Seventh NAWQA Taxonomy Workshop
on Harmonization of Algal Taxonomy

10-13 May, 2002

Report No. 02-21

Phycology Section/Diatom Analysis Laboratory
Patrick Center for Environmental Research
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Prepared by
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Introduction

The seventh NAWQA Diatom Taxonomy Workshop was held at the Academy of Natural Sciences of Philadelphia on May 10-13, 2002. Specialists participating in the workshop were Dr. R. Jan Stevenson and Kalina Manoylov from Michigan State University; Dr. Rex L. Lowe from Bowling Green State University; William R. Cody, environmental consultant based in Ohio; Dr. Peter A. Siver from Connecticut College; P. B. Hamilton from the Canadian Museum of Nature, Ottawa; Dr. Yangdong Pan and Christine Weilhoefer from Portland State University; Dr. Sarah Spaulding from the University of Colorado. Dr. Marina G. Potapova, Dr. Eduardo A. Morales, Dr. Donald F. Charles, Diane M. Winter, Karin C. Ponader, Frank W. Acker and Mark Schadler from the Patrick Center for Environmental Research’s Phycology Section at the Academy of Natural Sciences of Philadelphia, also participated in the workshop and collaborated in its organization.

The first, second, and third NAWQA taxonomy workshops had the overall objectives of harmonizing taxa names used in the ANSP and University of Louisville/University of Michigan laboratories, identifying reference images for each taxon, and agreeing on up-to-date nomenclature to use when analyzing NAWQA 1994 and 1997-start samples (See Clason and Charles, 1999; 2000; and Morales and Potapova, 2000). The fourth NAWQA Diatom Taxonomy Workshop focused on issues concerning the taxonomy of some problematic Navicula and Gomphonema species occurring in NAWQA material (Morales, 2001a). During the fifth workshop additional problematic species in the genus Navicula were studied (Morales, 2001 b). The sixth workshop dealt with the genus Gomphonema, of which several morphologically variable species and varieties occur in NAWQA material (Morales, 2002).

The seventh workshop concentrated on problematic species of the genus Nitzschia, a genus that has many representatives in NAWQA samples. Some of these taxa were arranged in the following complexes:

**Complex 1 (Presented by K. Manