety 1 has a strongly convex valve. The areolae are round and widely spaced in radiate rows. In some specimens the central area is hyaline except for a single strutted process.

DISTRIBUTION.—Widespread in Recent sediment especially in Suisun and San Pablo Bays.

REMARKS.—Although Hasle (1979) includes forms similar to this variety in the nominate variety (see fig. 25, Hasle 1979), this variety is easily recognizable and shows a distinct distributional pattern in Recent sediments of the bay (Laws 1983b). Therefore, it is recorded in this study as a distinct variety. Future studies may show that the morphological and geographical separation of these varieties is not real.

Thalassiosira eccentrica (Ehrenberg) Cleve, 1904

(Pl. 10, fig. 6, 7; Pl. 11, fig. 1–9)

DESCRIPTION.—Fryxell and Hasle 1972:300–312, fig. 1–18.

ECOLOGY.—Planktonic, typically marine neritic but present in oceanic plankton.

DISTRIBUTION.—Rare, but widespread in Sangamon and Recent sediment.

REMARKS.—According to Fryxell and Hasle (1972:302), the pattern of areolae is that of “. . . eccentric (rather than concentric) arcs, grading into fasciculated structure on some valves.” Furthermore, Fryxell and Hasle indicate that the number and distribution of tubular processes are more valuable diagnostic characters. Therefore,

I have adopted a broad concept of areolation in *T. eccentrica*, while adhering strictly to their description of position and number of tubular processes (i.e., one central strutted tubulus, one large marginal labiate process, a double row of marginal strutted tubuli, and strutted tubuli scattered evenly over the valve face).

Thalassiosira hendeyi Hasle and Fryxell, 1977

(Pl. 10, Fig. 2–5)

DESCRIPTION.—Hasle and Fryxell 1977:25, fig. 35–45.

ECOLOGY.—Planktonic, coastal marine, warm water.

DISTRIBUTION.—Rare in Sangamon and Recent sediments.

Thalassiosira lacustris (Grunow) Hasle, 1977

(Pl. 6, fig. 7, 8; Pl. 7, Fig. 1, 2)

DESCRIPTION.—Hustedt 1928:432, fig. 235 (as *Coscinodiscus lacustris*); Hasle and Fryxell 1977:40.

ECOLOGY.—Probably mesohalobous, coastal marine, planktonic, and benthic (Pankow 1976).

DISTRIBUTION.—Widespread in Sangamon and Recent sediment, most abundant in samples from Suisun and San Pablo bays.

REMARKS.—Two morphs are present in this material. One is robust and corresponds to var. *hyperborea* Grunow (Hustedt 1928:433, fig. 235c); the other probably corresponds to the more delicate variety *septentrionalis* Grunow (Hustedt 1928, Fig. 235d). The robust forms show 10–14 large marginal spines and a double row of tubular processes along the margin (Pl. 7, Fig. 1). The lightly silicified delicate forms have a single ring of small marginal processes (7 in 10 μm , see Pl. 7, Fig. 2), which appear to penetrate the valve surface and are suggestive of strutted processes.

Thalassiosira nodulolineata (Hendey)

Hasle and Fryxell, 1977

(Pl. 10, Fig. 1)

DESCRIPTION.—Hasle and Fryxell 1977:35, fig. 86–93.

ECOLOGY.—Planktonic, coastal marine and brackish water.

DISTRIBUTION.—Rare in Sangamon sediments; frequent and widespread in Recent sediments, most common in Suisun and San Pablo bays.

Thalassiosira cf. *T. pacifica*

Gran and Angst, 1931

(Pl. 11, Fig. 9)

DESCRIPTION.—Gran and Angst 1931:437, fig. 12.

ECOLOGY.—Poorly known.

DISTRIBUTION.—Very rare in Sangamon sediments.

REMARKS.—Identification of this species is dif-

ficult because the original description and figures have not been emended to include characters presently used to distinguish species of *Thalassiosira*. The specimen pictured in Plate 11, Figure 9 shows the fasciculated pattern described by Gran and Angst (1931). It also shows a single row of marginal tubuli, which may correspond to the single row of marginal "spinules" described by Gran and Angst; but this specimen is larger than theirs (72 μm versus 46 μm). Schrader (1973) and Barron (1975) figure specimens of *T. pacifica*. Schrader's specimens are the proper size but show eccentric rather than fasciculated areolae. Schrader states that his identifications were based on comparison with specimens figured by Jousé (1962). Specimens figured by Barron (1975, pl. 14, fig. 7, 8) compare more favorably to the original description, but one specimen is much larger (100 μm), and neither illustration shows marginal tubuli.

Thalassiosira punctigera (Castracane) Hasle, 1983
(Pl. 9, Fig. 7, 8)

DESCRIPTION.—Gran and Angst 1931:443, fig. 19, 20 as *Coscinodiscus angstii*. Hasle (1983).

ECOLOGY.—Planktonic, marine to brackish water, originally described from Puget Sound.

DISTRIBUTION.—Rare in Recent sediment of Central San Francisco Bay and San Pablo Bay.

REMARKS.—These specimens are questionably assigned to *T. punctigera*. The circlet of large, marginal processes shown by Gran and Angst (1931) and Fryxell (1975, fig. 25, 26) are not evident on these specimens. Other features agree with the diagnosis of *T. punctigera*. The diameter of these specimens reaches 115 μm .

Thalassiosira sp. 1

(Pl. 9, Fig. 6)

DESCRIPTION.—Valve circular, flat. Mantle distinct in valve view, about one-sixth the diameter; diameter 26 μm . Areolae small, circular, in radial rows arranged in indistinct bundles with an overprinted concentric pattern (a Fibonacci sequence). Areolae in central area larger (15–18 in 10 μm) than near the margin where they are 25–30 in 10 μm . A single central pore (strutted process) adjacent to central areolae. Pores scattered on valve face. A single row of marginal pores, seven to nine in 10 μm . Seven to eight large tubuli (labiate processes) around the margin at irregular intervals. A single row of spines around the margin, 13–14 in 10 μm .

DISTRIBUTION.—A single specimen from the Yerba Buena mud.

Trachyneis Cleve, 1894

Trachyneis aspera (Ehrenberg) Cleve, 1894

(Pl. 29, Fig. 13)

DESCRIPTION.—Hendey 1964:236, pl. 29, fig. 13.

ECOLOGY.—Polyhalobous, meioeuryhaline, benthic (Pankow 1976).

DISTRIBUTION.—Rare in Sangamon and Recent sediments.

Trachysphenia Petit, 1877

Trachysphenia acuminata Peragallo
in Temperé and Peragallo, 1910

(Pl. 16, Fig. 11)

DESCRIPTION.—Hustedt 1955:14, pl. 4, fig. 50–54.

ECOLOGY.—Benthic, brackish water, epiphytic.

DISTRIBUTION.—Widespread but not common in Sangamon and Recent sediments.

Triceratium Ehrenberg, 1841

Triceratium dubium Brightwell, 1859

(Pl. 14, Fig. 8)

DESCRIPTION.—Hustedt 1930a:806, fig. 469. Hendey 1970: 119, pl. 6, fig. 67.

ECOLOGY.—Common in subtropical waters, neritic marine, benthic.

DISTRIBUTION.—Widespread but rare in Recent, most common in samples from Suisun Bay.

Genus and Species *indeterminate*

(Pl. 12, Fig. 12)

DESCRIPTION.—Valve triangular in outline, almost semilanceolate, asymmetrical, with one bluntly rounded angle and two strongly produced, subacute angles. Longest side 12–15 μm . All margins slightly concave. Valve surface punctate. Punctae large, round, in rows that follow the valve margin; 14–16 in 10 μm along the margin.

DISTRIBUTION.—Rare in the upper part of the Yerba Buena mud.

REMARKS.—This taxon is very similar to *Euodia barbadensis* Greville (1861), except for the protracted ends on the specimens described above. According to Van Landingham (1971), *Euodia* is not a valid genus and most species originally assigned to it were placed in *Hemidiscus* or *Triceratium*. However "*Euodia*" *barbadensis*, the type of the genus, was never reassigned. It is likely that neither "*Euodia barbadensis*" or this taxon belongs to *Hemidiscus* or *Triceratium*. This species and "*E. barbadensis*" may represent Greville's original concept of "*Euodia*" or a new genus.

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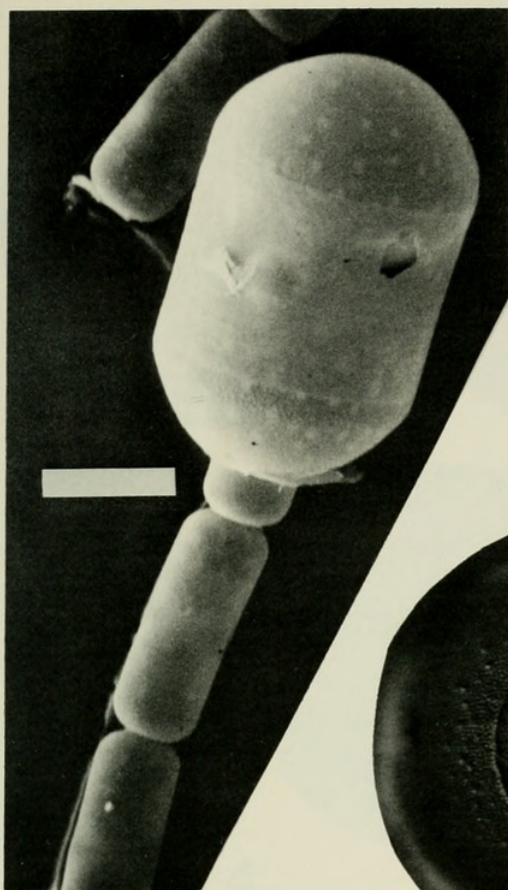
ance. I wish to thank the Estuarine Studies Group of the Water Resources Division of the U.S. Geological Survey at Menlo Park, California, especially Drs. John Conomos and Frederick Nicols for kindly allowing me to participate in the benthic sampling program aboard the RV ESTERO. Many people contributed their support, ideas, and expertise to this work, but at the risk of omitting someone I would like to especially thank

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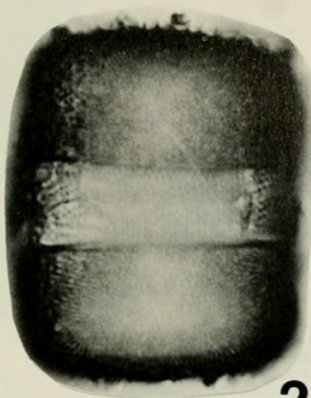
Plate 1

FIGURE:

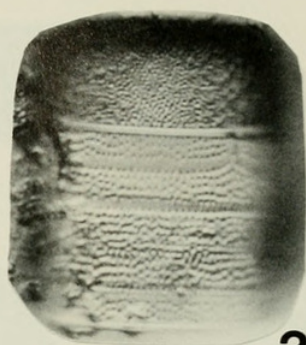
1. *Melosira moniliformis* (O. Müller) Agardh; scale bar equals 40 μm ; with initial cell.
2. *Melosira moniliformis* (O. Müller) Agardh; L = 38 μm .
3. *Melosira moniliformis* (O. Müller) Agardh; L = 37 μm .
4. *Melosira moniliformis* (O. Müller) Agardh; L = 50 μm .
5. *Melosira moniliformis* (O. Müller) Agardh; D = 37 μm .
6. *Melosira moniliformis* (O. Müller) Agardh; L = 37 μm .
7. *Melosira nummuloides* (Dillw.) Agardh; L = 42 μm .
8. *Aulacosira ambigua* (Grunow) Simonsen; L = 12 μm .
9. *Aulacosira italica* (Ehrenberg) Simonsen; L = 17 μm .
10. *Aulacosira italica* (Ehrenberg) Simonsen; L = 31 μm .
11. *Aulacosira granulata* (Ehrenberg) Simonsen; L = 35 μm .
12. *Aulacosira granulata* (Ehrenberg) Simonsen; D = 24 μm .
13. *Aulacosira granulata* (Ehrenberg) Simonsen; D = 21 μm .
14. *Aulacosira granulata* (Ehrenberg) Simonsen; D = 21 μm . Same specimen as in Figure 13.
15. *Aulacosira granulata* (Ehrenberg) Simonsen; D = 25 μm .



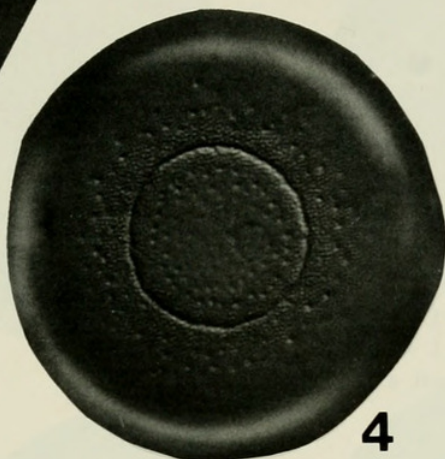
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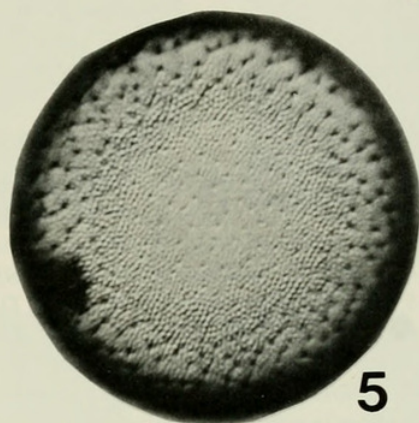
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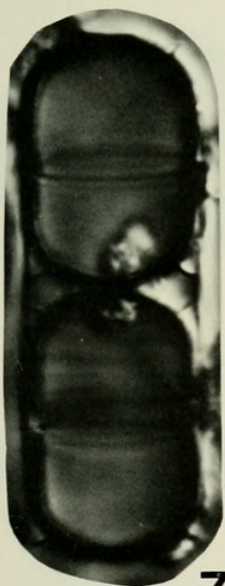
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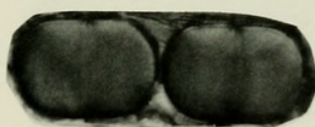
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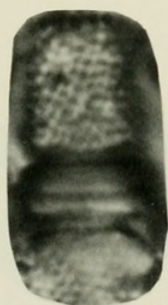
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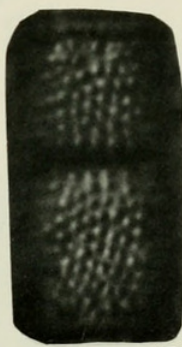
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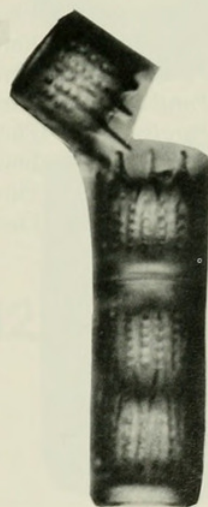
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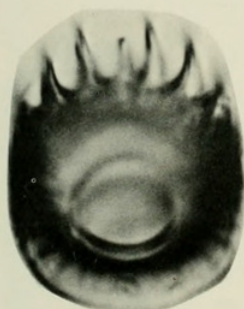
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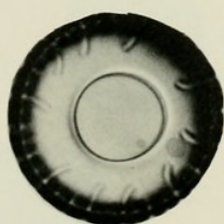
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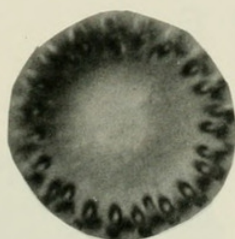
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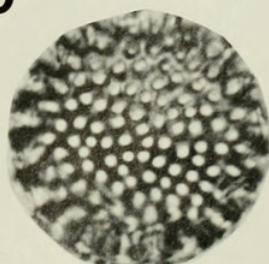
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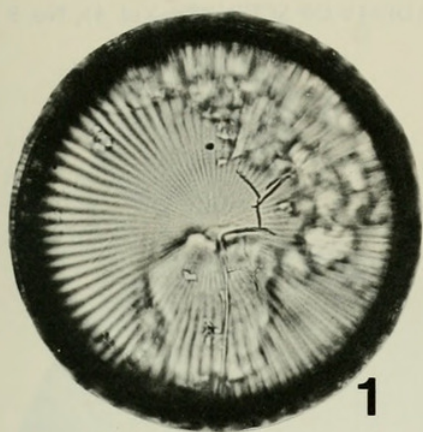


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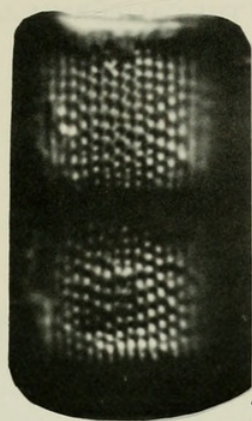
Plate 2

FIGURE:

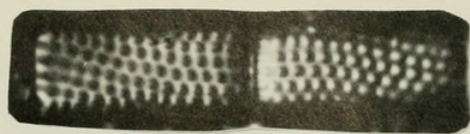
1. *Melosira arenaria* Moore; D = 72 μ m.
2. *Aulacosira islandica* (O. Müller) Simonsen; L = 28 μ m.
3. *Aulacosira islandica* (O. Müller) Simonsen; L = 29 μ m.
4. *Aulacosira islandica* (O. Müller) Simonsen; L = 30 μ m.
5. *Paralia sulcata* (Ehrenberg) Cleve; D = 35 μ m. a: focus down, b: focus up.
6. *Paralia sulcata* (Ehrenberg) Cleve; L = 60 μ m.
7. *Paralia sulcata* (Ehrenberg) Cleve; D = 32 μ m.
8. *Paralia sulcata* (Ehrenberg) Cleve; D = 39 μ m.
9. *Paralia sulcata* (Ehrenberg) Cleve; D = 35 μ m.
10. *Paralia sulcata* (Ehrenberg) Cleve; D = 38 μ m.
11. *Paralia sulcata* (Ehrenberg) Cleve; D = 33 μ m; a: upper valve of cell, b: lower valve of cell.
12. *Paralia sulcata* (Ehrenberg) Cleve; L = 45 μ m.
13. *Paralia sulcata* (Ehrenberg) Cleve; D = 32 μ m; a: focus up, b: focus down.
14. *Paralia sulcata* (Ehrenberg) Cleve; L = 28 μ m.
15. *Paralia sulcata* (Ehrenberg) Cleve; D = 11 μ m.
16. *Paralia sulcata* (Ehrenberg) Cleve; D = 11 μ m.
17. *Paralia sulcata* (Ehrenberg) Cleve; L = 16 μ m.



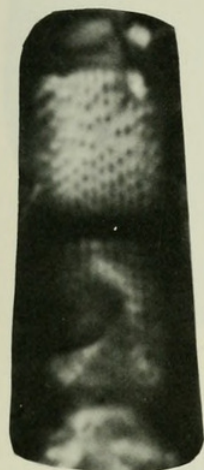
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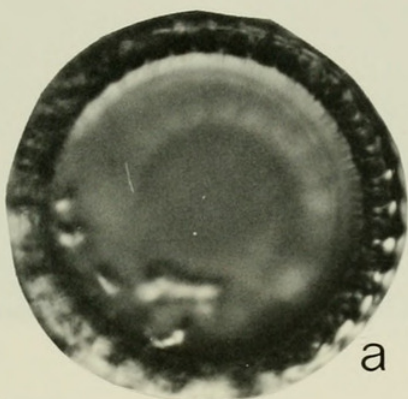
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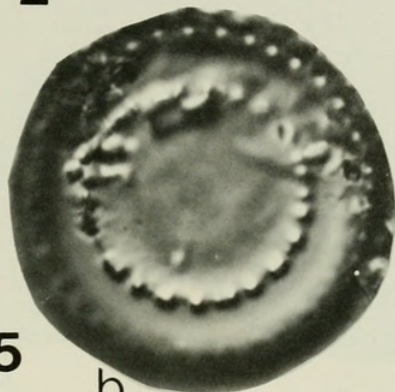


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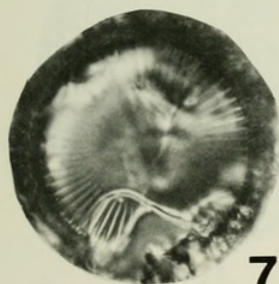
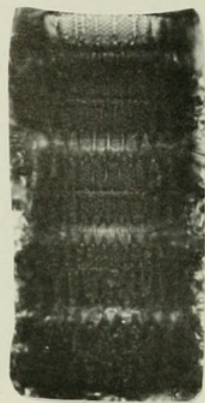
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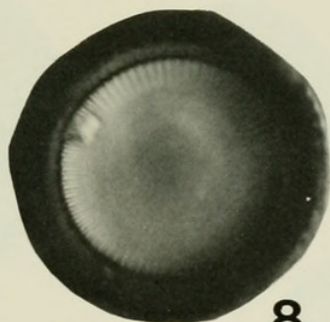


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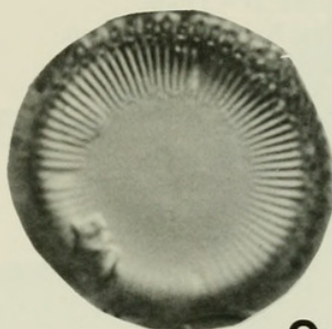
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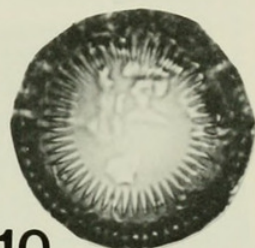
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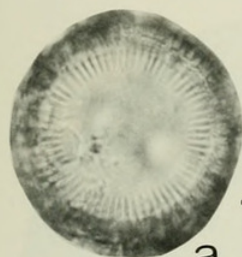
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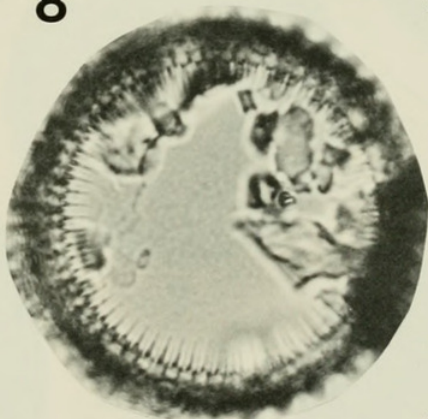


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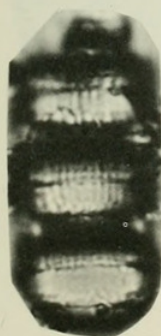
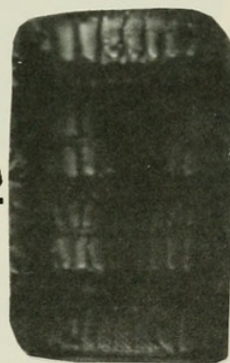
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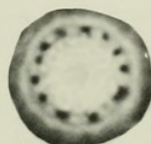
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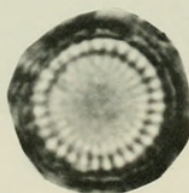
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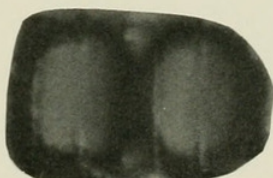
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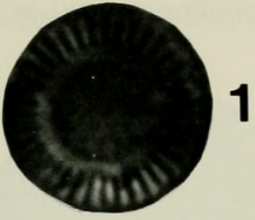
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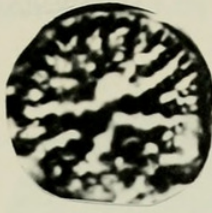
Plate 3

FIGURE:

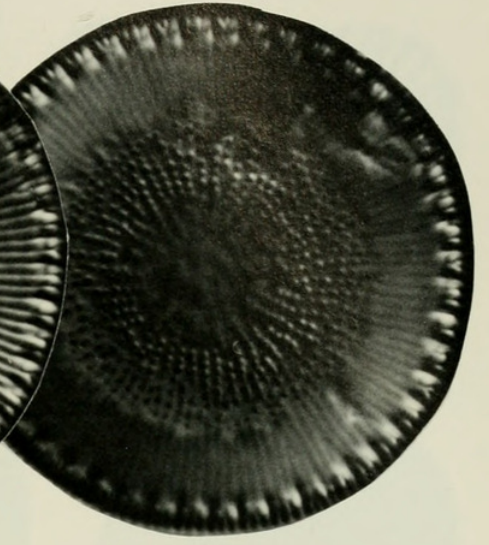
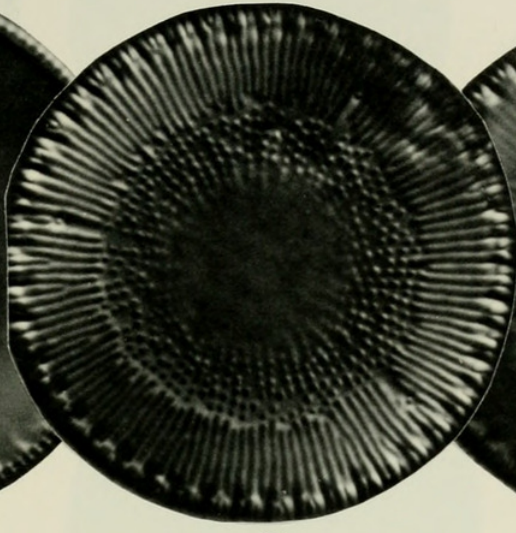
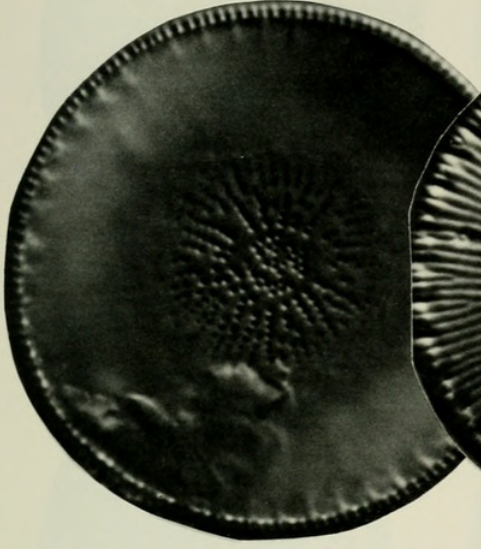
1. *Cyclotella stelligera* Cleve; D = 8 μ m.
2. *Cyclotella pygmaea* Pantocsek; D = 13 μ m.
3. *Cyclotella comta* (Ehrenberg) Kutzing; D = 35 μ m.
4. *Cyclotella striata* (Kutzing) Grunow; D = 20 μ m.
5. *Cyclotella menegheniana* Kutzing; D = 10 μ m.
6. *Cyclotella striata* (Kutzing) Grunow; D = 27 μ m.
7. *Cyclotella stylorum* Brightwell; D = 38 μ m.
8. *Cyclotella stylorum* Brightwell; D = 82 μ m.
9. *Cyclotella stylorum* Brightwell; D = 50 μ m.



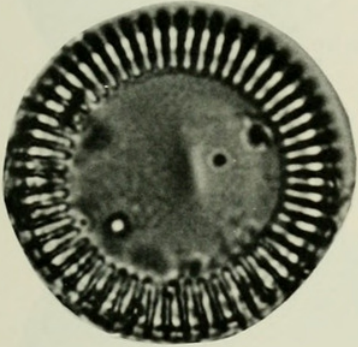
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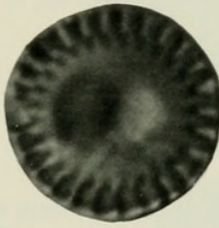
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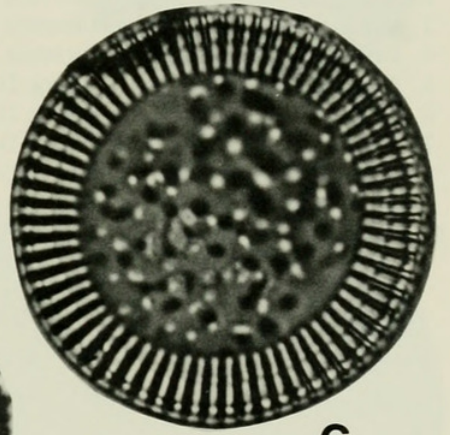
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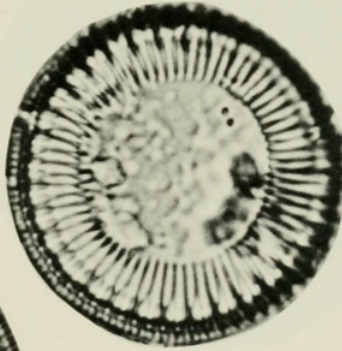
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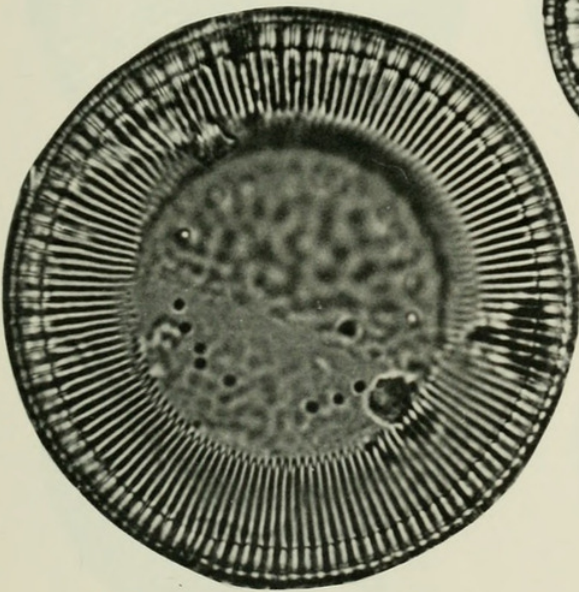
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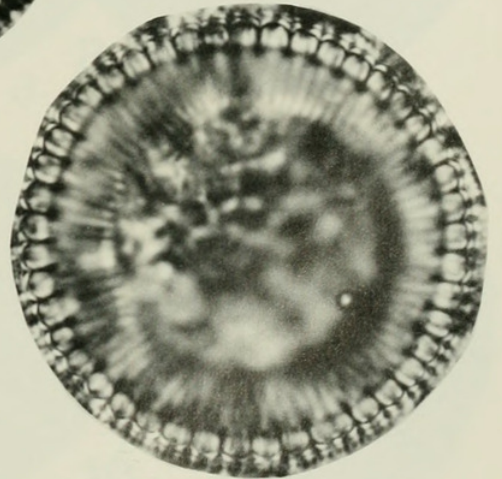
6



7



8



9

Plate 4

FIGURE:

1. *Stephanodiscus carconensis* Eulenstein in Grunow; D = 60 μm .
2. *Stephanodiscus carconensis* Eulenstein in Grunow; D = 20 μm .
3. *Stephanodiscus carconensis* Eulenstein in Grunow; D = 12 μm ; a: focus down, b: focus up.
4. *Stephanodiscus carconensis* Eulenstein in Grunow; D = 36 μm .
5. *Stephanodiscus niagarae* Ehrenberg; D = 39 μm .
6. *Stephanodiscus niagarae* Ehrenberg; D = 48 μm .
7. *Stephanodiscus niagarae* Ehrenberg; D = 27 μm .
8. *Stephanodiscus niagarae* Ehrenberg; D = 61 μm ; a, focus down, b, focus up.
9. *Stephanodiscus astrea* (Ehrenberg) Grunow; D = 22 μm .
10. *Stephanodiscus astrea* (Ehrenberg) Grunow; D = 19 μm ; a, focus down, b, focus up.

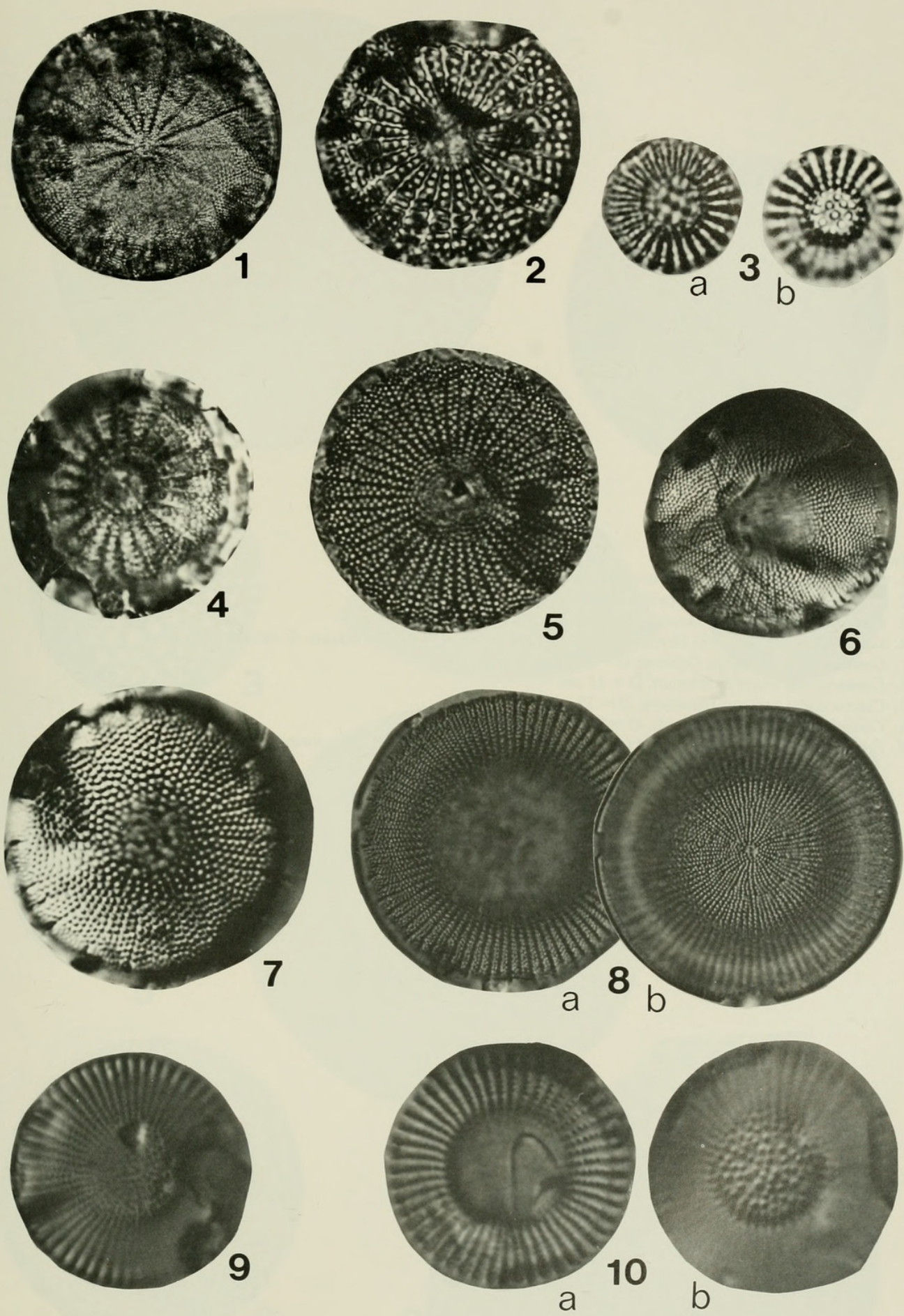


Plate 5

FIGURE:

1. *Coscinodiscus jonesianus* (Greville) Ostenfeld; scale bar is 20 μm .
2. *Coscinodiscus jonesianus* (Greville) Ostenfeld; D = 104 μm .
3. *Coscinodiscus decrescens* Grunow; D = 25 μm .
4. *Coscinodiscus oculus-iridis* Ehrenberg; D = 150 μm ; a: central area and margin, b: entire valve.
5. *Coscinodiscus decrescens* Grunow; D = 19 μm .
6. *Coscinodiscus obscurus* Schmidt; D = 85 μm .
7. *Coscinodiscus radiatus* Ehrenberg; D = 35 μm .
8. *Coscinodiscus obscurus* Schmidt; D = 74 μm .
9. *Coscinodiscus obscurus* Schmidt; D = 85 μm ; central area and margin of specimen in Figure 7.

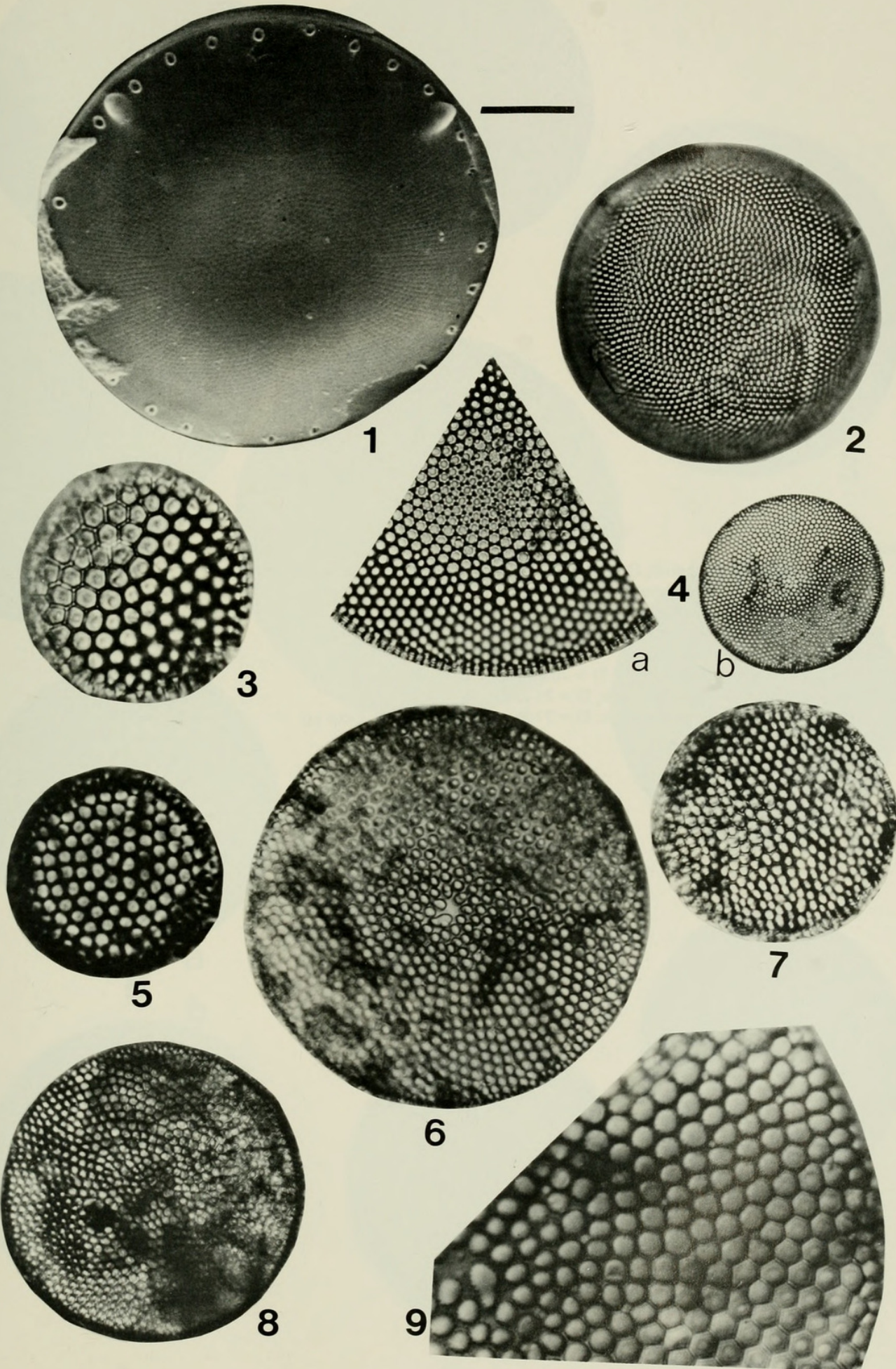
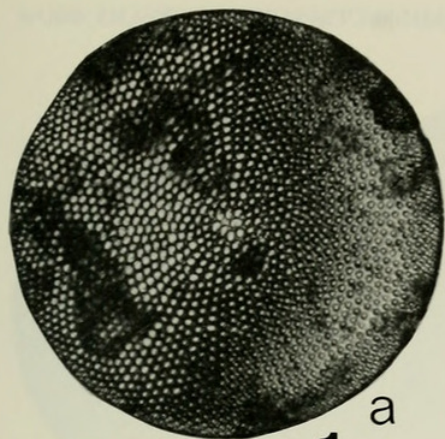


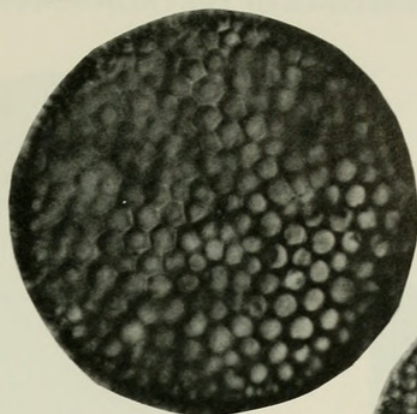
Plate 6

FIGURE:

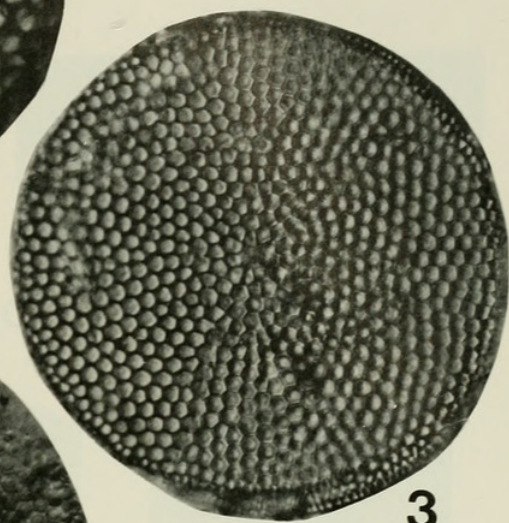
1. *Coscinodiscus obscurus* Schmidt; D = 123 μm ; a: entire valve, b: center area and margin.
2. *Coscinodiscus radiatus* Ehrenberg; D = 40 μm .
3. *Coscinodiscus radiatus* Ehrenberg; D = 64 μm .
4. *Coscinodiscus radiatus* Ehrenberg; D = 70 μm .
5. *Stephanopyxis*? sp.; D = 26 μm .
6. *Coscinodiscus marginatus* Ehrenberg; D = 26 μm ; a: focus up, b: focus down.
7. *Thalassiosira lacustris* (Grunow) Hasle; D = 25 μm .
8. *Thalassiosira lacustris* (Grunow) Hasle; D = 37 μm ; a: focus down, b: focus up.



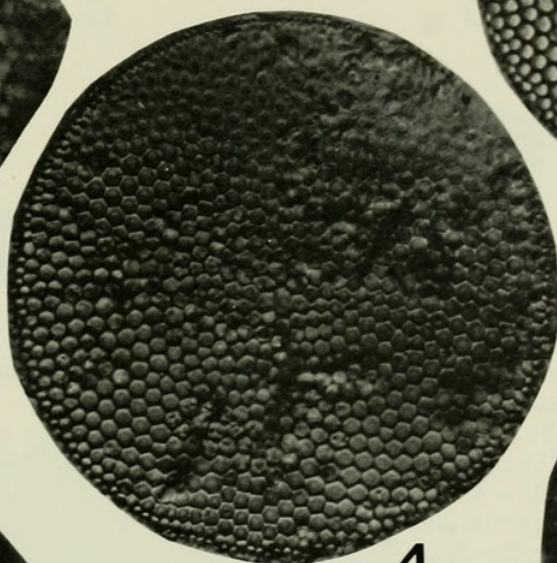
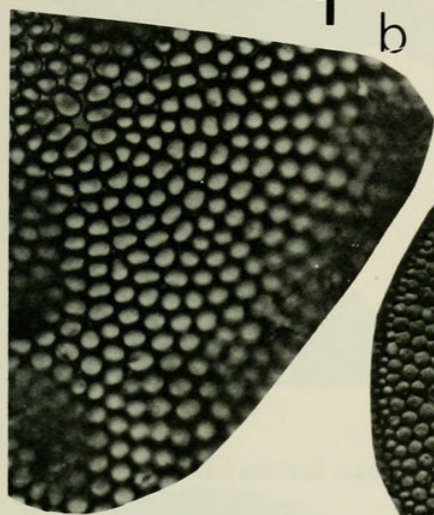
1 a
b



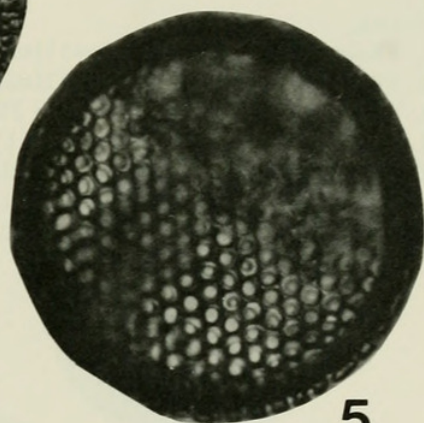
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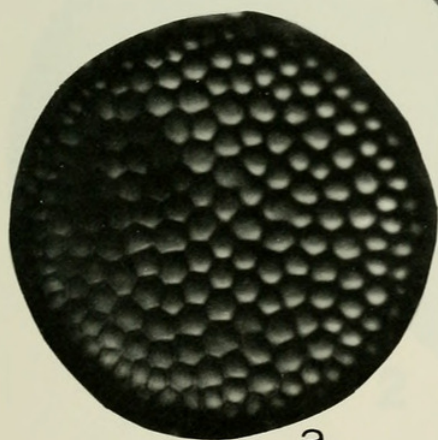
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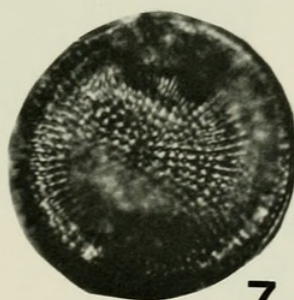
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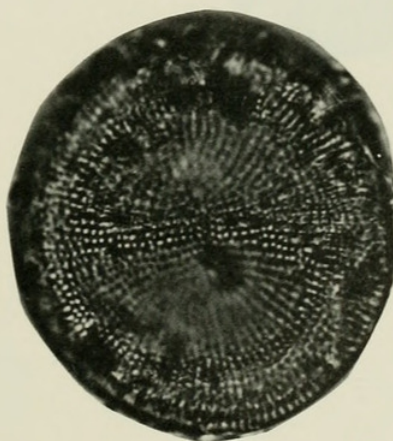
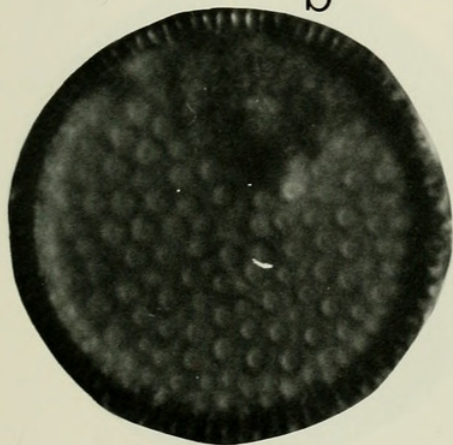
5



6 a
b



7



8 a
b

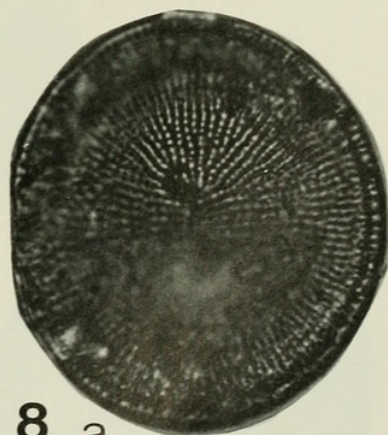


Plate 7

FIGURE:

1. *Thalassiosira lacustris* (Grunow) Hasle; D = 60 μm ; a: focus up, b: focus down, c-f: margin showing tubular processes.
2. *Thalassiosira lacustris* (Grunow) Hasle; D = 29 μm .
3. *Coscinodiscus nitidus* Gregow; D = 25 μm .
4. *Cyclotella pygmaea* Pantocsek; D = 13 μm .
5. *Cyclotella striata* (Kutzing) Grunow; D = 32 μm .
6. *Cyclotella striata* (Kutzing) Grunow; D = 20 μm .
7. *Cyclotella comta* (Ehrenberg) Kutzing; D = 30 μm .

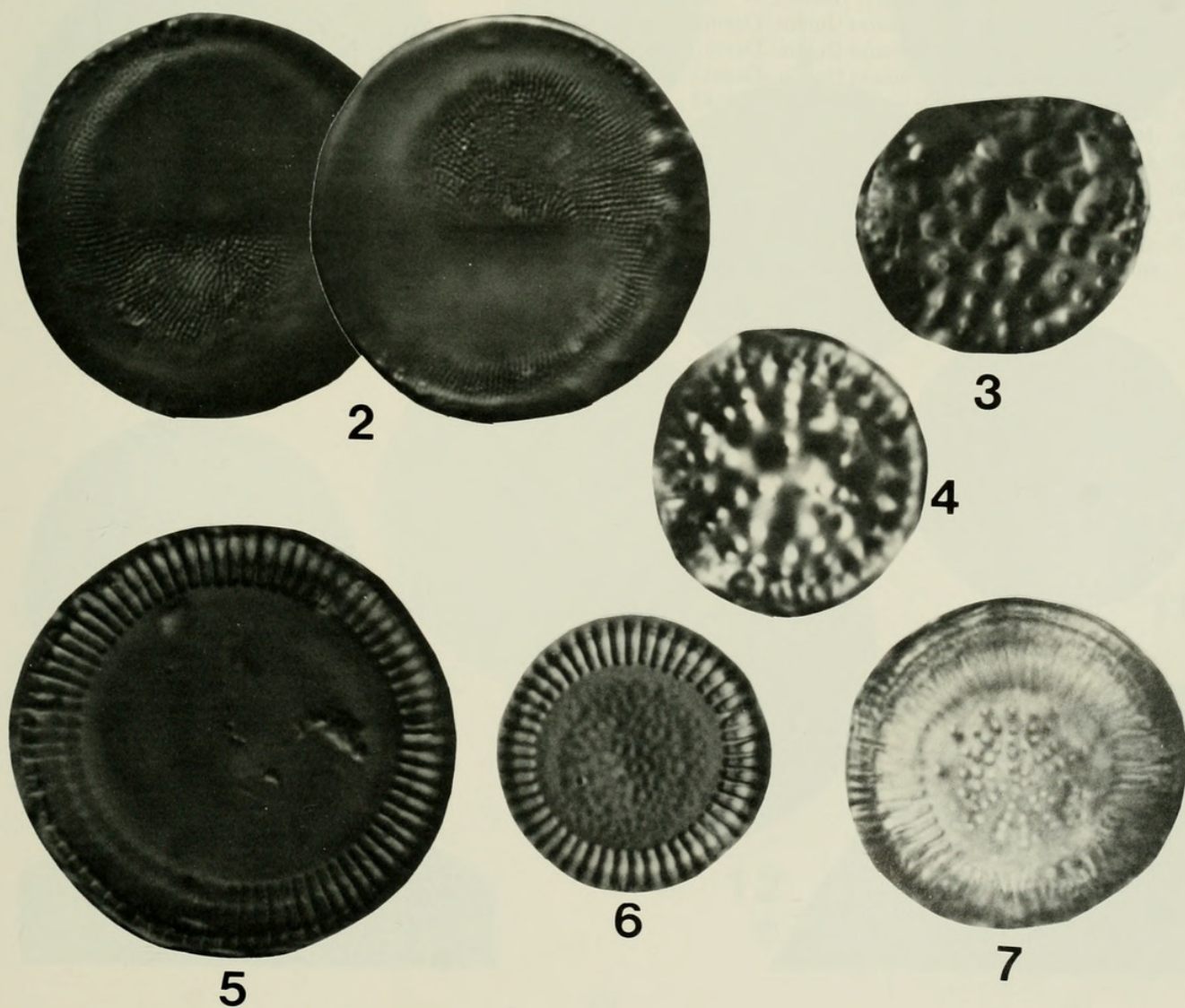
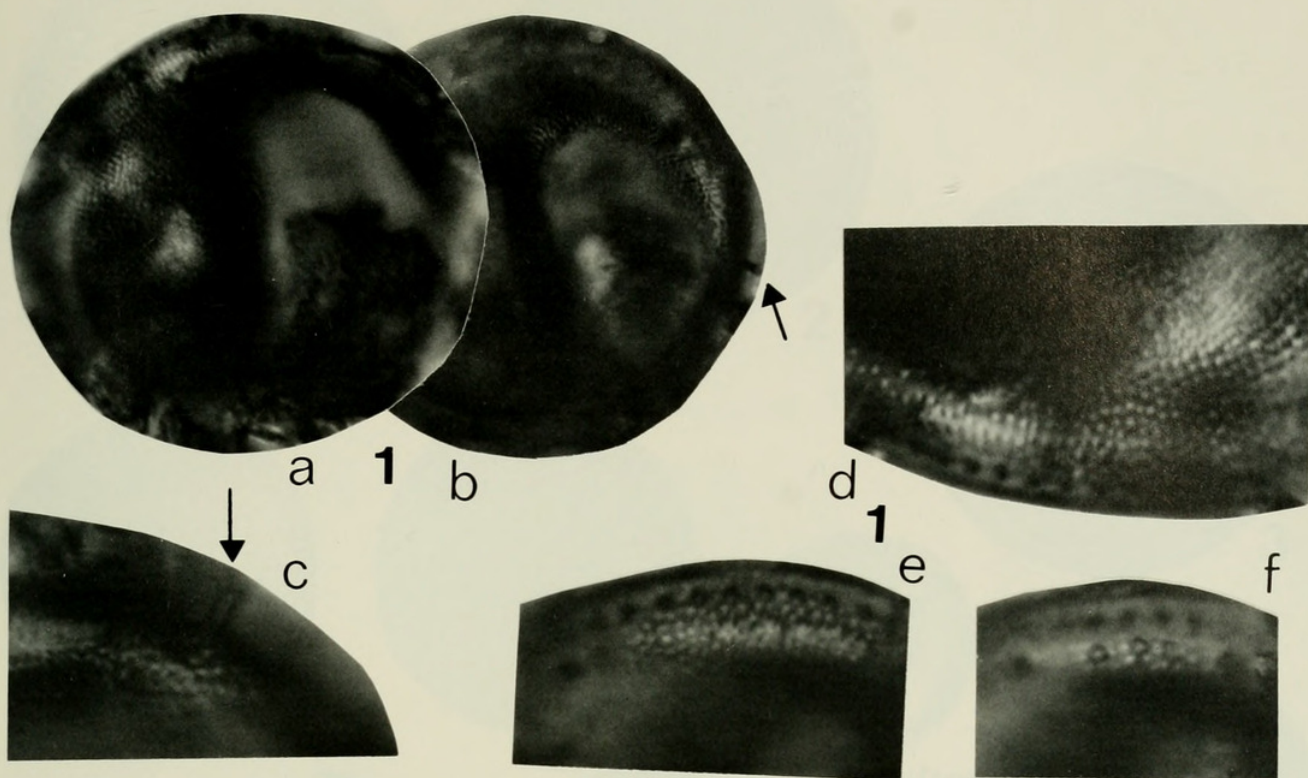


Plate 8

FIGURE:

1. *Actinocyclus normanii* (Gregory) Hustedt; D = 46 μ m.
2. *Actinocyclus normanii* (Gregory) Hustedt; D = 43 μ m.
3. *Actinocyclus normanii* (Gregory) Hustedt; D = 49 μ m.
4. *Actinocyclus normanii* f. *subsalsa* (Juhlin.-Dannt.) Hustedt; D = 23 μ m.
5. *Actinocyclus normanii* f. *subsalsa* (Juhlin.-Dannt.) Hustedt; D = 27 μ m.
6. *Actinocyclus normanii* f. *subsalsa* (Juhlin.-Dannt.) Hustedt; D = 18 μ m.
7. *Actinocyclus normanii* (Gregory) Hustedt; D = 45 μ m.
8. *Actinocyclus normanii* f. *subsalsa* (Juhlin.-Dannt.) Hustedt; D = 17 μ m.
9. *Actinocyclus normanii* (Gregory) Hustedt; D = 32 μ m.
10. *Actinocyclus normanii* f. *subsalsa* (Juhlin.-Dannt.) Hustedt; D = 22 μ m; arrow shows pseudonodule.
11. *Actinocyclus normanii* (Gregory) Hustedt; D = 44 μ m.
12. *Actinocyclus normanii* (Gregory) Hustedt; D = 48 μ m; a, b: focus down, shows pseudonodule(s)?; b: marginal focus, enlargement; c: entire valve, focus down; d: focus up; e: focus down, marginal focus, shows striate margin.

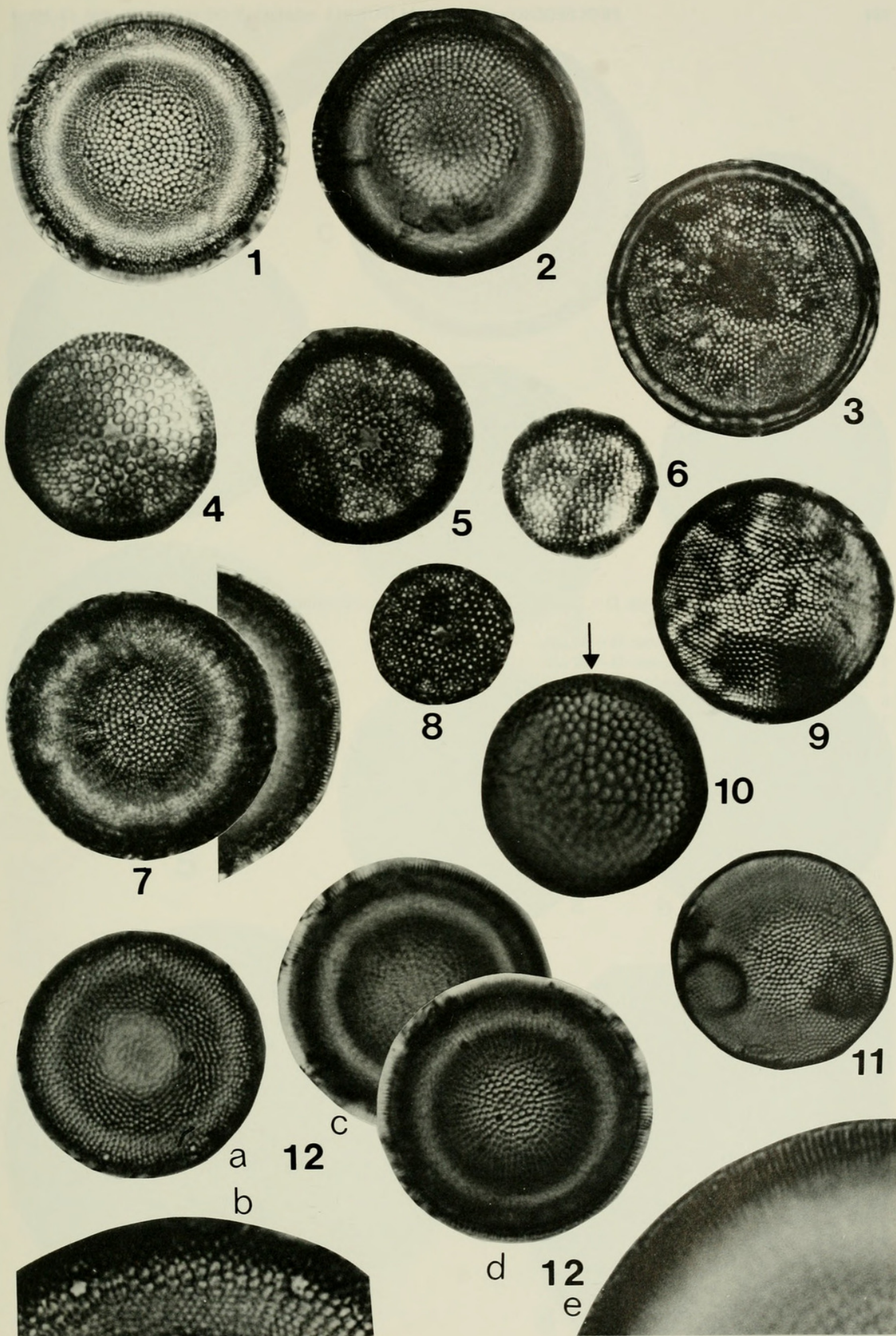


Plate 9

FIGURE:

1. *Actinocyclus octanarius* Ehrenberg; D = 72 μ m; a: marginal enlargement, b: entire valve; c: dark field.
2. *Actinocyclus?* sp. 1; D = 28 μ m.
3. *Coscinodiscus curvatulus* Grunow; D = 64 μ m.
4. *Coscinodiscus curvatulus* Grunow; D = 88 μ m.
5. *Actinocyclus octanarius* Ehrenberg; D = 96 μ m.
6. *Thalassiosira* sp. 1; D = 26 μ m; a: focus down, b: focus up.
7. *Thalassiosira punctigera* (Castracane) Hasle; D = 85 μ m.
8. *Thalassiosira punctigera* (Castracane) Hasle; D = 115 μ m.

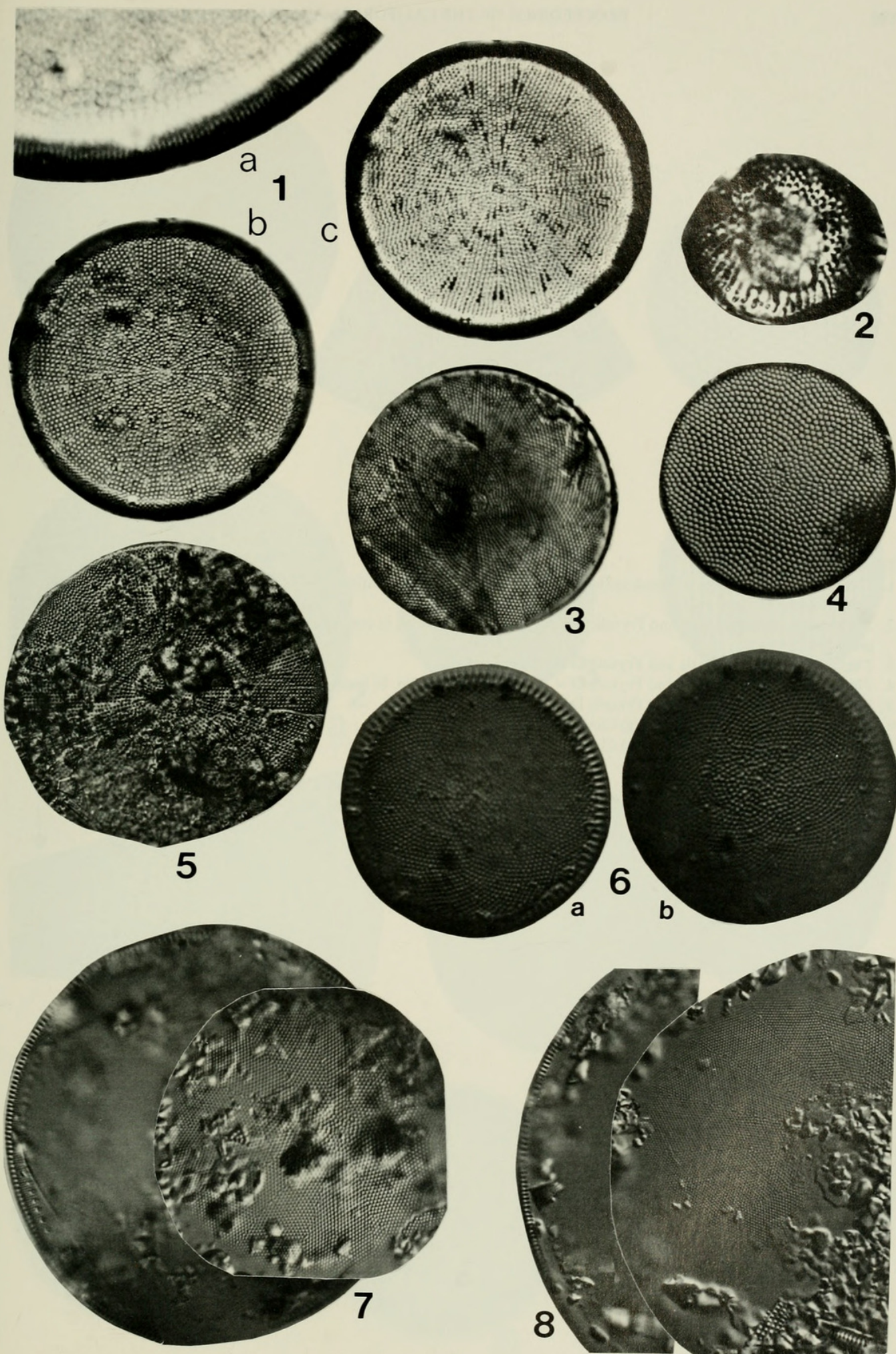


Plate 10

FIGURE:

1. *Thalassiosira nodulolineata* (Hendey) Hasle and Fryxell; D = 50 μm ; a: entire valve, b: central area and marginal enlargement, c: focus down, d: dark field.
2. *Thalassiosira hendeyi* Hasle and Fryxell; D = 68 μm ; a: entire valve, b: central area and marginal enlargement, arrows show processes.
3. *Thalassiosira hendeyi* Hasle and Fryxell; D = 30 μm .
4. *Thalassiosira hendeyi* Hasle and Fryxell; D = 27 μm ; a: focus down, b: focus up.
5. *Thalassiosira hendeyi* Hasle and Fryxell; D = 28 μm .
6. *Thalassiosira eccentrica* (Ehrenberg) Cleve; D = 46 μm .
7. *Thalassiosira eccentrica* (Ehrenberg) Cleve; D = 48 μm .

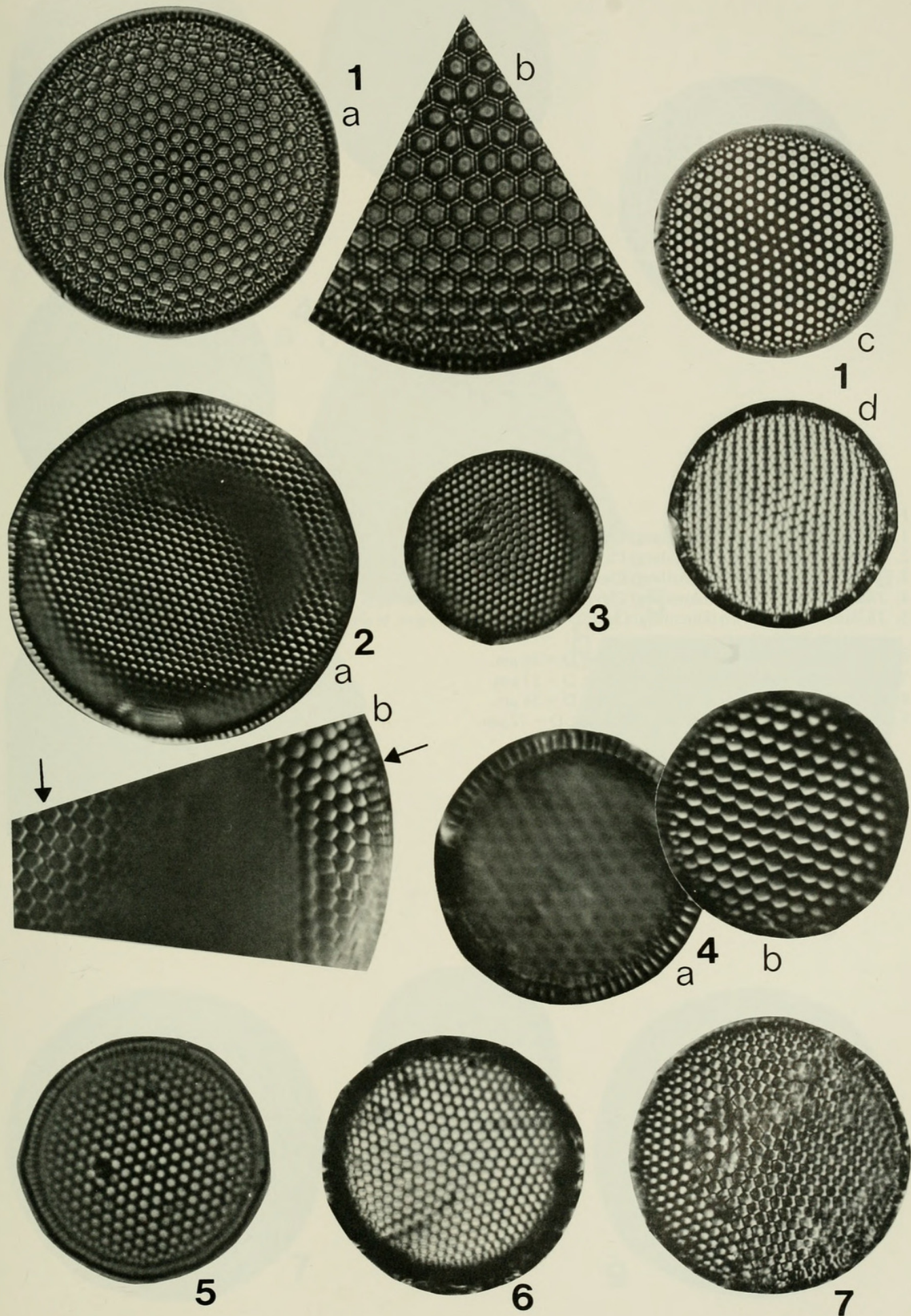
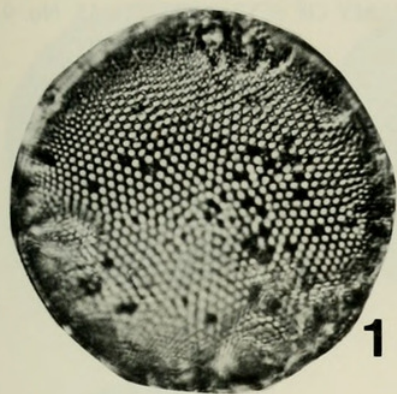


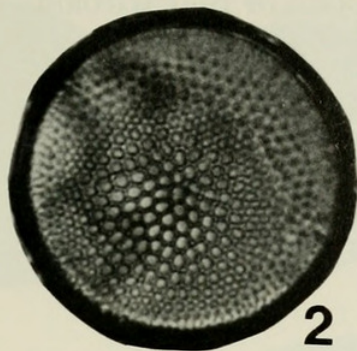
Plate 11

FIGURE:

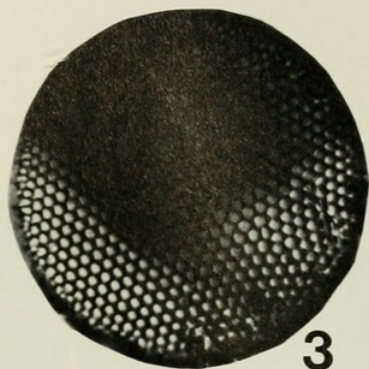
1. *Thalassiosira eccentrica* (Ehrenberg) Cleve; D = 40 μm .
2. *Thalassiosira eccentrica* (Ehrenberg) Cleve; D = 33 μm .
3. *Thalassiosira eccentrica* (Ehrenberg) Cleve; D = 45 μm .
4. *Thalassiosira eccentrica* (Ehrenberg) Cleve; D = 66 μm ; a: entire valve, b: central area and marginal enlargement.
5. *Thalassiosira eccentrica* (Ehrenberg) Cleve; D = 42 μm ; a: entire valve, b: central area and marginal enlargement, note tubular process at 3 o'clock.
6. *Thalassiosira eccentrica* (Ehrenberg) Cleve; D = 36 μm .
7. *Thalassiosira eccentrica* (Ehrenberg) Cleve; D = 53 μm .
8. *Thalassiosira eccentrica* (Ehrenberg) Cleve; D = 34 μm .
9. *Thalassiosira* cf. *T. pacifica* Gran and Angst; D = 72 μm .



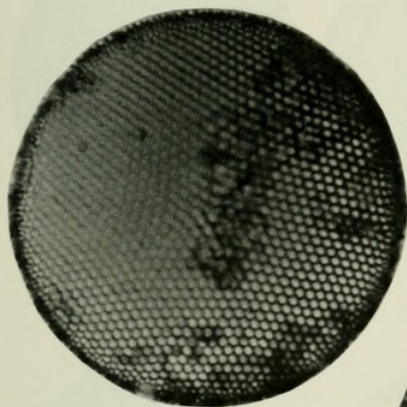
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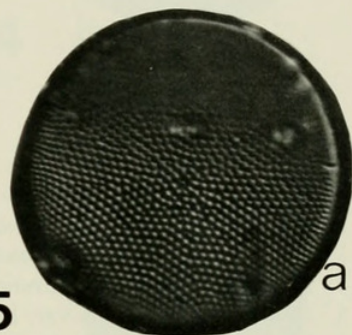
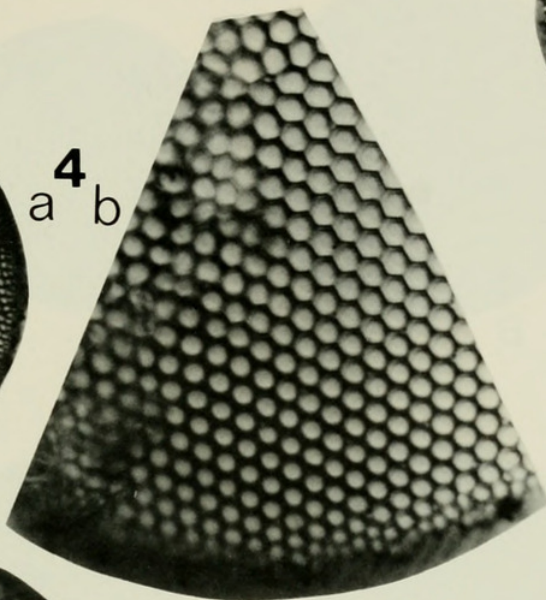
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3

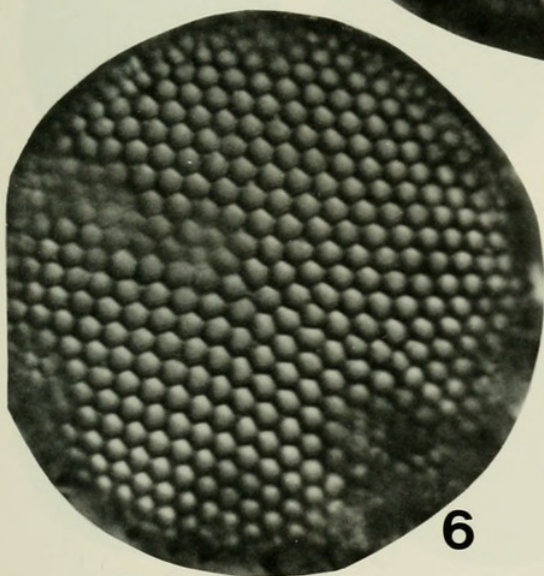


4
a b

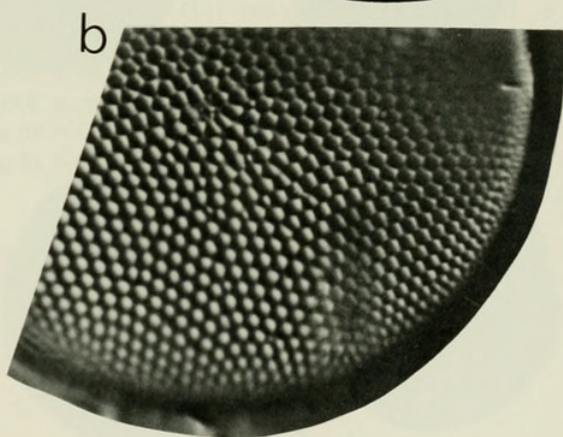


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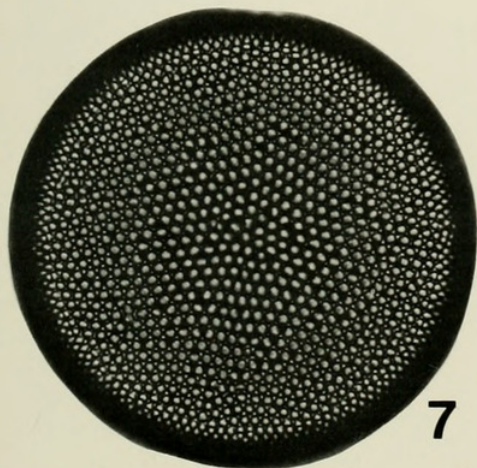
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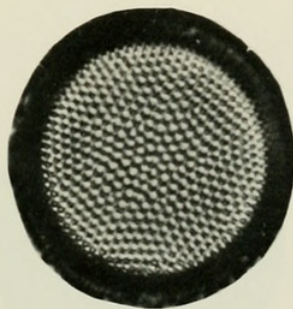
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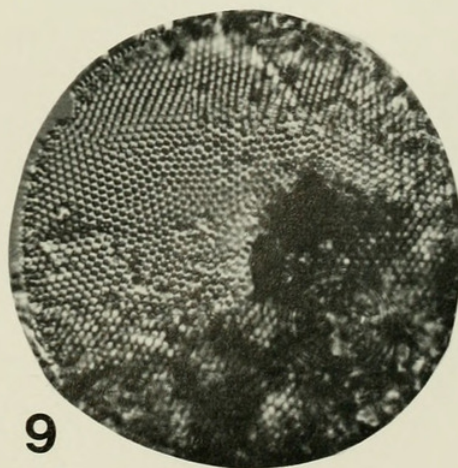
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7



8

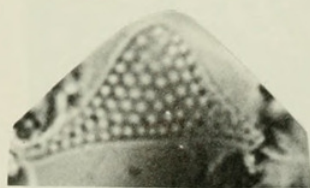
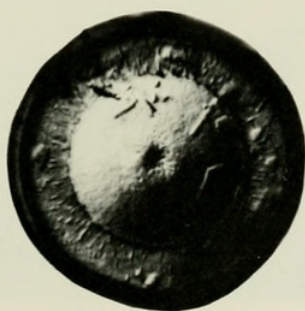
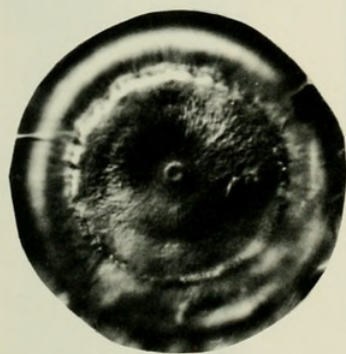
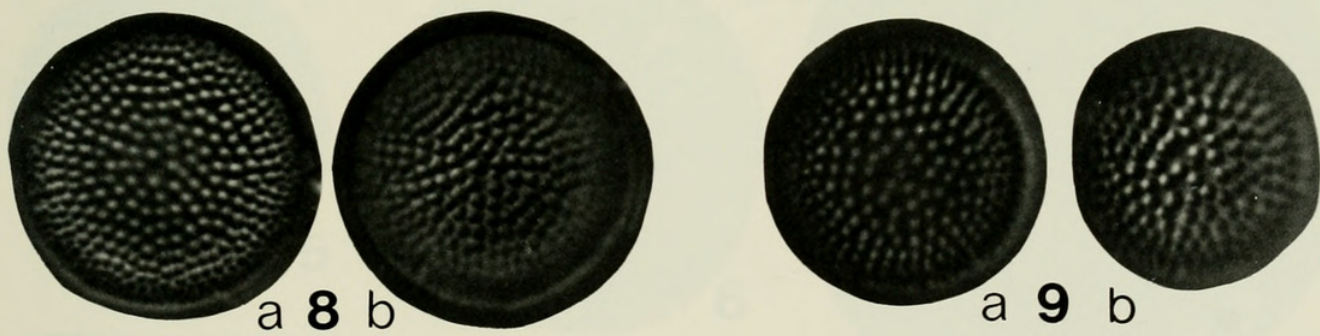
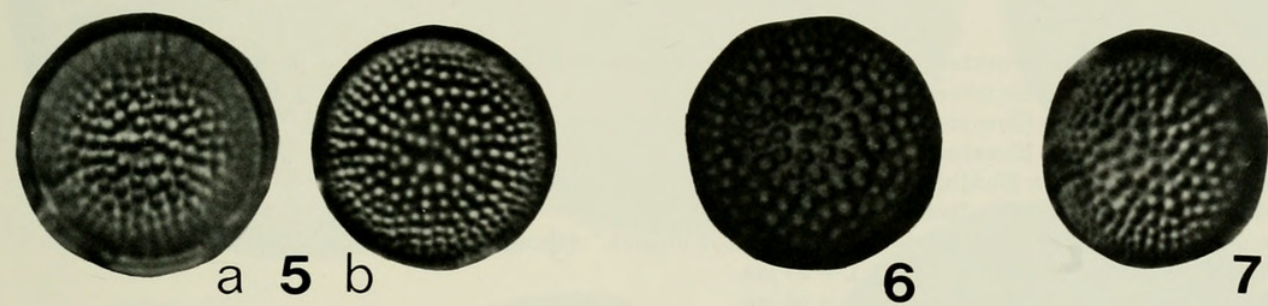
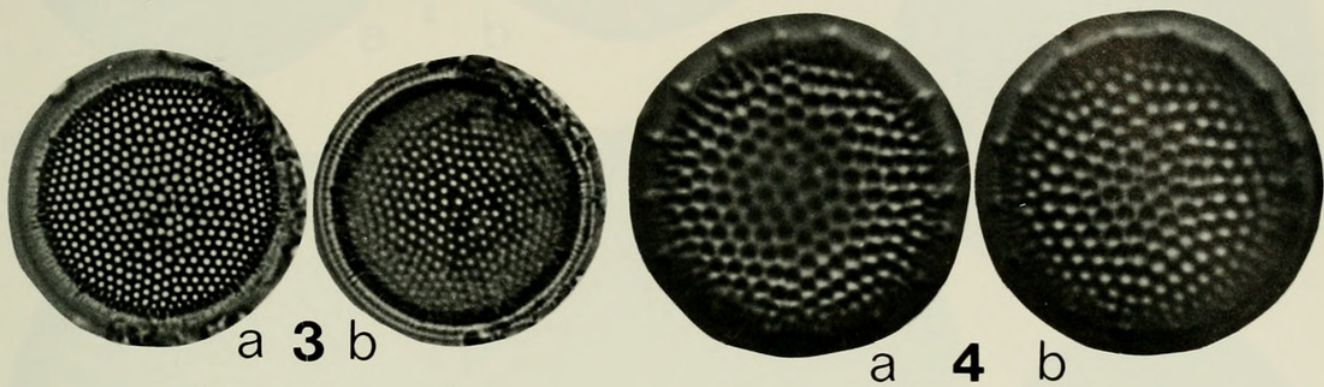
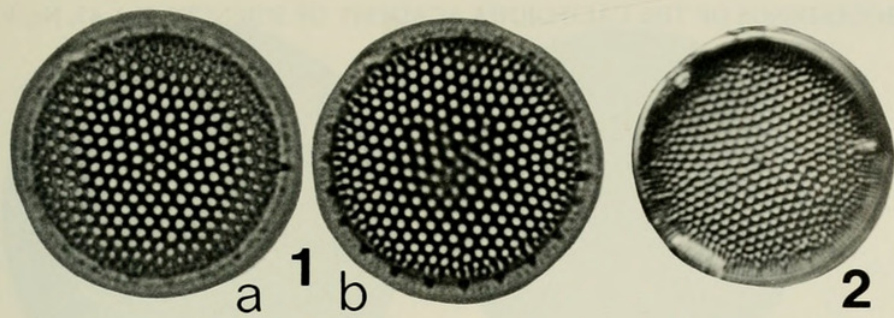


9

Plate 12

FIGURE:

1. *Thalassiosira decipiens* (Grunow) Jorgensen; D = 32 μm ; a: focus up, b: focus down.
2. *Thalassiosira decipiens* (Grunow) Jorgensen; D = 27 μm .
3. *Thalassiosira decipiens* (Grunow) Jorgensen; D = 40 μm ; a, focus up, b, focus down.
4. *Thalassiosira decipiens* (Grunow) Jorgensen; D = 21 μm ; a: focus down, b: focus up.
5. *Thalassiosira decipiens* var. 1; D = 14 μm ; a: focus down, b: focus up.
6. *Thalassiosira decipiens* var. 1; D = 16 μm .
7. *Thalassiosira decipiens* var. 1; D = 11 μm .
8. *Thalassiosira decipiens* var. 1; D = 15 μm ; a: focus down, b: focus up.
9. *Thalassiosira decipiens* var. 1; D = 14 μm ; a: focus down, b: focus up.
10. *Hyalodiscus scoticus* (Kutzing) Grunow; D = 96 μm .
11. *Hyalodiscus scoticus* (Kutzing) Grunow; D = 88 μm .
12. Genus and species indeterminate; L = 15 μm .



10

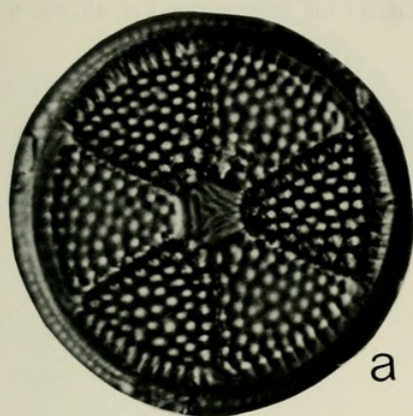
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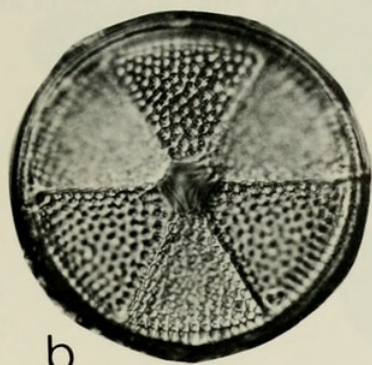
Plate 13

FIGURE:

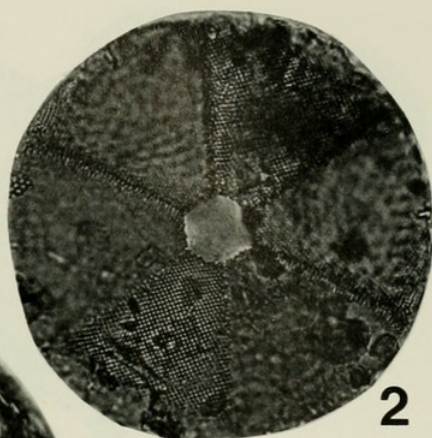
1. *Actinoptychus senarius* Ehrenberg; D = 86 μ m; a: bright field, b: dark field.
2. *Actinoptychus senarius* Ehrenberg; D = 96 μ m.
3. *Actinoptychus senarius* Ehrenberg; D = 77 μ m; a: focus up, b: focus down.
4. *Actinoptychus senarius* Ehrenberg; D = 60 μ m.
5. *Actinoptychus splendens* (Shadbolt) Ralfs; D = 21 μ m.
6. *Actinoptychus splendens* (Shadbolt) Ralfs; D = 40 μ m.
7. *Actinoptychus senarius* Ehrenberg; D = 76 μ m; "Debya insignis," Auxospore of *A. senarius*.
8. *Biddulphia aurita* (Lyngbye) Brébisson; L = 64 μ m.
9. *Biddulphia aurita* (Lyngbye) Brébisson; L = 68 μ m.
10. *Biddulphia aurita* (Lyngbye) Brébisson; L = 42 μ m.



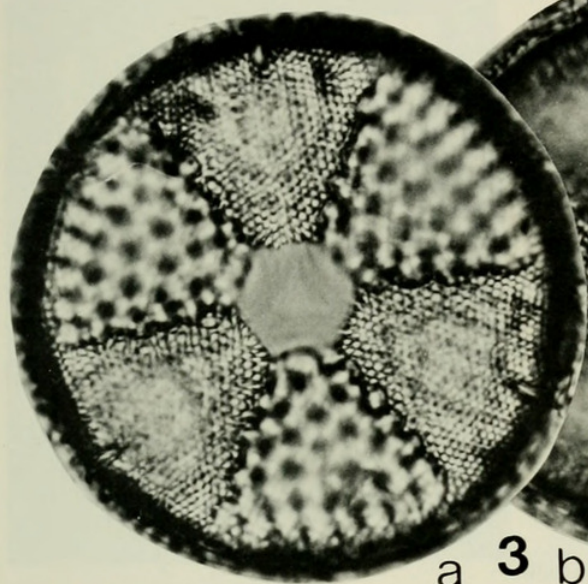
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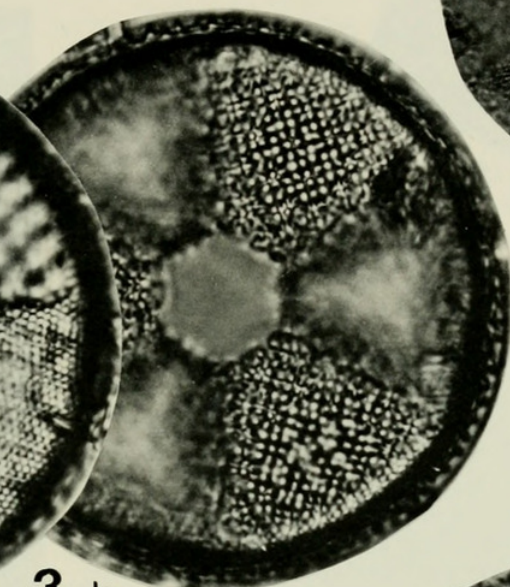
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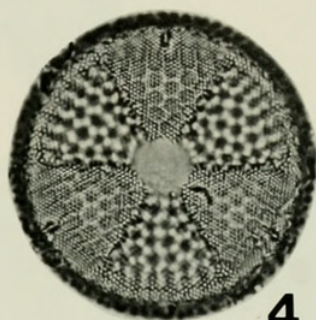
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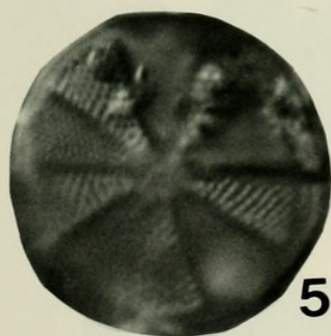
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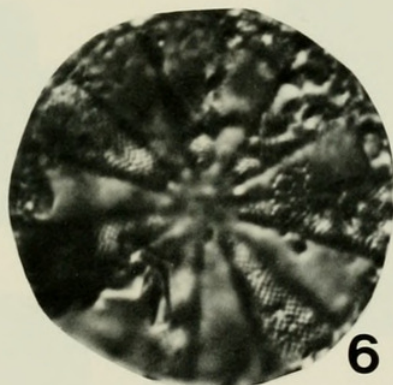
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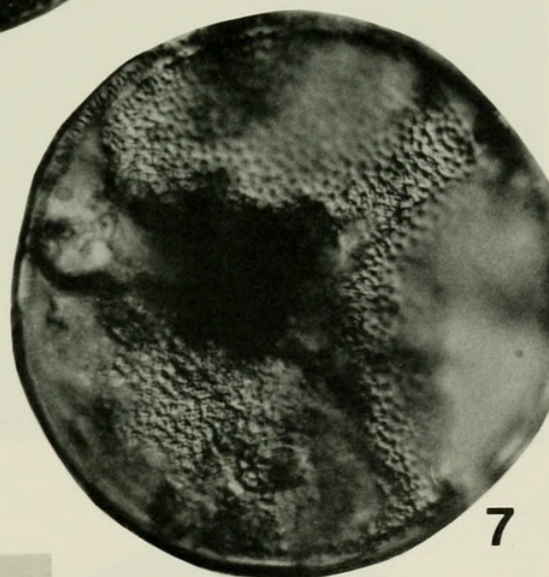
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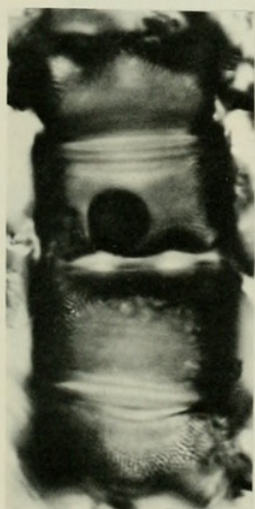
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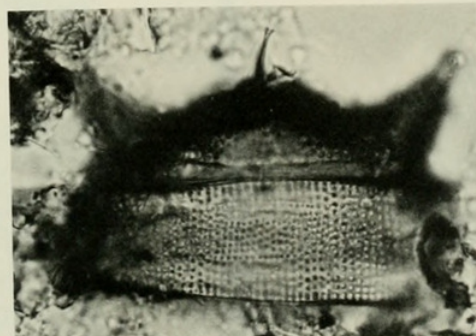
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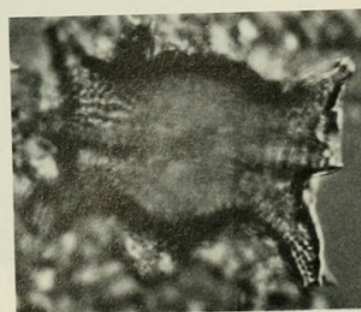
7



8



9



10

Plate 14

FIGURE:

1. *Biddulphia laevis* Ehrenberg; L = 51 μ m.
2. *Biddulphia alternas* (Bailey) Van Heurck; L = 27 μ m.
3. *Hydrosera triquetra* Wallich; L = 72 μ m.
4. *Isthmia nervosa* Kutzing; Scale bar is 100 μ m.
5. *Arachnoidiscus ehrenbergii* Bailey; Scale bar is 40 μ m.
6. *Terpsinoe americana* (Bailey) Ralfs in Pritchard; L = 56 μ m.
7. *Terpsinoe americana* (Bailey) Ralfs in Pritchard; L = 48 μ m; girdle view.
8. *Triceratium dubium* Brightwell; L = 39 μ m.
9. *Rhizosolenia* sp. 1; L = 120 μ m.
10. *Cerataulus turgidus* (Ehrenberg) Ehrenberg; L = 64 μ m.

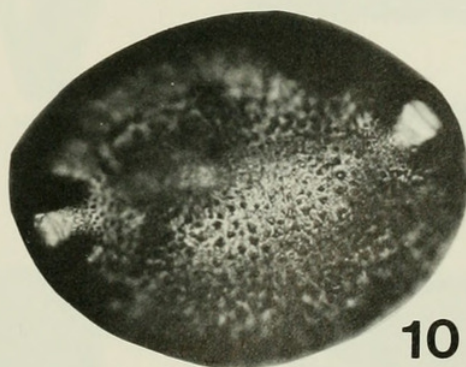
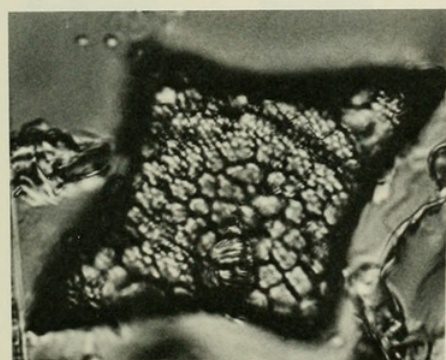
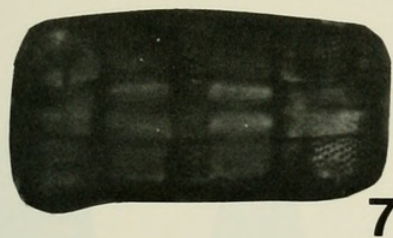
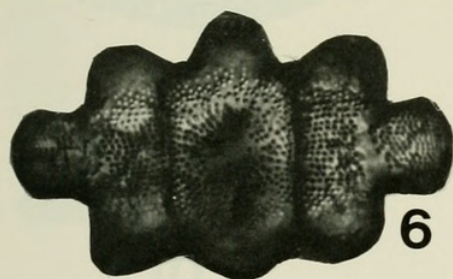
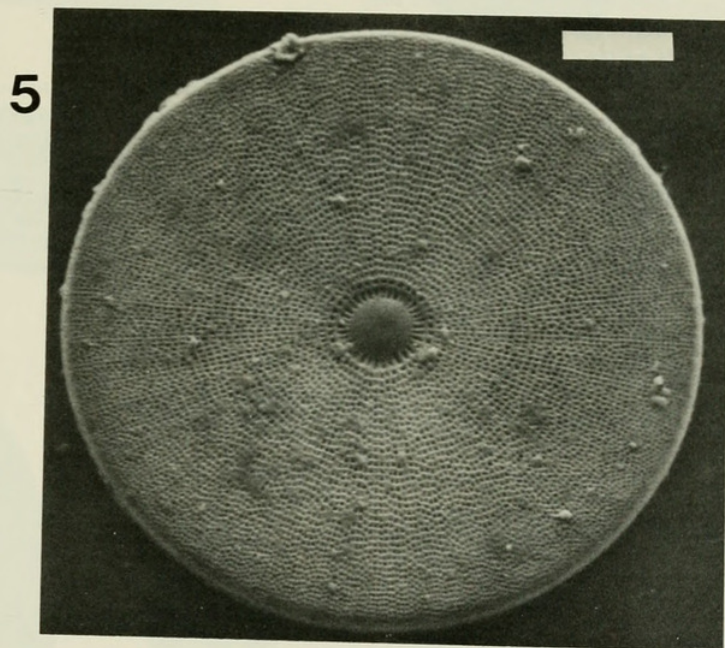
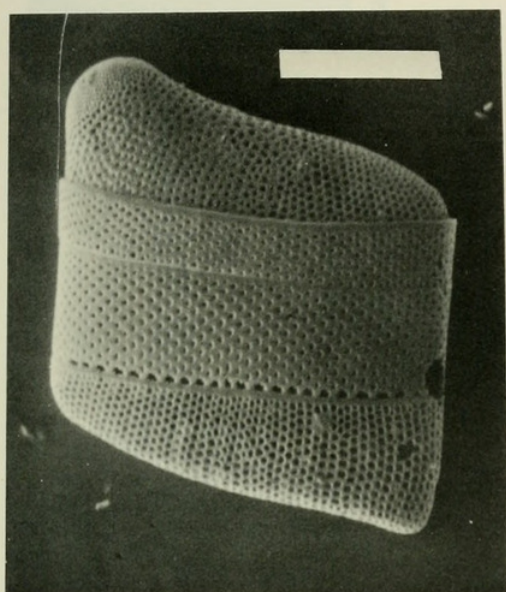
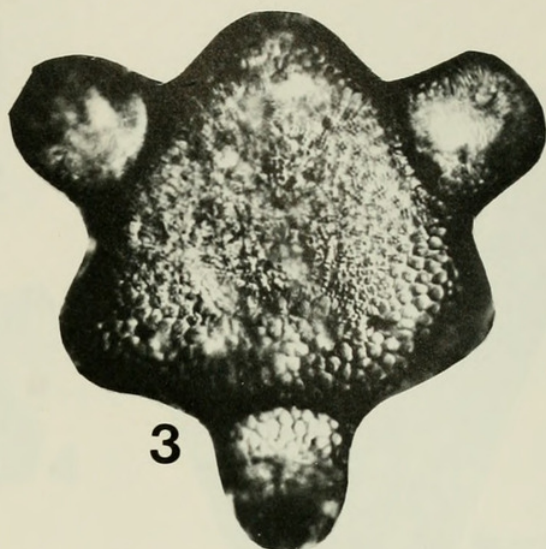
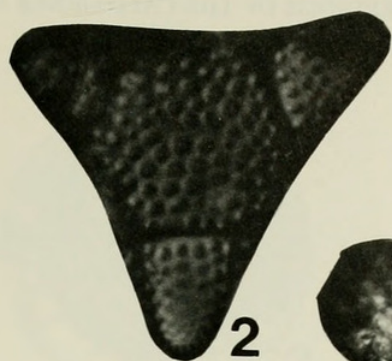
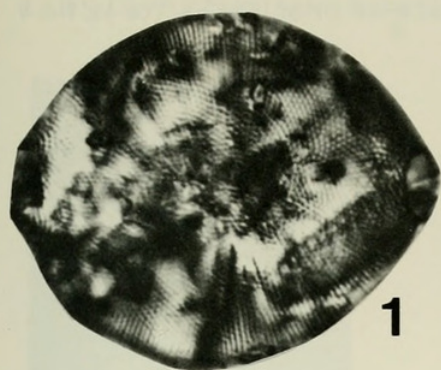


Plate 15

FIGURE:

1. *Chaetoceros cinctus* Gran; L = 26 μ m.
2. *Chaetoceros* sp. 1; D = 16 μ m.
3. *Chaetoceros*? sp. 2; L = 73 μ m (of each spine).
4. *Chaetoceros mitra* (Bailey) Cleve; L = 20 μ m.
5. *Ditylum brightwellii* (West) Grunow in Van Heurck; L = 80 μ m.
6. *Ditylum brightwellii* (West) Grunow in Van Heurck; D = 48 μ m.
7. *Cymatosira belgica* Grunow in Van Heurck; L = 14 μ m; a: dark field, b: bright field, girdle view.
8. *Cymatosira belgica* Grunow in Van Heurck; L = 17 μ m.
9. *Cymatosira belgica* Grunow in Van Heurck; L = 35 μ m.
10. *Eunotogramma marina* (Smith) Peragallo; L = 21 μ m.
11. *Diatoma vulgare* var. *breve* Grunow; L = 22 μ m.
12. *Diatoma anceps* (Ehrenberg) Kirchn. in Cohn; L = 19 μ m.
13. *Cymatosira belgica* Grunow; L = 14 μ m; girdle view.
14. *Grammatophora marina* (Lyngbye) Kutzing; L = 36 μ m.
15. *Dimeregramma minor* (Gregory) Ralfs; L = 48 μ m.
16. *Dimeregramma minor* (Gregory) Ralfs; L = 48 μ m.
17. *Grammatophora marina* (Lyngbye) Kutzing; L = 35 μ m.
18. *Grammatophora marina* (Lyngbye) Kutzing; L = 27 μ m.

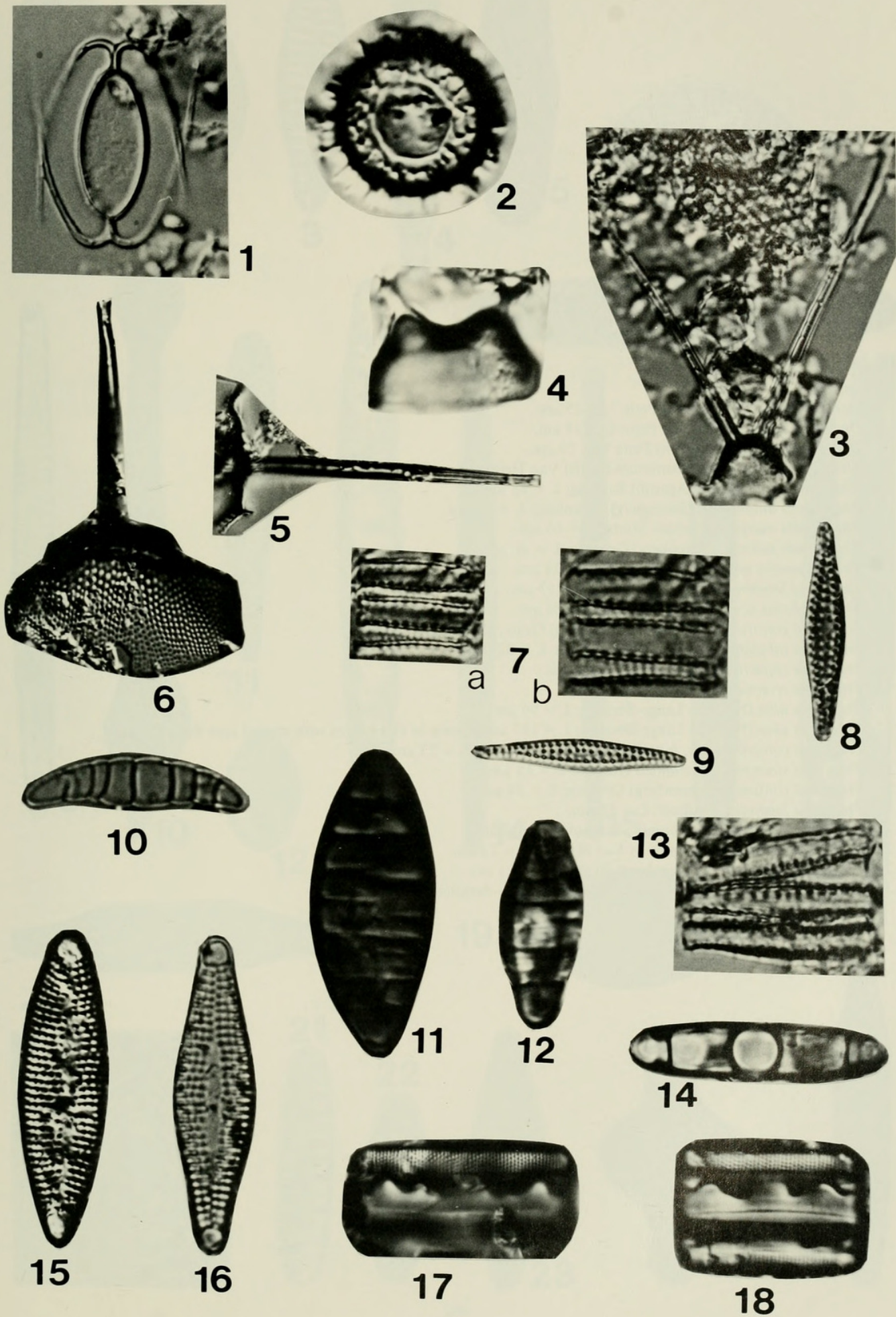


Plate 16

FIGURE:

1. *Opephora swartzii* (Grunow) Petit; L = 25 μ m.
2. *Opephora swartzii* (Grunow) Petit; L = 14 μ m.
3. *Opephora pacifica* (Grunow) Petit; L = 29 μ m.
4. *Meridion circulare* var. *constrictum* (Ralfs) Van Heurck; L = 28 μ m.
5. *Rhabdonema arcuatum* (Agardh) Kutzing; L = 53 μ m.
6. *Rhaphoneis ampiceros* (Ehrenberg) Ehrenberg; L = 35 μ m.
7. *Rhaphoneis margaritalimbata* Mertz; L = 10 μ m.
8. *Rhaphoneis surirella* (Ehrenberg) Grunow; L = 40 μ m.
9. *Thalassionema nitzschioides* Hustedt; L = 74 μ m.
10. *Tabellaria fenestra* (Lyngbye) Kutzing; L = 97 μ m.
11. *Trachysphenia acuminata* Peragallo?; L = 29 μ m.
12. *Fragilaria construens* var. *venter* (Ehrenberg) Grun.; L = 10 μ m.
13. *Fragilaria tabulata* (Agardh) Lange-Bertalot; L = 82 μ m.
14. *Fragilaria capucina* Desmazieres; L = 48 μ m.
15. *Fragilaria crotonensis* Kitton; L = 88 μ m.
16. *Fragilaria ulna* (Nitzsch) Lange-Bertalot; L = 96 μ m.
17. *Fragilaria ulna* (Nitzsch) Lange-Bertalot; L = 187 μ m; shown in two halves with central area for reference.
18. *Fragilaria construens* var. *binodis* (Ehrenberg) Grunow; L = 23 μ m.
19. *Fragilaria virescens* var. *elliptica* Hustedt; L = 15 μ m.
20. *Fragilaria construens* (Ehrenberg) Grunow; L = 24 μ m.
21. *Fragilaria lapponica* Grunow; L = 15 μ m.
22. *Fragilaria construens* var. *pumilla* Grunow; L = 12 μ m.
23. *Fragilaria brevistriata* Grunow in Van Heurck; L = 21 μ m.
24. *Fragilaria leptostauron* (Ehrenberg) Hustedt; L = 21 μ m.
25. *Fragilaria capucina* var. *vaucheriae* (Kutzing) Lange-Bertalot; L = 27 μ m.

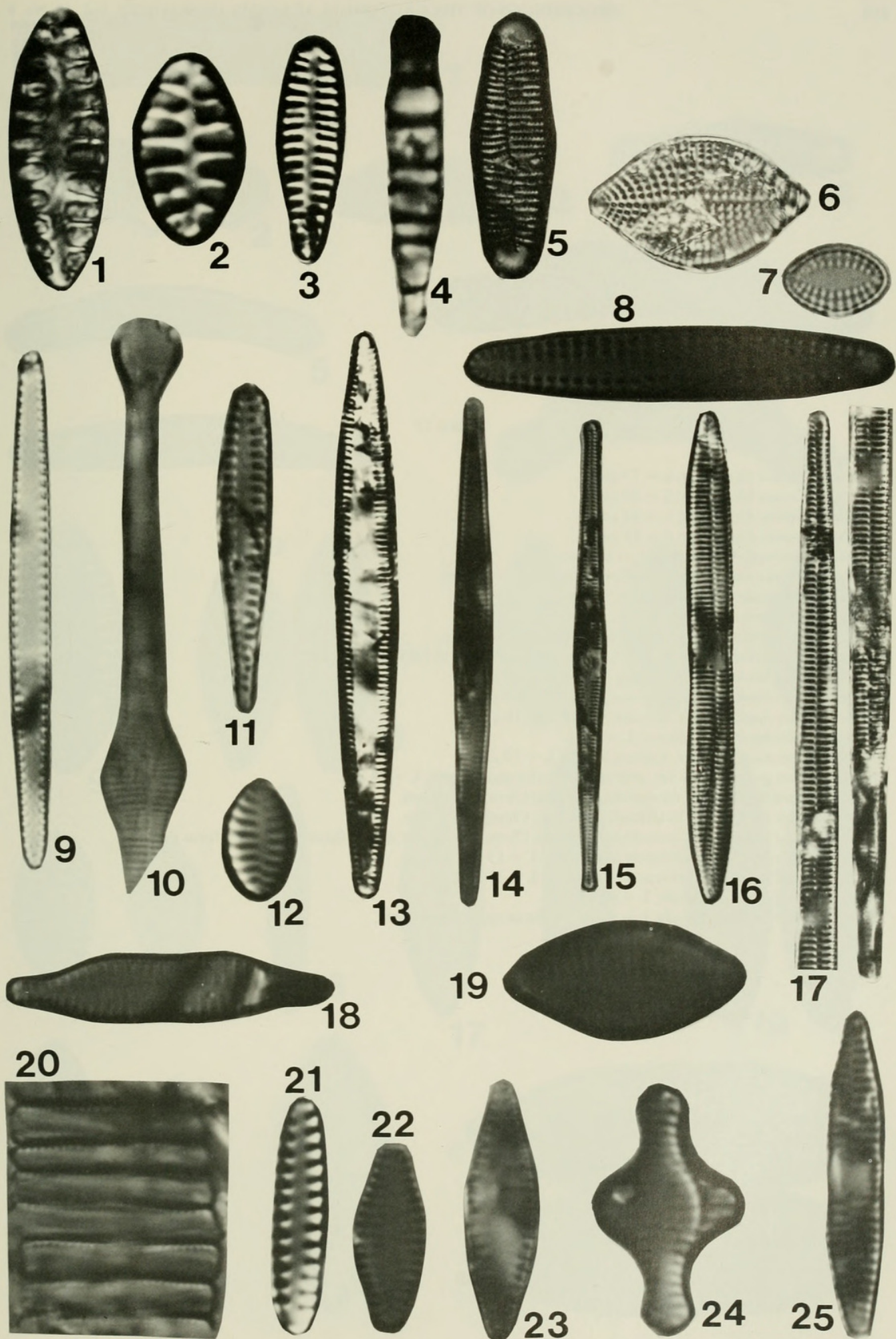
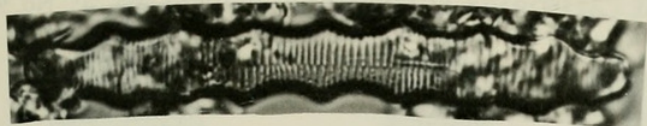


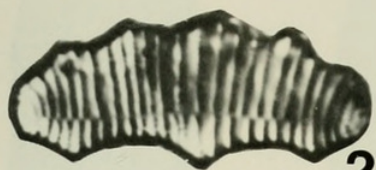
Plate 17

FIGURE:

1. *Eunotia eruca* Ehrenberg; L = 77 μ m.
2. *Eunotia eruca* Ehrenberg; L = 27 μ m.
3. *Eunotia eruca* Ehrenberg; L = 34 μ m.
4. *Eunotia arcus* Ehrenberg; L = 25 μ m.
5. *Eunotia monodon* Ehrenberg; L = 62 μ m.
6. *Eunotia arcus* var. *bidens* (Ehrenberg) Grunow; L = 50 μ m.
7. *Eunotia monodon* Ehrenberg; L = 52 μ m.
8. *Eunotia triodon* Ehrenberg; L = 32 μ m.
9. *Achnanthes conspicua* var. *brevistriata* Hustedt; L = 24 μ m.
10. *Achnanthes wellsiae* Reimer; L = 16 μ m; a: RV focus up, b: PRV focus down.
11. *Achnanthes haukiana* var. *rostrata* Schulz; L = 12 μ m.
12. *Achnanthes haukiana* var. *rostrata* Schulz; L = 10 μ m.
13. *Achnanthes haukiana* var. *rostrata* Schulz; L = 16 μ m.
14. *Achnanthes haukiana* Grunow; L = 8 μ m.
15. *Achnanthes haukiana* var. *rostrata* Schulz; L = 10 μ m.
16. *Achnanthes groenlandica* var. *phinneyi* McIntire and Reimer; L = 18 μ m.
17. *Achnanthes brevipes* var. *intermedia* (Kutzing) Cleve; L = 38 μ m.
18. *Achnanthes brevipes* var. *intermedia* (Kutzing) Cleve; L = 62 μ m.
19. *Achnanthes brevipes* var. *intermedia* (Kutzing) Cleve; L = 43 μ m; a: RV focus up, b: PRV focus down.
20. *Achnanthes lanceolata* Brébisson in Kutzing; L = 15 μ m.
21. *Achnanthes lanceolata* Brébisson in Kutzing; L = 11 μ m.
22. *Achnanthes brevipes* Agardh; L = 47 μ m.
23. *Achnanthes longipes* Agardh; L = 52 μ m; a: focus up, b: focus down.



1



2



3



4



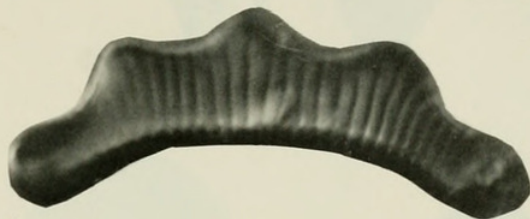
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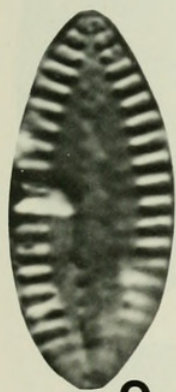
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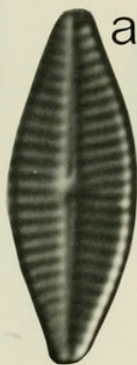
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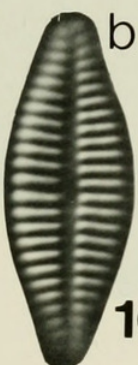
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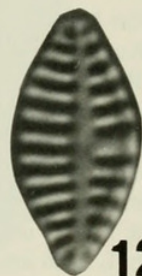
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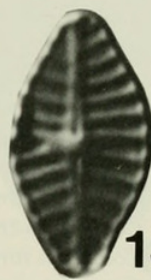
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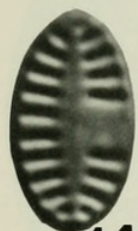
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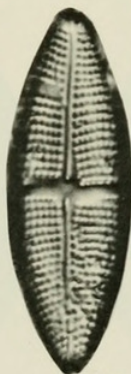
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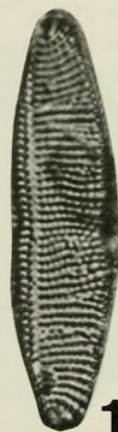
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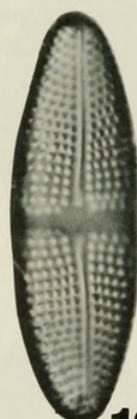
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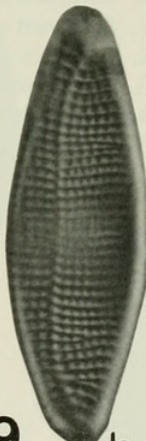
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18



a 19



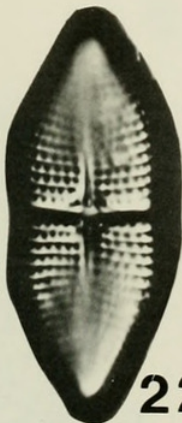
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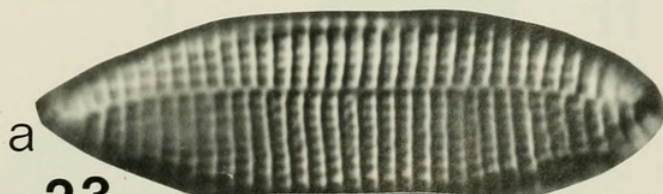
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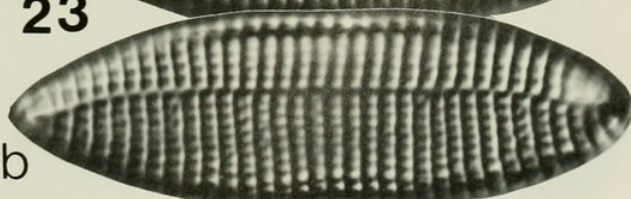


22



a

23



b

Plate 18

FIGURE:

1. *Achnanthes yaquiniensis* McIntire and Reimer; L = 37 μm .
2. *Achnanthes parvula* Kutzing; L = 31 μm ; a: RV focus up, b: PRV focus down.
3. *Achnanthes wellsiae* Reimer?; L = 16 μm ; a: RV focus up, b: PRV focus down.
4. *Cocconeis scutellum* Ehrenberg; L = 25 μm .
5. *Cocconeis placentula* Ehrenberg; L = 24 μm ; a: central area, focus up, b: margin focus down.
6. *Cocconeis placentula* Ehrenberg; L = 30 μm .
7. *Cocconeis vitrea* Brun; L = 41 μm .
8. *Cocconeis vitrea* Brun; L = 44 μm .
9. *Cocconeis vitrea* Brun; L = 26 μm .
10. *Cocconeis diminuta* Pantocsek; L = 13 μm .
11. *Cocconeis diminuta* Pantocsek; L = 11 μm .
12. *Cocconeis diminuta* Pantocsek; L = 15 μm .
13. *Cocconeis californica* (Grunow) Cleve; L = 19 μm .
14. *Cocconeis californica* (Grunow) Cleve; L = 19 μm .
15. *Cocconeis decipiens* Cleve; L = 40 μm .
16. *Cocconeis* sp. 1; L = 19 μm .

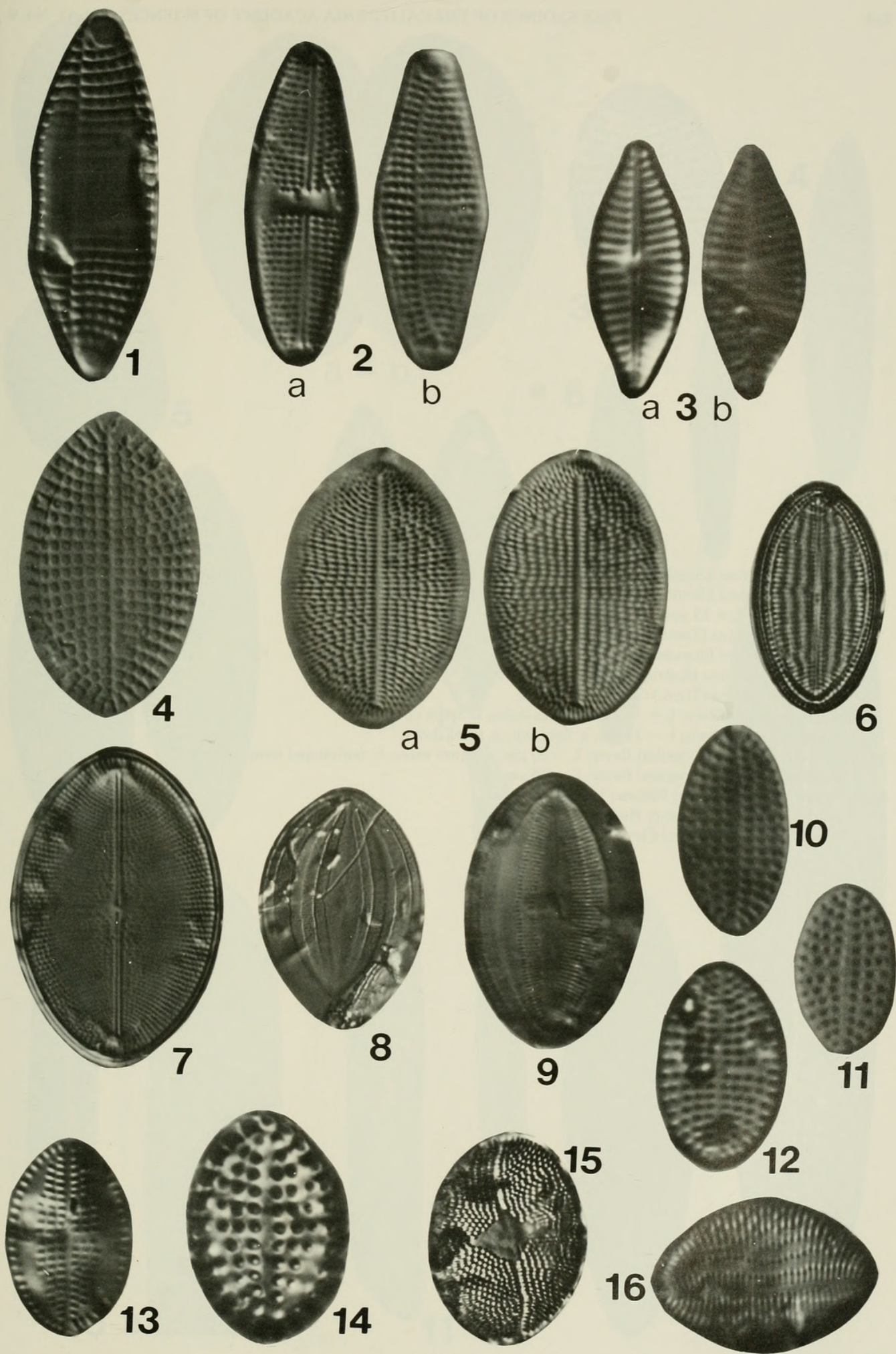


Plate 19

FIGURE:

1. *Cocconeis fasciolata* Ehrenberg; L = 26 μ m.
2. *Cocconeis fasciolata* Ehrenberg; L = 29 μ m; a: focus up, b: focus down.
3. *Cocconeis* sp. 2; L = 15 μ m.
4. *Amphipleura rutilans* (Trent.) Cleve; L = 30 μ m.
5. *Cocconeis scutellum* Ehrenberg?; L = 24 μ m.
6. *Rhoicosphenia curvata* (Kutzing) Grun. in Rabenhorst; L = 29 μ m.
7. *Amphipleura rutilans* (Trent.) Cleve; L = 24 μ m.
8. *Mastogloia exigua* Lewis; L = 30 μ m; a: focus down, b: focus up.
9. *Mastogloia exigua* Lewis; L = 35 μ m; a: focus up, b: focus down.
10. *Gyrosigma eximium* (Thwaites) Boyer; L = 90 μ m; a: entire valve, b: central and terminal nodules.
11. *Gyrosigma eximium* (Thwaites) Boyer; L = 86 μ m.
12. *Gyrosigma exile* (Grunow) Reimer; L = 88 μ m.
13. *Frustulia asymmetrica* (Cleve) Hustedt; L = 65 μ m.
14. *Frustulia interposita* (Lewis) Cleve; L = 100 μ m.

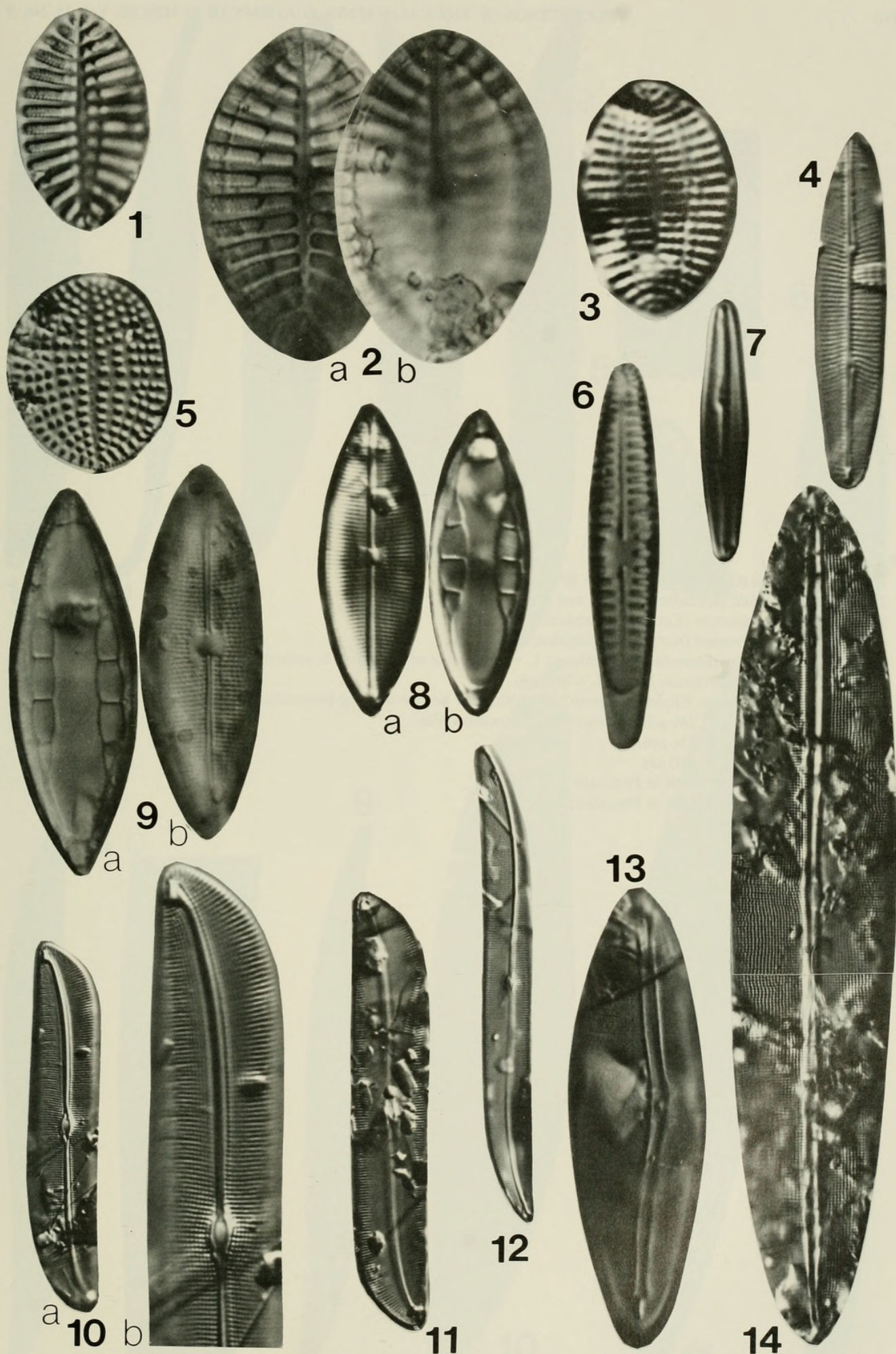


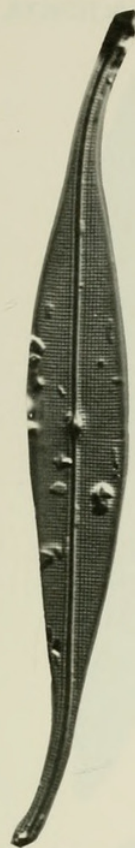
Plate 20

FIGURE:

1. *Gyrosigma exile* (Grunow) Reimer; L = 80 μ m.
2. *Gyrosigma fasciola* (Ehrenberg) Griffen and Henfrey; L = 112 μ m.
3. *Gyrosigma acuminatum* (Kutzing) Rabenhorst; L = 84 μ m.
4. *Gyrosigma acuminatum* (Kutzing) Rabenhorst; L = 84 μ m.
5. *Gyrosigma balticum* (Ehrenberg) Rabenhorst; L = 250 μ m; a: entire valve, b: central area.
6. *Pleurosigma diverse-striatum* Meist.; L = 108 μ m.
7. *Pleurosigma angulatum* (Queckett) Smith?; $\times 1,250$; polar nodule showing perpendicular striae.
8. *Pleurosigma* sp. 1; L = 240 μ m; a: entire valve, b: central area.
9. *Pleurosigma* sp. 1; L = 256 μ m.
10. *Pleurosigma* sp. 2; L = 220 μ m.
11. *Pleurosigma normanii* Ralfs in Pritchard; L = 216 μ m.
12. *Pleurosigma normanii* Ralfs in Pritchard; L = 190 μ m.



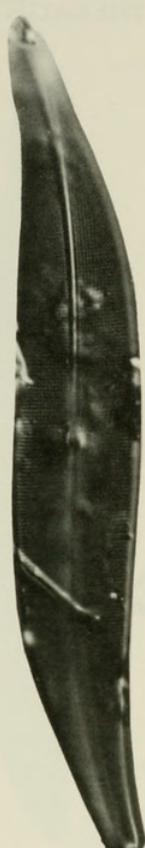
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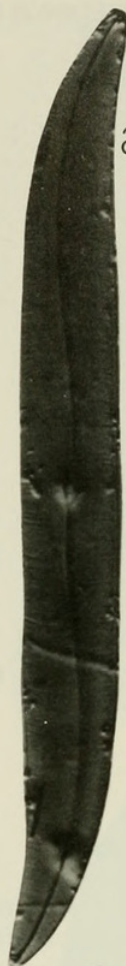
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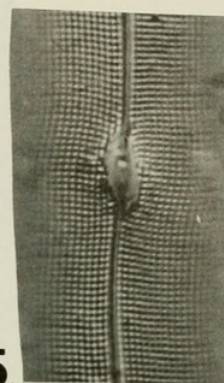
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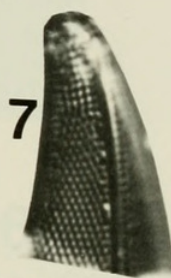


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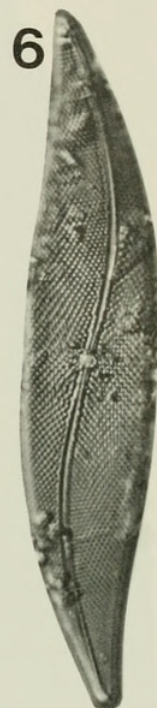


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b



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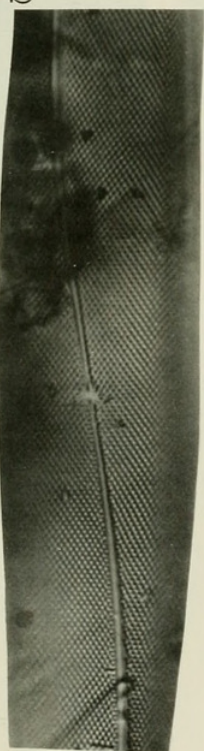


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a

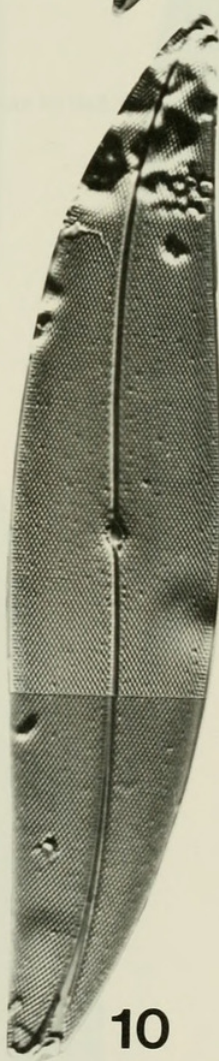
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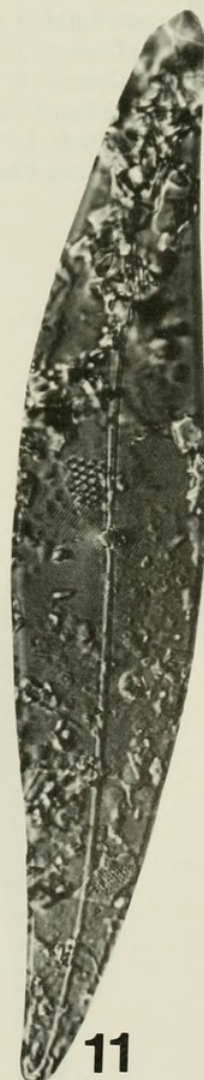
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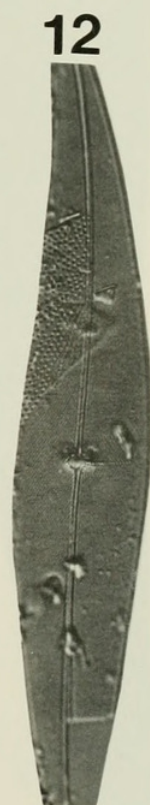
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10



11



12

Plate 21

FIGURE:

1. *Pleurosigma strigosum* Smith; L = 232 μm .
2. *Pleurosigma strigosum* Smith; L = 201 μm .
3. *Pleurosigma strigosum* Smith; L = 160 μm ; a: entire valve, b: central area and terminal nodule.
4. *Pleurosigma strigosum* Smith; L = 230 μm ; a: entire valve, b: end, c: central area.
5. *Pleurosigma formosum* Smith; L = 525 μm .
6. *Pleurosigma australe* Grunow; L = 109 μm .
7. *Pleurosigma australe* Grunow; L = 102 μm .
8. *Pleurosigma angulatum* Smith?; L = 110 μm . (For half of valve.)
9. *Stauroneis obtusa* Lagerstedt; L = 32 μm .
10. *Stauroneis smithii* var. *incisa* Pantocsek; L = 30 μm .

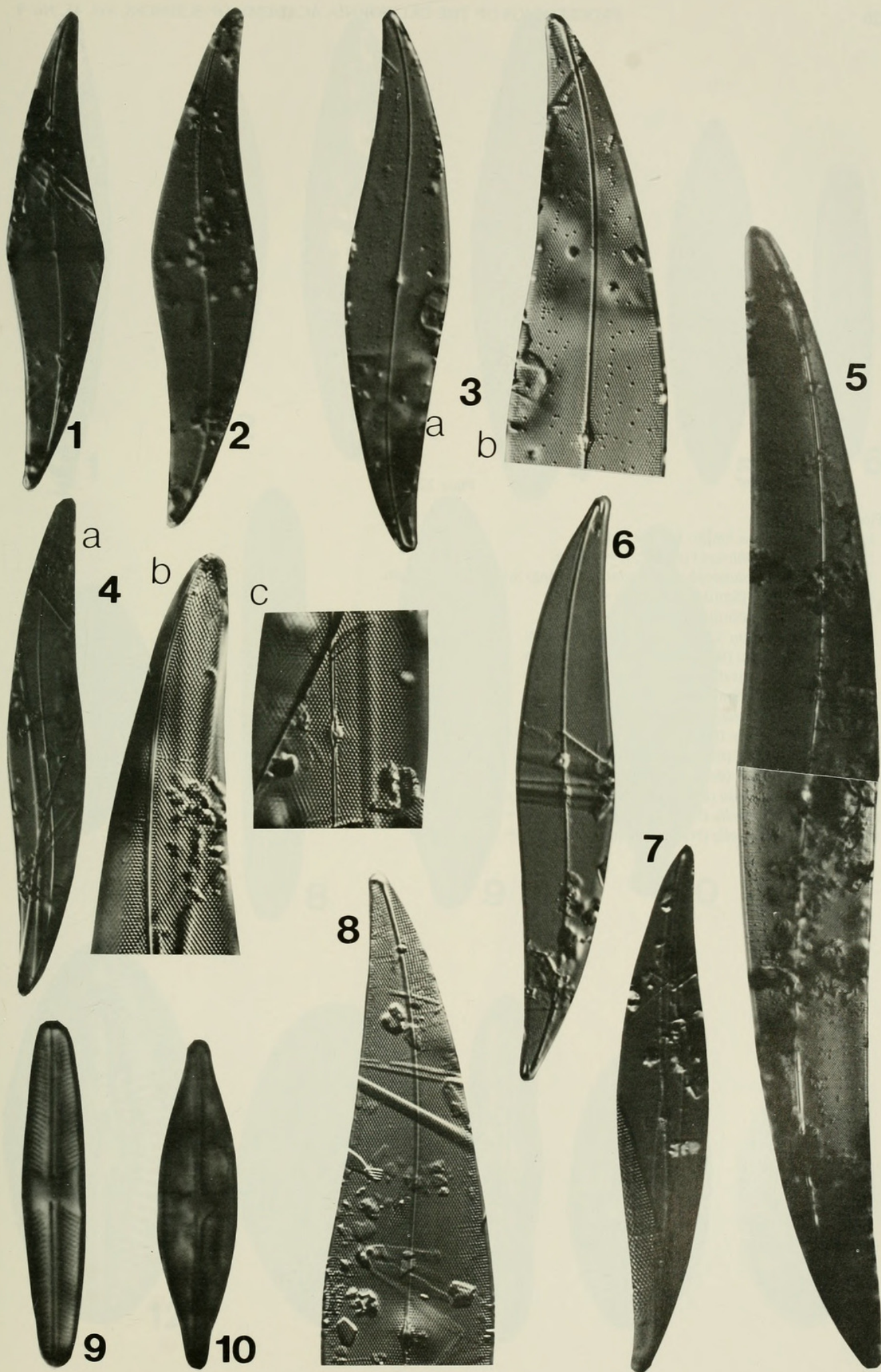


Plate 22

FIGURE:

1. *Stauroneis acuta* Smith; L = 80 μ m.
2. *Stauroneis amphioxys* Gregory; L = 40 μ m.
3. *Anomoeoneis sphaerophora* f. *costata* (Kutzing) Schmid; L = 75 μ m.
4. *Caloneis westii* (Smith) Hendey; L = 88 μ m.
5. *Caloneis westii* (Smith) Hendey; L = 65 μ m.
6. *Caloneis bacillum* (Grunow) Cleve; L = 29 μ m.
7. *Diploneis smithii* (Brébisson) Cleve; L = 38 μ m.
8. *Caloneis alpestris* (Grunow) Cleve; L = 67 μ m.
9. *Caloneis westii* (Smith) Hendey; L = 77 μ m.
10. *Caloneis amphisbaena* (Bory) Cleve; L = 72 μ m.
11. *Caloneis bacillum* (Grunow) Cleve; L = 39 μ m.
12. *Diploneis smithii* (Brébisson) Cleve; L = 36 μ m.
13. *Diploneis smithii* (Brébisson) Cleve; L = 29 μ m.
14. *Caloneis ventricosa* (Ehrenberg) Meister; L = 61 μ m.
15. *Diploneis oblongella* (Naeg. in Kutzing) Ross; L = 29 μ m.
16. *Diploneis oblongella* (Naeg. in Kutzing) Ross; L = 25 μ m.

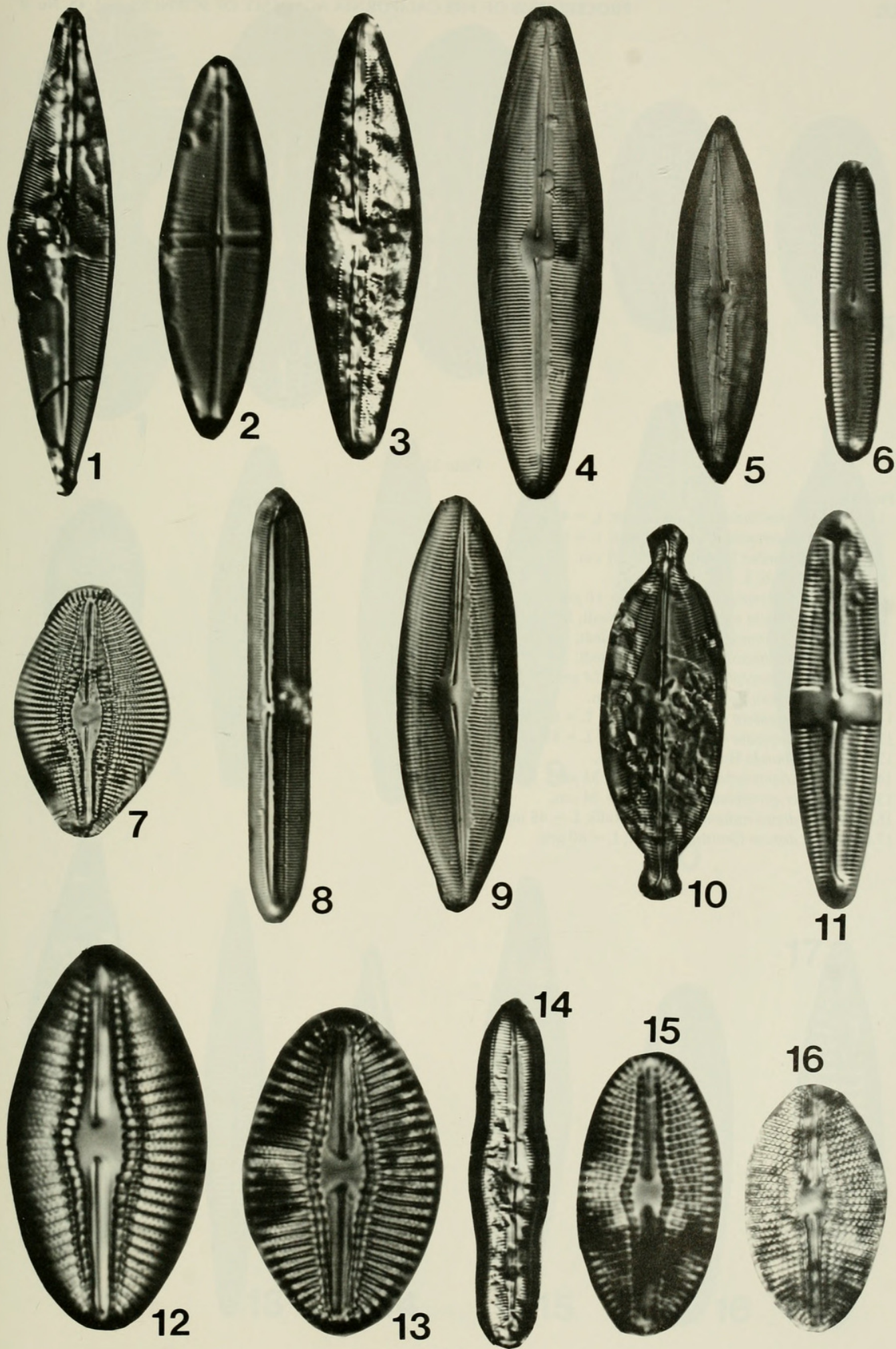
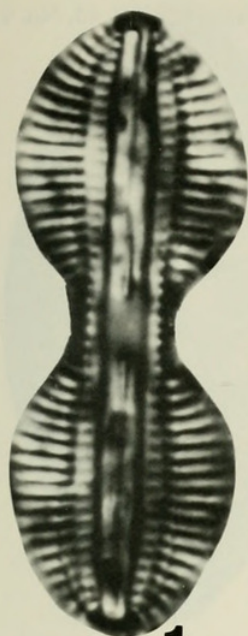


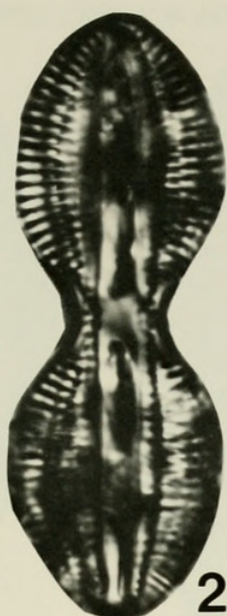
Plate 23

FIGURE:

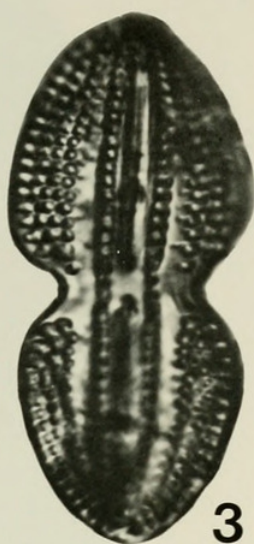
1. *Diploneis interrupta* (Kutzing) Cleve; L = 40 μ m.
2. *Diploneis interrupta* (Kutzing) Cleve; L = 60 μ m.
3. *Diploneis bombus* Ehrenberg; L = 51 μ m.
4. *Diploneis* sp. 6; L = 27 μ m.
5. *Diploneis decipiens* Cleve-Euler; L = 16 μ m.
6. *Diploneis papula* var. *constricta* Hustedt; L = 21 μ m.
7. *Navicula circumtexta* Meister in Hustedt; L = 29 μ m.
8. *Navicula circumtexta* Meister in Hustedt; L = 29 μ m.
9. *Navicula cryptocephala* Kutzing; L = 24 μ m.
10. *Navicula aurora* Sovereign; L = 64 μ m.
11. *Navicula cuspidata* (Kutzing) Kutzing; L = 69 μ m.
12. *Navicula cuspidata* (Kutzing) Kutzing; L = 88 μ m.
13. *Navicula abunda* Hustedt; L = 71 μ m.
14. *Navicula cryptocephala* Kutzing; L = 34 μ m.
15. *Navicula cryptocephala* Kutzing; L = 34 μ m.
16. *Navicula digito-radiata* (Gregory) Ralfs; L = 48 μ m.
17. *Navicula distans* (Smith) Schmidt; L = 80 μ m.



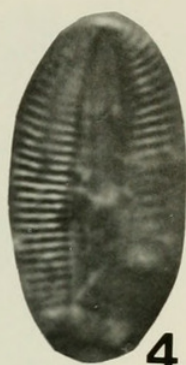
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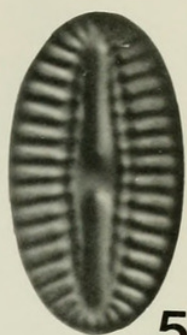
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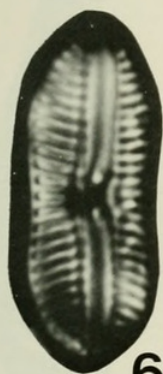
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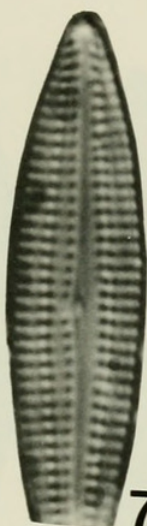
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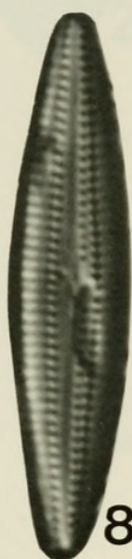
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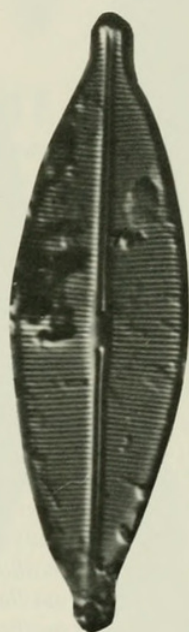
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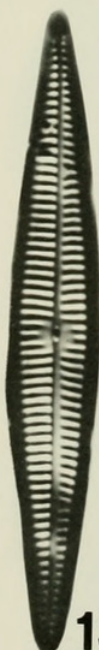
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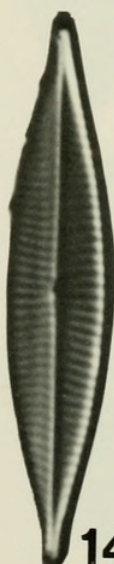
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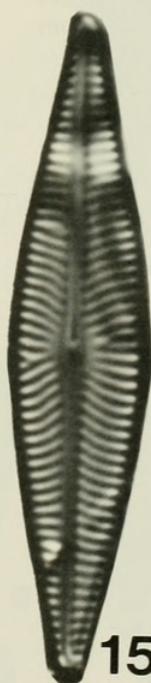
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13



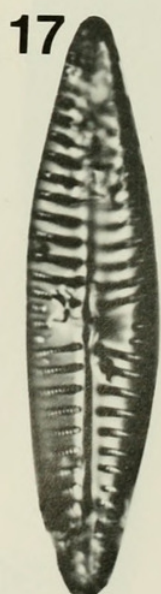
14



15



16



17

Plate 24

FIGURE:

1. *Navicula punctulata* Smith; L = 93 μ m.
2. *Navicula granulata* Bailey; L = 60 μ m.
3. *Navicula elginensis* (Gregory) Ralfs; L = 32 μ m.
4. *Navicula gregaria* Donkin; L = 24 μ m.
5. *Navicula gregaria* Donkin; L = 22 μ m.
6. *Navicula salinarum* Grunow; L = 34 μ m.
7. *Navicula salinarum* Grunow; L = 24 μ m.
8. *Navicula salinarum* Grunow; L = 28 μ m.
9. *Navicula gregaria* Donkin; L = 22 μ m.
10. *Navicula gregaria* Donkin; L = 23 μ m.
11. *Navicula gregaria* Donkin; L = 27 μ m.
12. *Navicula hummii* Hustedt; L = 19 μ m; a: focus up, b: focus down.
13. *Navicula mutica* Kutzing; L = 22 μ m.
14. *Navicula mutica* Kutzing; L = 16 μ m.
15. *Navicula pusilla* var. 1; L = 14 μ m.
16. *Navicula pusilla* Smith; L = 38 μ m.
17. *Navicula pusilla* var. 1; L = 25 μ m.
18. *Navicula pygmaea* Kutzing; L = 24 μ m.
19. *Navicula peregrina* (Ehrenberg) Kutzing; L = 113 μ m.
20. *Navicula peregrina* (Ehrenberg) Kutzing; L = 120 μ m.

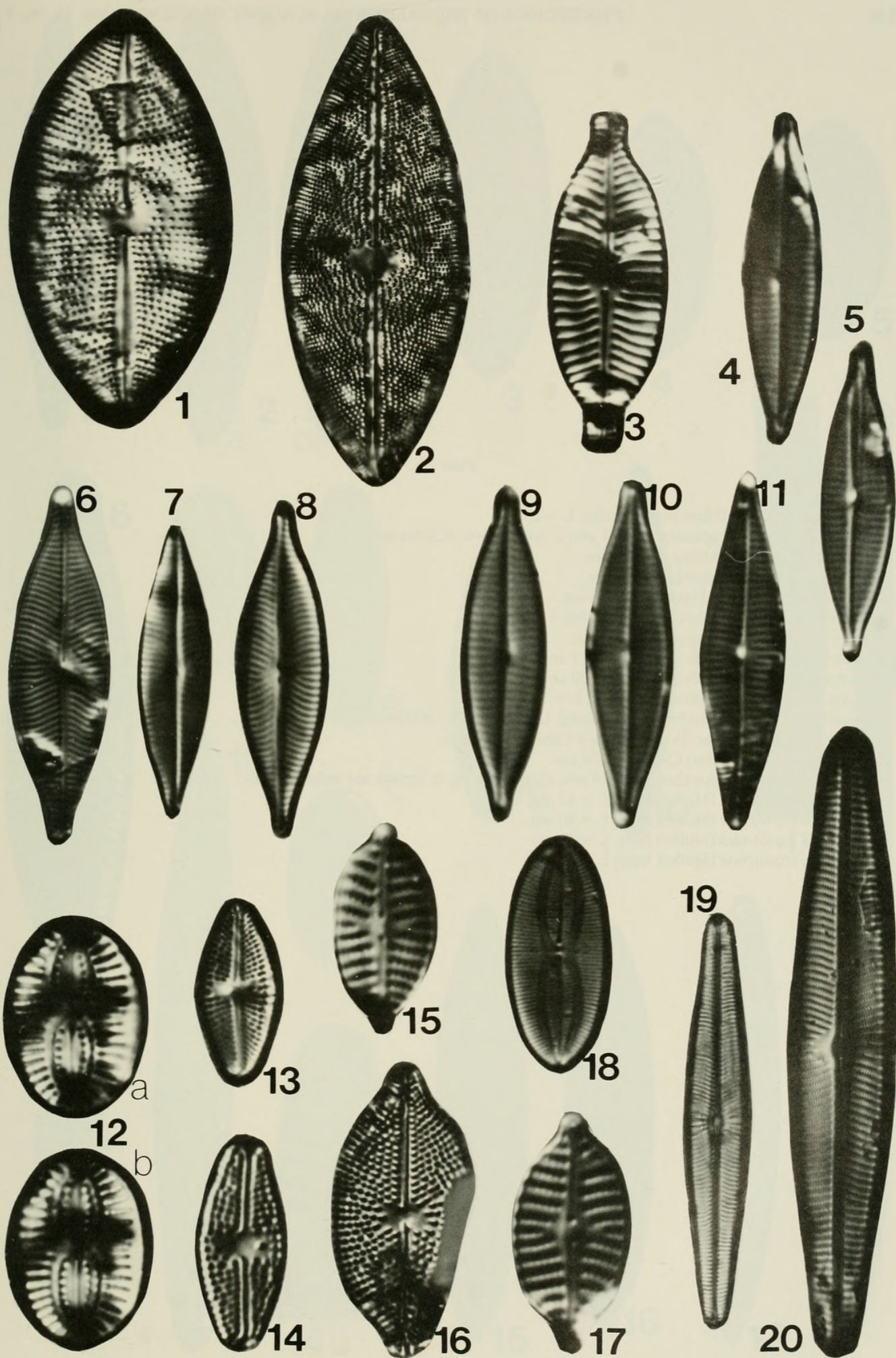


Plate 25

FIGURE:

1. *Navicula peregrina* (Ehrenberg) Kutzing; L = 55 μ m.
2. *Navicula expansa* Haglestein; L = 83 μ m; a: focus down, b: focus up.
3. *Navicula pygmeae* Kutzing; L = 32 μ m.
4. *Navicula pygmeae* Kutzing; L = 24 μ m.
5. *Navicula subforcipata* Hustedt; L = 16 μ m.
6. *Navicula pseudolanceolata* Lange-Bertalot; L = 52 μ m.
7. *Navicula auriculata* Hustedt; L = 10 μ m.
8. *Achnanthes lanceolata* Brébisson; L = 17 μ m.
9. *Achnanthes lanceolata* Brébisson; L = 20 μ m.
10. *Navicula secreta* var. *apiculata* Patrick; L = 33 μ m.
11. *Navicula scopulorum* Brébisson in Kutzing; L = 221 μ m; a: entire valve, b: central area.
12. *Navicula reichardtii* var. *tschuktschorum* Cleve; L = 11 μ m.
13. *Navicula spicula* (Hickie) Cleve; L = 56 μ m.
14. *Pinnularia borealis* Ehrenberg; L = 34 μ m; a: entire valve, b: central and polar nodules.
15. *Navicula tripunctata* (Muller) Bory; L = 42 μ m.
16. *Navicula tripunctata* (Muller) Bory; L = 40 μ m.
17. *Navicula tripunctata* (Muller) Bory; L = 30 μ m.
18. *Navicula tripunctata* (Muller) Bory; L = 26 μ m.

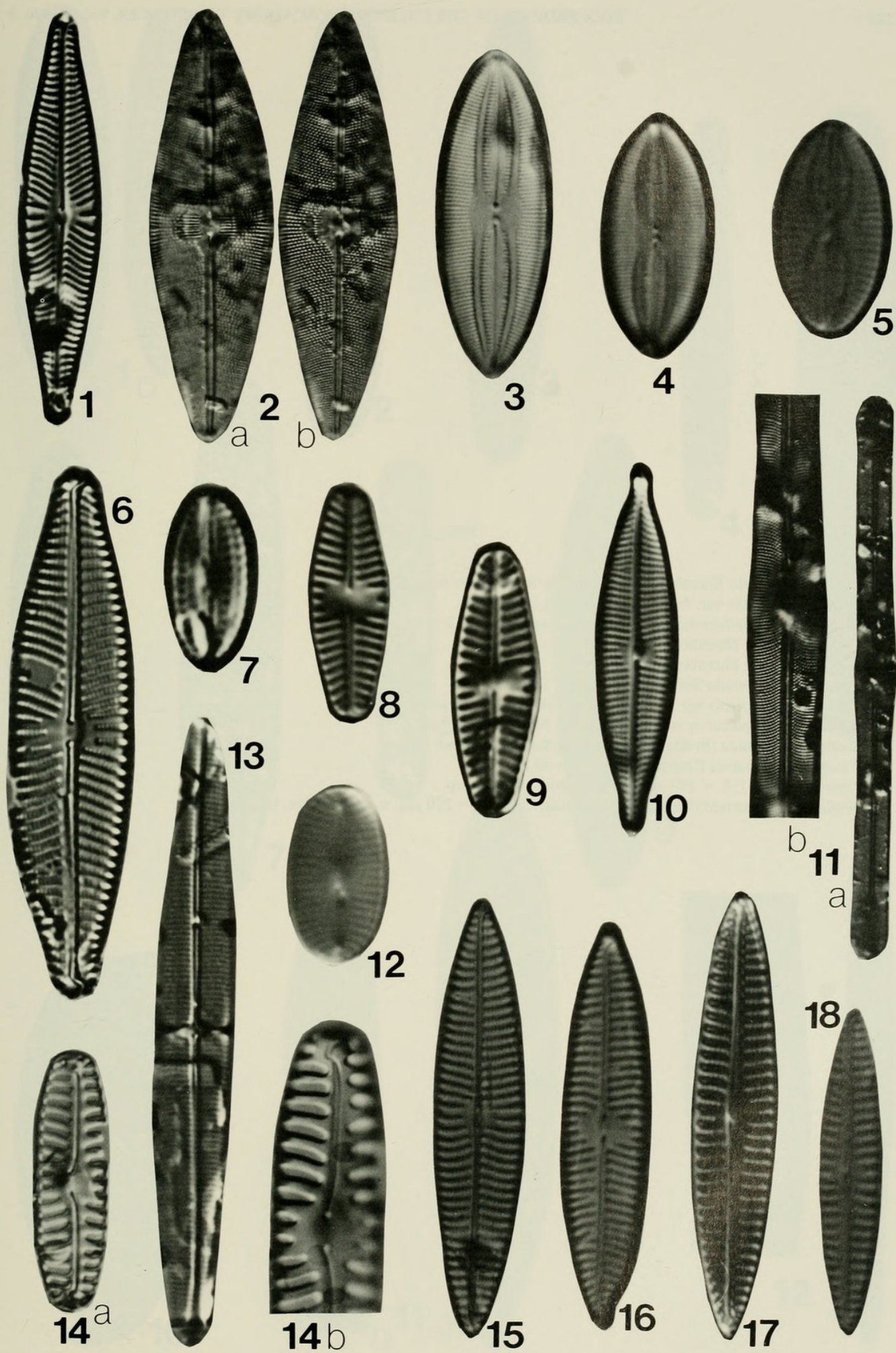


Plate 26

FIGURE:

1. *Pinnularia borealis* Ehrenberg; L = 56 μm ; a: focus up, b: focus down.
2. *Pinnularia borealis* var. *brevicostata* Hustedt; L = 57 μm .
3. *Pinnularia subcapitata* var. *paucistriata* (Grunow) Cleve; L = 40 μm .
4. *Pinnularia gibba* Ehrenberg; L = 48 μm .
5. *Pinnularia gibba* Ehrenberg; L = 59 μm .
6. *Pinnularia acuminata* Smith; L = 43 μm .
7. *Pinnularia abaujensis* var. *rostrata* (Patr.) Patrick; L = 48 μm .
8. *Pinnularia microstauron* var. *biundulata* O. Müller; L = 59 μm .
9. *Scoliopleura tumida* (Brébisson in Kützing) Rabenhorst; L = 89 μm .
10. *Entomoneis paludosa* (Smith) Reimer; L = 40 μm .
11. *Entomoneis* sp. 1; L = 109 μm ; a: focus down, b: focus up.
12. *Scoliotropis latestriata* (Brébisson in Kützing) Cleve; L = 260 μm ; a: entire valve, b: central area.

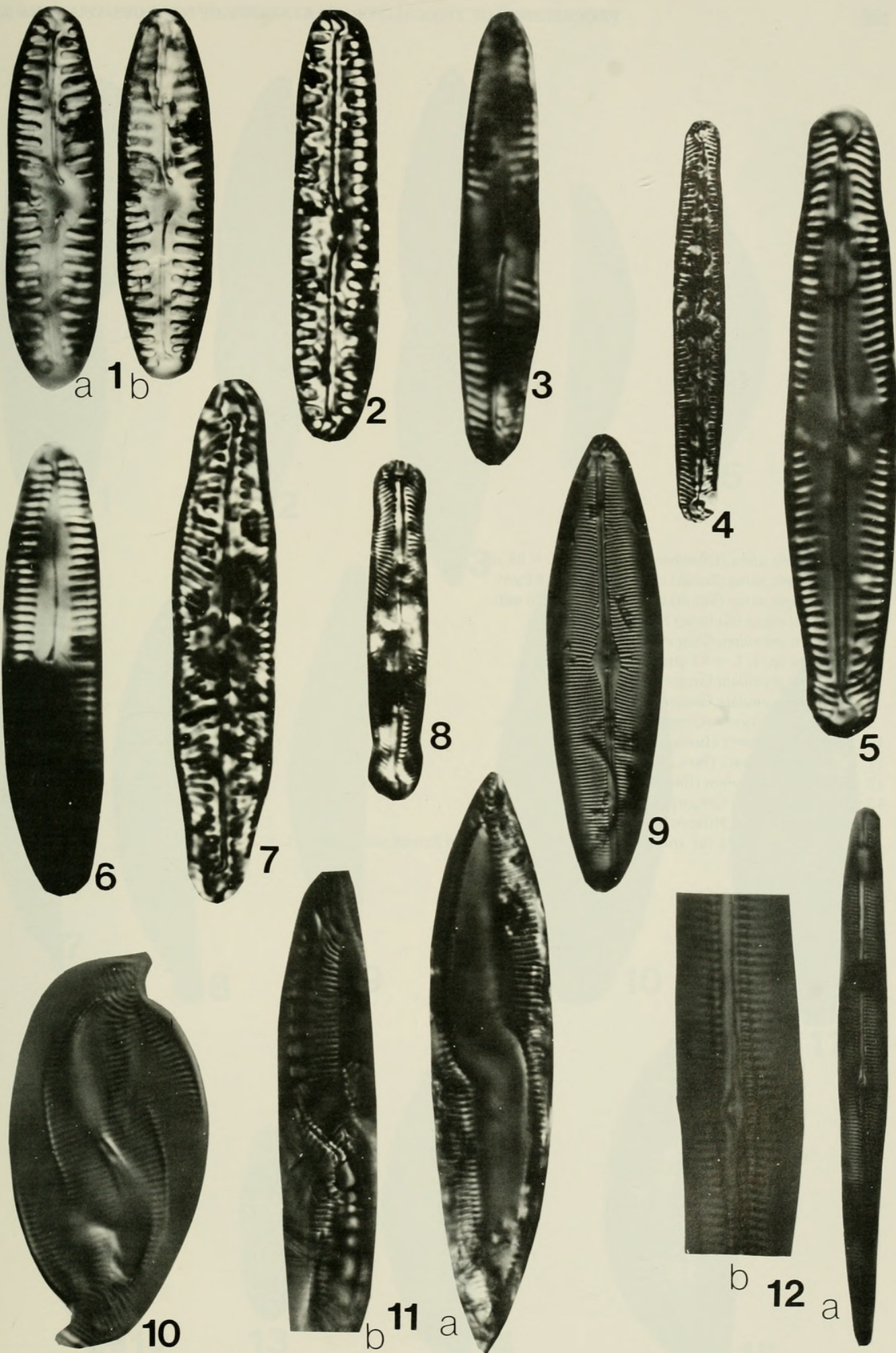
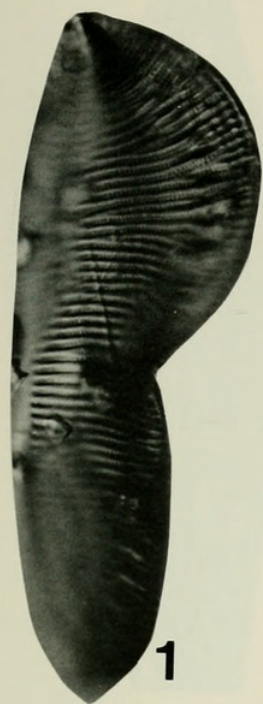


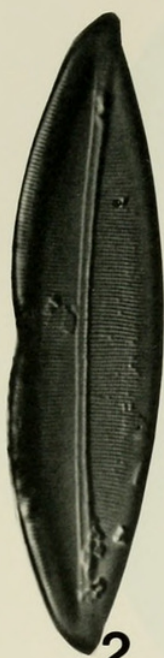
Plate 27

FIGURE:

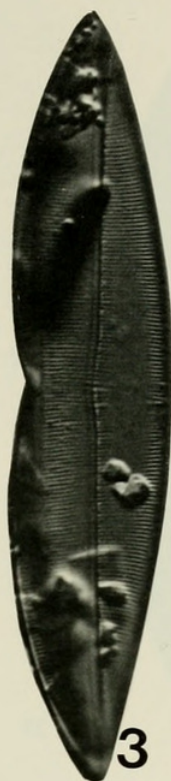
1. *Entomoneis alata* (Ehrenberg) Ehrenberg; L = 88 μ m.
2. *Plagiotropis vitrea* (Smith) comb. nov.; L = 82 μ m.
3. *Plagiotropis vitrea* (Smith) comb. nov.; L = 96 μ m.
4. *Amphora ovalis* (Kutzing) Kutzing; L = 23 μ m.
5. *Amphora granulata* Gregory; L = 24 μ m.
6. *Amphora* sp. 1; L = 43 μ m.
7. *Amphora granulata* Gregory; L = 74 μ m.
8. *Amphora granulata* Gregory; L = 40 μ m.
9. *Amphora ventricosa* (Gregory) Hendey; L = 43 μ m.
10. *Amphora sublaevis* Hustedt; L = 51 μ m.
11. *Cymbella prostrata* (Berk.) Cleve; L = 56 μ m.
12. *Cymbella triangulum* (Ehrenberg) Cleve; L = 50 μ m.
13. *Cymbella sinuata* Gregory; L = 15 μ m.
14. *Cymbella minuta* Hilse in Rabenhorst; L = 24 μ m.
15. *Cymbella prostrata* var. *auerswaldii* (Rabhorst) Reimer in Patrick and Reimer; L = 28 μ m.



1



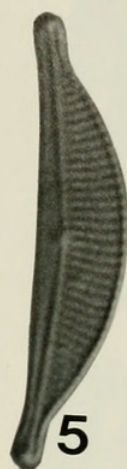
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3



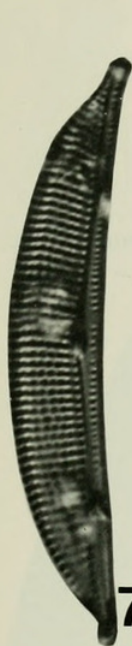
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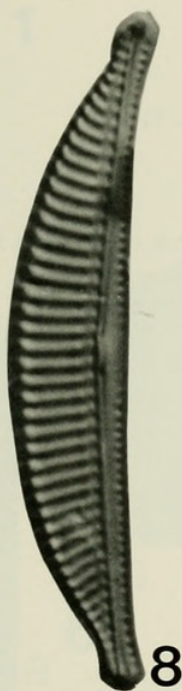
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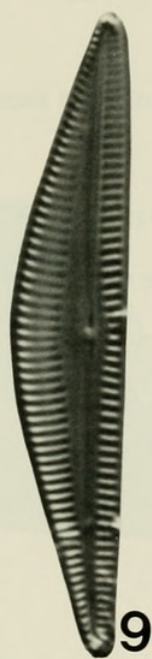
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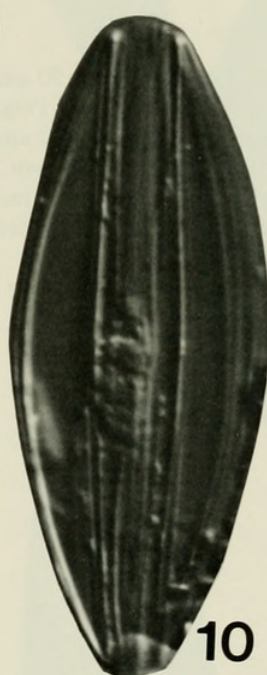
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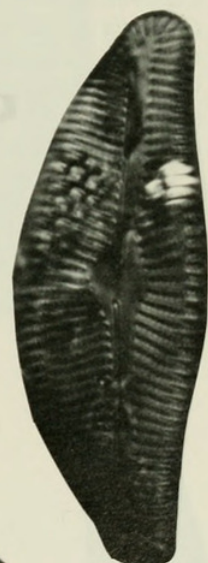
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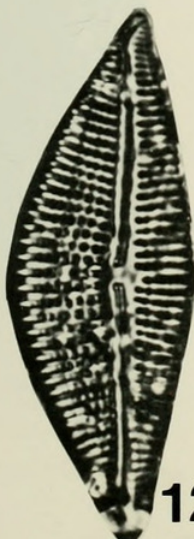
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10



11



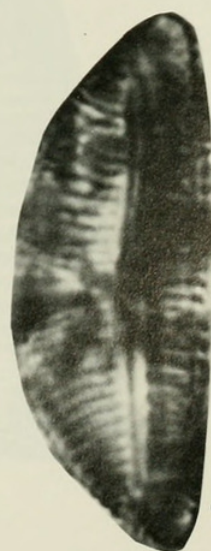
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13



14

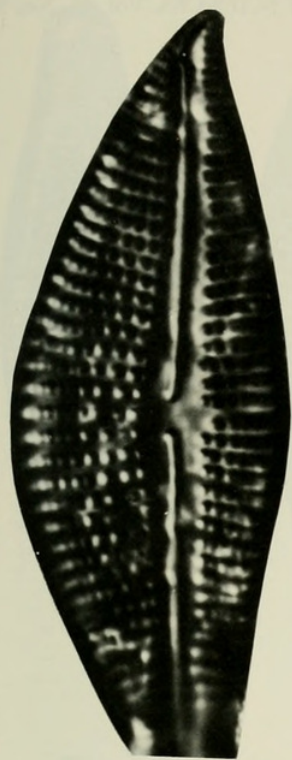


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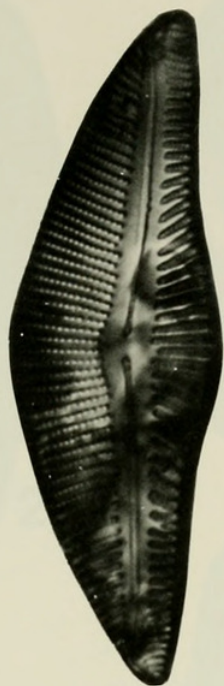
Plate 28

FIGURE:

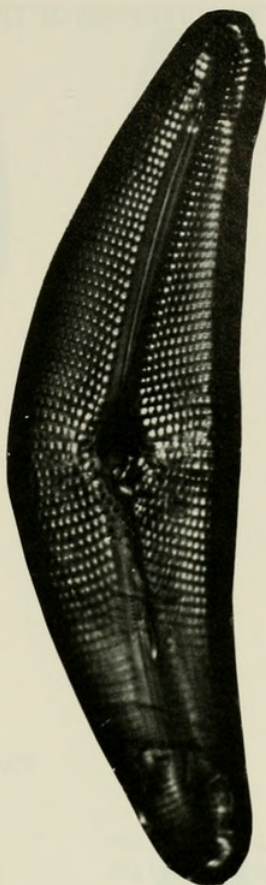
1. *Cymbella triangulum* (Ehrenberg) Cleve; L = 50 μ m.
2. *Cymbella muellerii* var. *ventricosa* (Temp. and Perg.) Reimer in Patrick and Reimer; L = 74 μ m.
3. *Cymbella mexicana* (Ehrenberg) Cleve; L = 112 μ m.
4. *Cymbella mexicana* (Ehrenberg) Cleve; L = 85 μ m.
5. *Cymbella mexicana* (Ehrenberg) Cleve; L = 90 μ m.
6. *Cymbella mexicana* var. *janischii* (Schmidt) Reimer in Patrick and Reimer; L = 200 μ m; a: entire valve, b: central area, c: polar nodule.
7. *Cymbella cistula* (Ehrenberg) Kirchn. in Cohn; L = 88 μ m; a: entire valve, b: central and polar nodules.



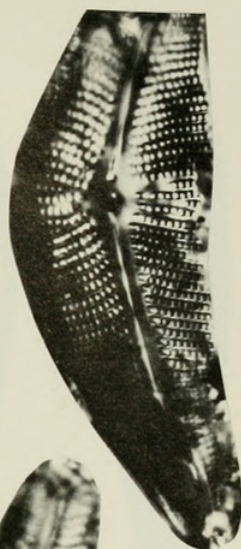
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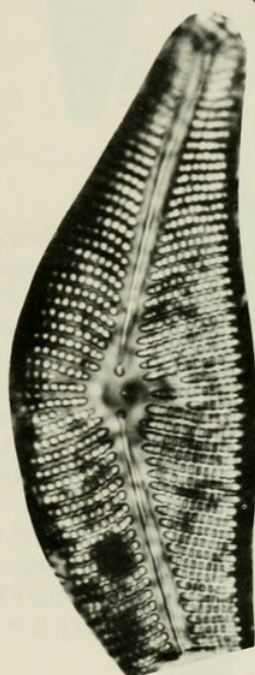
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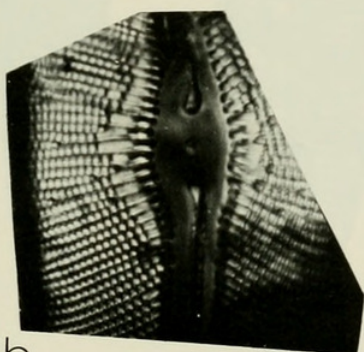
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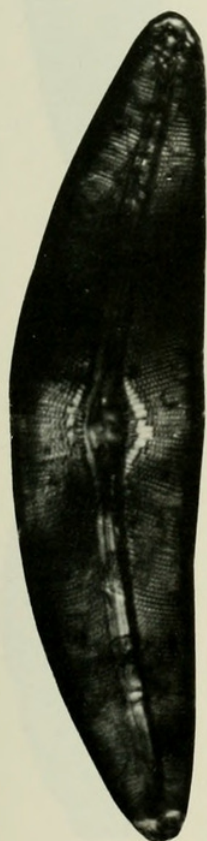
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5

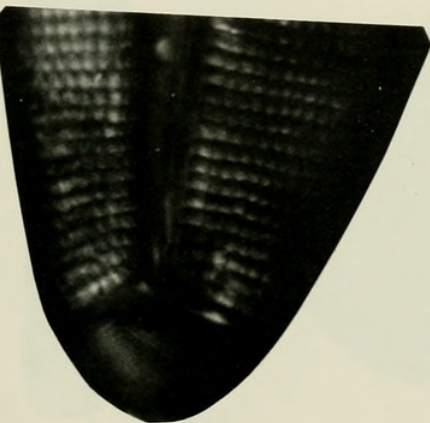


b

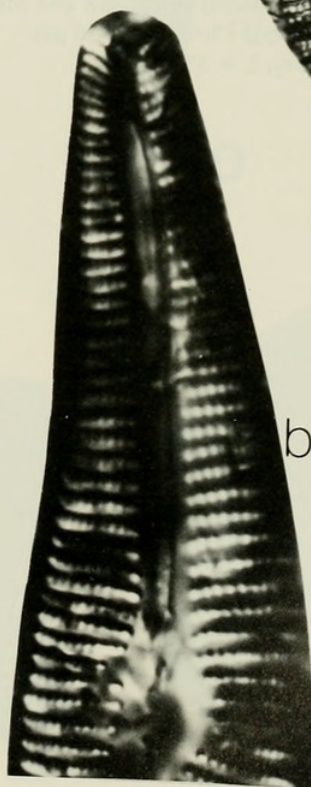


a

6



c



b

7

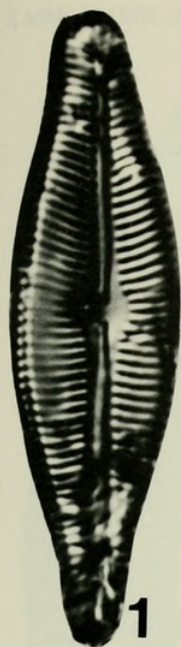
a



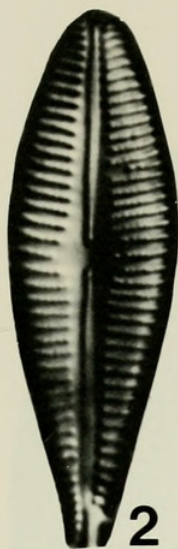
Plate 29

FIGURE:

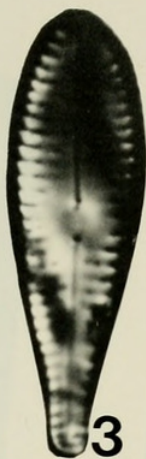
1. *Gomphonema ventricosum* Gregory; L = 44 μ m.
2. *Gomphonema ventricosum* Gregory; L = 40 μ m.
3. *Gomphonema grovei* M. Schmidt; L = 26 μ m.
4. *Gomphonema gracile* (Ehrenberg) emend. Van Heurck; L = 24 μ m.
5. *Gomphonema angustatum* var. *sarcophagus* (Greg.) Grun.; L = 26 μ m.
6. *Gomphonema angustatum* var. *sarcophagus* (Greg.) Grun.; L = 36 μ m.
7. *Gomphonema parvulum* (Kutzing) Kutzing; L = 23 μ m.
8. *Gomphonema rhombicum* Fricke; L = 29 μ m.
9. *Gomphonema septum* Moghadam; L = 48 μ m.
10. *Gomphonema affine* Kutzing; L = 39 μ m.
11. *Gomphoneis erienne* (Ehrenberg) Cleve; L = 80 μ m.
12. *Gomphoneis herculeana* (Grunow) Skvortzow and Meyer; L = 32 μ m.
13. *Trachyneis aspera* (Ehrenberg) Cleve; L = 156 μ m.
14. *Auricula complexa* Gregory; L = 35 μ m.



1



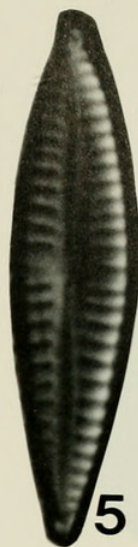
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3



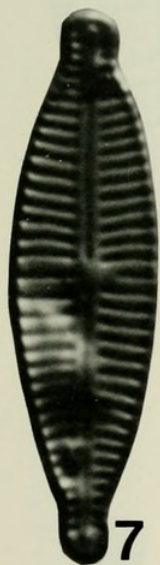
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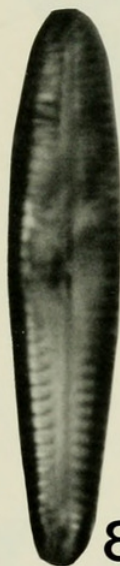
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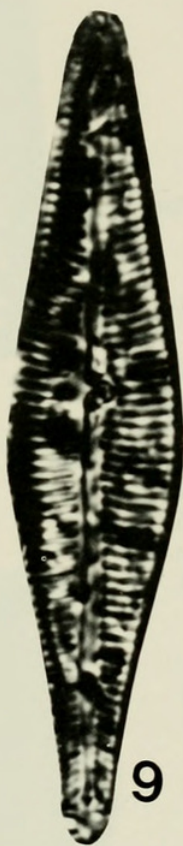
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7



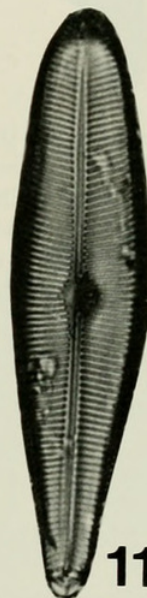
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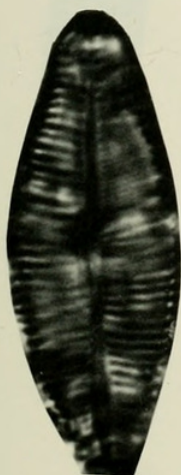
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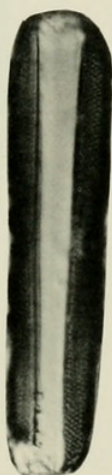
10



11



12



13



a

14



b

Plate 30

FIGURE:

1. *Epithemia turgida* (Ehrenberg) Kutzing; L = 76 μ m.
2. *Epithemia turgida* var. *westermanii* (Ehrenberg) Grunow; L = 52 μ m.
3. *Epithemia argus* (Ehrenberg) Kutzing; L = 56 μ m.
4. *Epithemia sorex* Kutzing; L = 37 μ m.
5. *Epithemia adnata* var. *porcellus* (Kutzing) Patrick; L = 61 μ m.
6. *Rhopalodia gibba* (Ehrenberg) O. Müller; L = 71 μ m.
7. *Rhopalodia gibberula* (Ehrenberg) O. Müller; L = 34 μ m; girdle view.
8. *Rhopalodia gibberula* (Ehrenberg) O. Müller; L = 24 μ m.
9. *Rhopalodia gibberula* (Ehrenberg) O. Müller; L = 23 μ m.
10. *Rhopalodia gibberula* (Ehrenberg) O. Müller; L = 22 μ m.
11. *Rhopalodia operculata* (Agardh) Hakansson; L = 24 μ m.
12. *Denticula subtilis* Grunow; L = 30 μ m.
13. *Denticula subtilis* Grunow; L = 18 μ m.

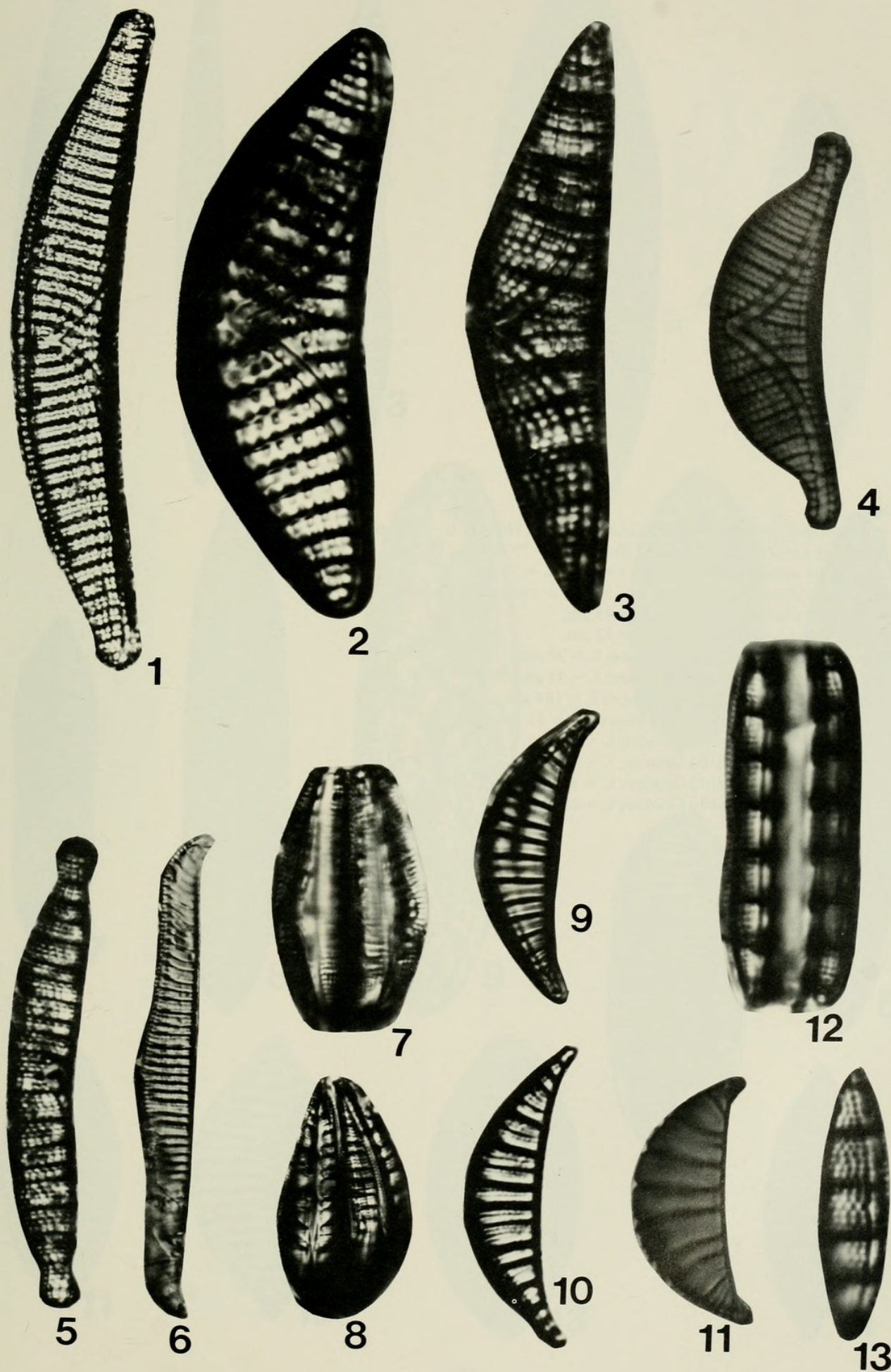


Plate 31

FIGURE:

1. *Pseudoeunotia doliolus* (Wallich) Grunow in Van Heurck; L = 52 μ m.
2. *Bacillaria paxillifer* (O. F. Müller) Hendey; L = 75 μ m.
3. *Hantzschia amphioxys* (Ehrenberg) Grunow; L = 72 μ m.
4. *Nitzschia tryblionella* Hantzsch; L = 56 μ m; a: focus down, b: focus up.
5. *Nitzschia tryblionella* Hantzsch; L = 45 μ m.
6. *Nitzschia tryblionella* Hantzsch; L = 72 μ m.
7. *Nitzschia acuminata* (Smith) Grunow; L = 30 μ m.
8. *Nitzschia acuminata* (Smith) Grunow; L = 44 μ m.
9. *Nitzschia circumsuta* (Bailey) Grunow; L = 184 μ m.
10. *Nitzschia levidensis* (Smith) Van Heurck; L = 56 μ m.
11. *Nitzschia punctata* (Smith) Grunow; L = 50 μ m.
12. *Nitzschia punctata* (Smith) Grunow; L = 24 μ m.
13. *Nitzschia punctata* (Smith) Grunow; L = 37 μ m.
14. *Nitzschia punctata* (Smith) Grunow; L = 21 μ m.

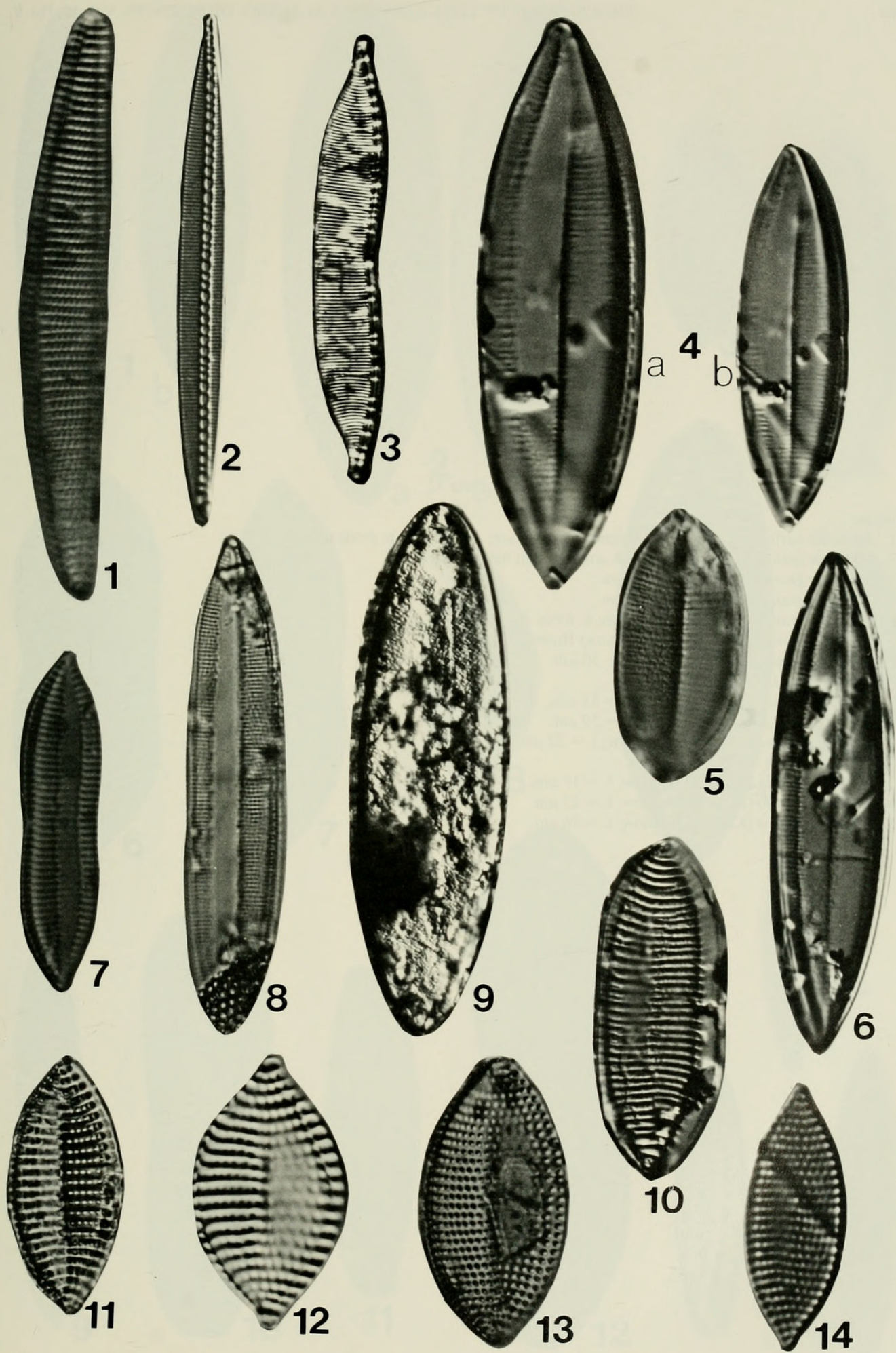


Plate 32

FIGURE:

1. *Nitzschia navicularis* (Brébisson) Grunow; L = 72 μ m; a: focus up, b: focus down.
2. *Nitzschia granulata* Grunow; L = 48 μ m; a: bright field, b: dark field
3. *Nitzschia granulata* var. 1; L = 39 μ m.
4. *Nitzschia granulata* var. 1; L = 50 μ m.
5. *Nitzschia granulata* var. 1; L = 42 μ m; a: focus down, b: focus up.
6. *Nitzschia punctata* var. *coarcta* (Grunow) Hustedt; L = 33 μ m.
7. *Nitzschia panduriformis* Gregory; L = 30 μ m.
8. *Nitzschia* sp. 1; L = 26 μ m.
9. *Nitzschia pseudohybrida* Hustedt; L = 81 μ m.
10. *Nitzschia pseudohybrida* Hustedt; L = 59 μ m.
11. *Nitzschia dissipata* (Kutzing) Grunow; L = 32 μ m.
12. *Nitzschia plana* Smith; L = 99 μ m.
13. *Nitzschia pusilla* (Kutzing) Grunow; L = 17 μ m.
14. *Nitzschia pusilla* (Kutzing) Grunow; L = 27 μ m.
15. *Nitzschia pusilla* (Kutzing) Grunow; L = 16 μ m.

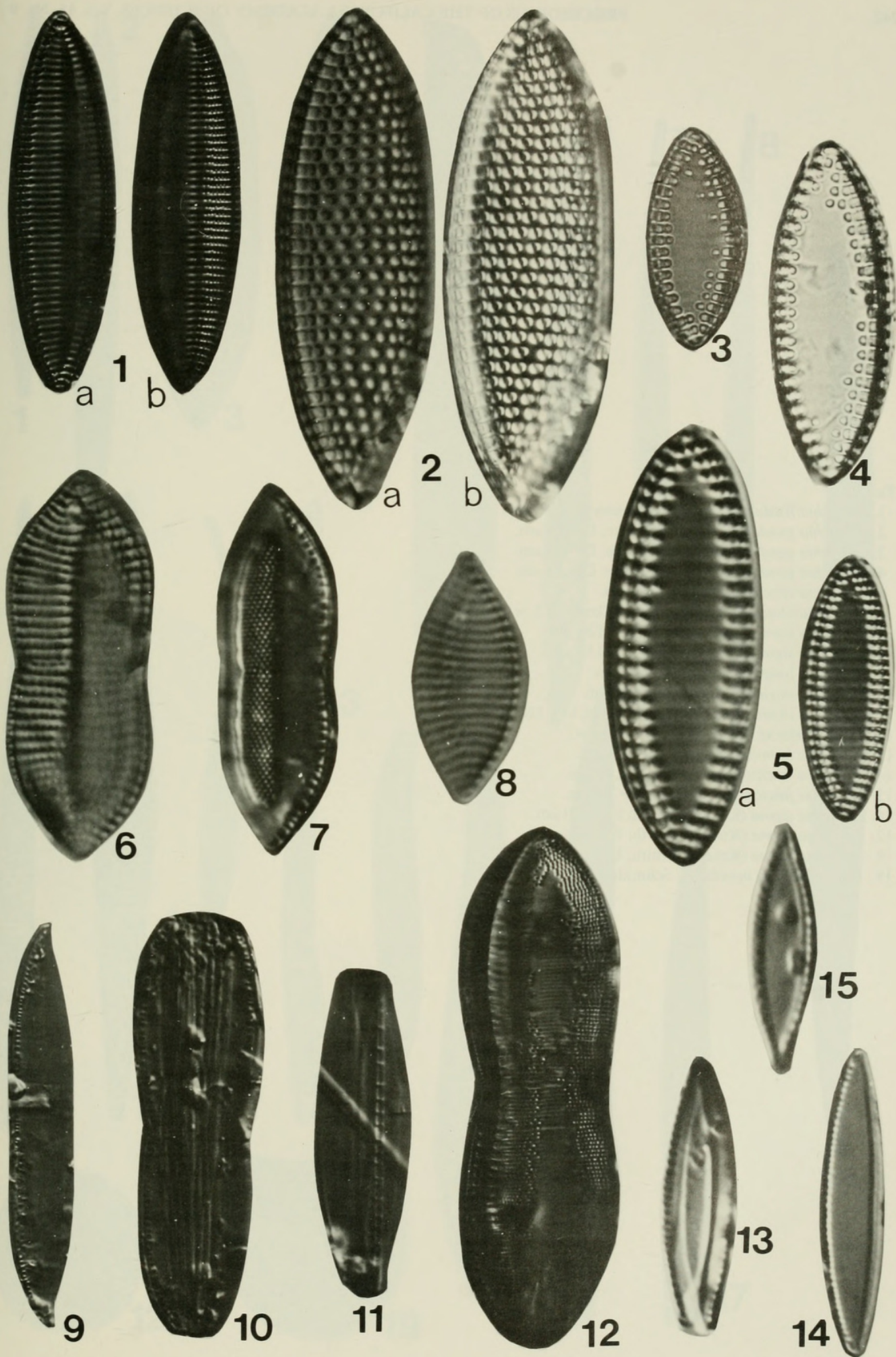


Plate 33

FIGURE:

1. *Nitzschia frustulum* (Kutzing) Grunow; L = 33 μ m.
2. *Nitzschia gandersheimiensis* Krasske; L = 78 μ m.
3. *Nitzschia gandersheimiensis* Krasske; L = 31 μ m.
4. *Nitzschia gandersheimiensis* Krasske; L = 32 μ m.
5. *Nitzschia vitrea* Norman; L = 68 μ m.
6. *Nitzschia obtusa* var. *scalpeliformis* Grunow; L = 125 μ m.
7. *Nitzschia sigmaformis* Hustedt; L = 120 μ m.
8. *Nitzschia sigmaformis* Hustedt; L = 136 μ m.
9. *Nitzschia longa* Grunow; L = 160 μ m.
10. *Nitzschia angularis* Smith; L = 120 μ m.
11. *Nitzschia closterium* (Ehrenberg) Smith; L = 120 μ m.
12. *Campylodiscus ralfsii* Smith; D = 19 μ m.
13. *Nitzschia hummii* Hustedt; L = 119 μ m.
14. *Nitzschia fasciculata* Grunow; L = 48 μ m.
15. *Nitzschia fasciculata* Grunow; L = 55 μ m.
16. *Nitzschia sigma* (Kutzing) Smith; L = 120 μ m.
17. *Nitzschia sigma* (Kutzing) Smith; L = 97 μ m.
18. *Nitzschia sigma* (Kutzing) Smith; L = 176 μ m.
19. *Campylodiscus incertus* A. Schmidt; D = 32 μ m.

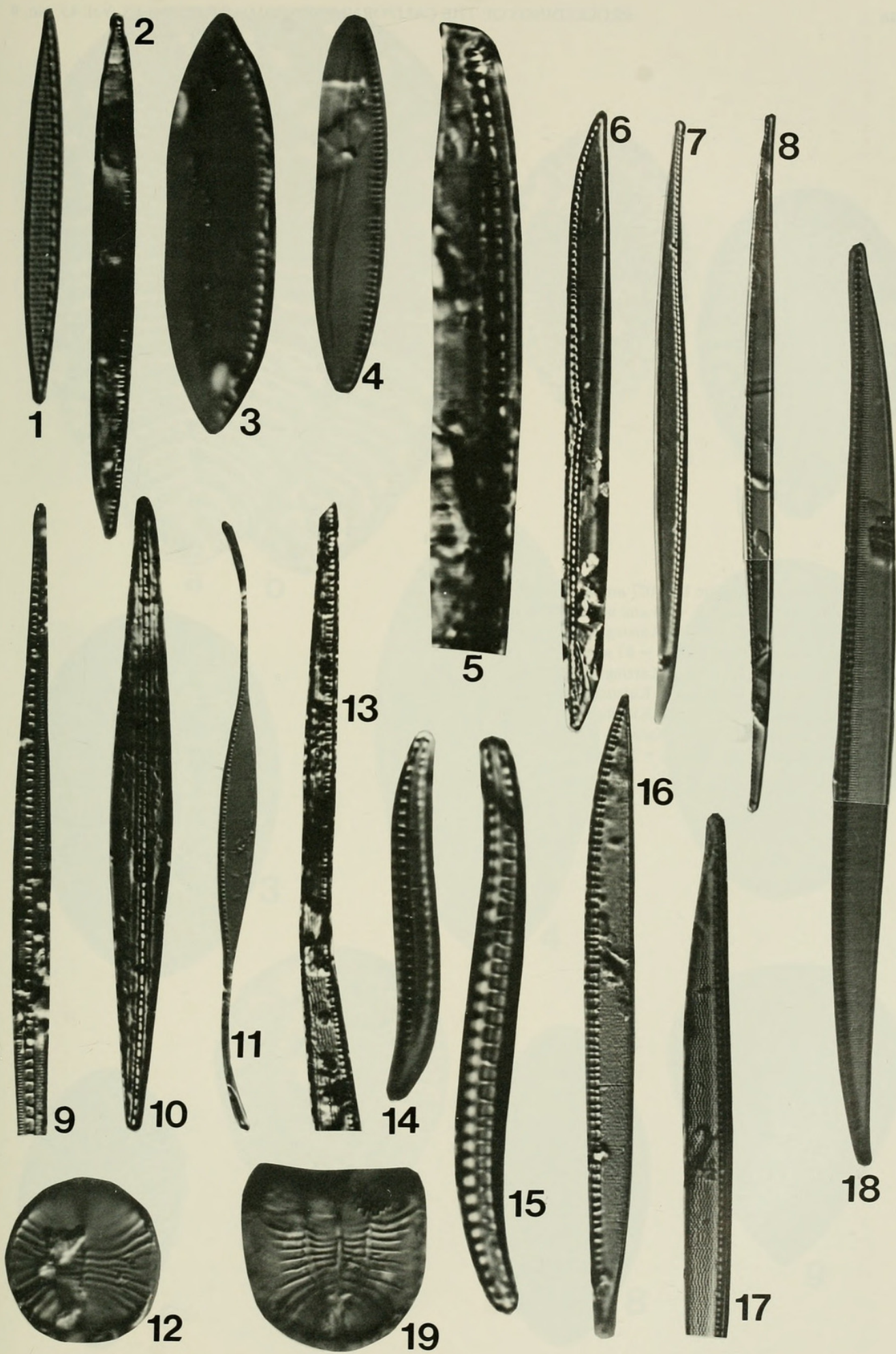


Plate 34

FIGURE:

1. *Surirella striatula* Turpin; L = 107 μ m; a: focus down, b: focus up.
2. *Surirella ovata* Kutzing; L = 54 μ m; a: dark field, b: bright field.
3. *Surirella fastuosa* (Ehrenberg) Kutzing; L = 91 μ m.
4. *Surirella torquata* Pantocsek; L = 83 μ m.
5. *Surirella fastuosa* (Ehrenberg) Kutzing; L = 85 μ m.
6. *Surirella crumena* Brébisson in Kutzing; L = 47 μ m.
7. *Surirella crumena* Brébisson in Kutzing; L = 56 μ m.
8. *Surirella gemma* (Ehrenberg) Kutzing; L = 57 μ m.
9. *Surirella peisonis* Pantocsek; L = 57 μ m.

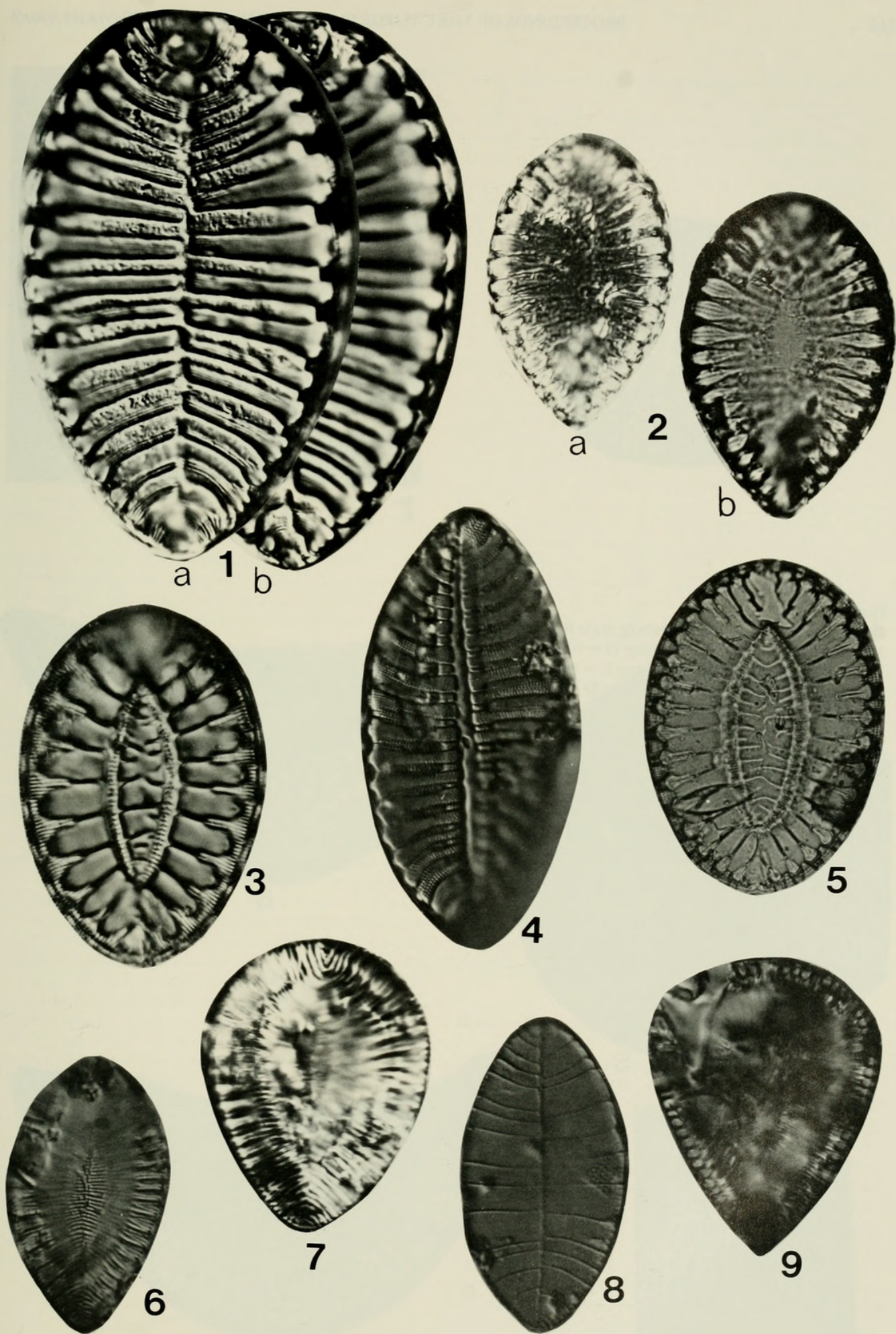
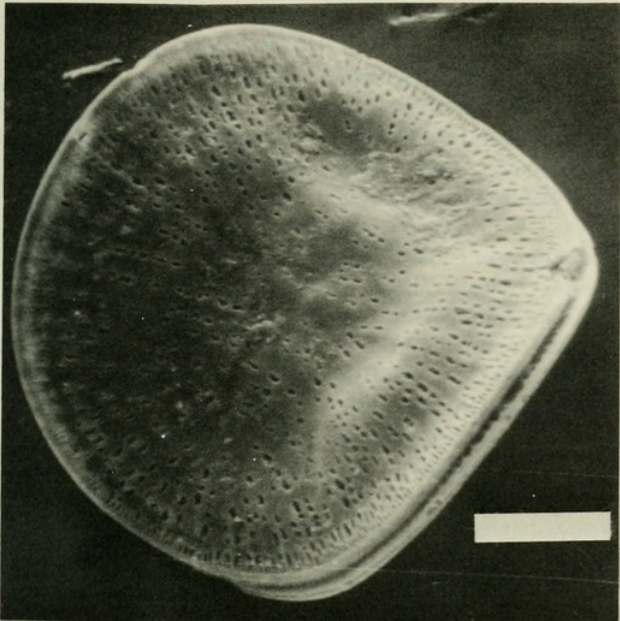


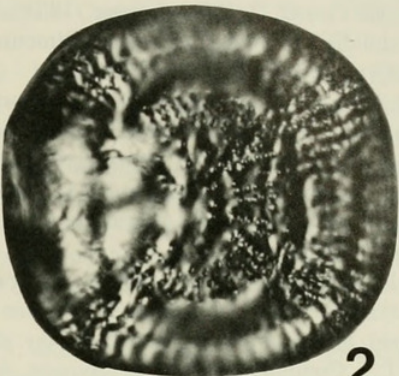
Plate 35

FIGURE:

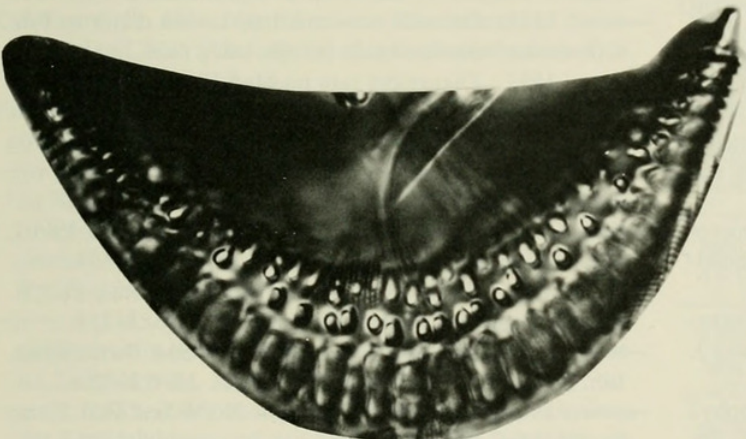
1. *Campylodiscus echeneis* Ehrenberg; scale bar is 40 μm .
2. *Campylodiscus clypeus* Ehrenberg; D = 108 μm .
3. *Campylodiscus echeneis* Ehrenberg; L = 83 μm ; a: focus down, b: focus up.
4. *Coscinodiscus marginatus* Ehrenberg; D = 83 μm ; a: entire valve, b: areolae magnified.



1

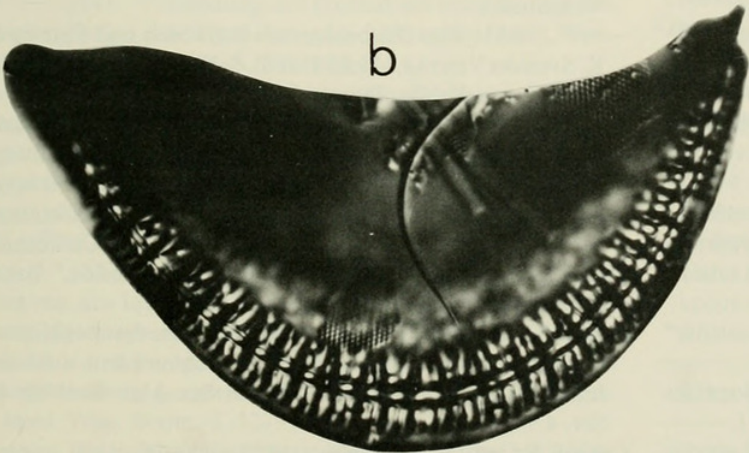


2

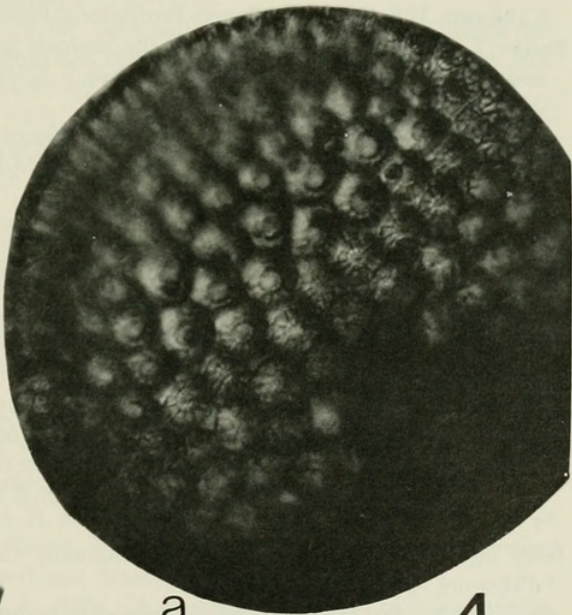


a

3

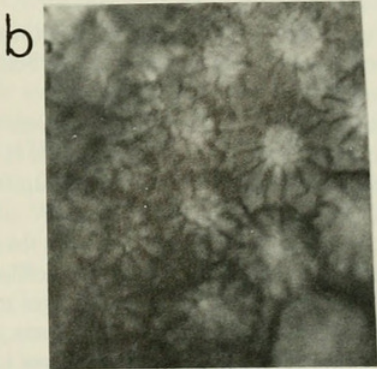


b



a

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b

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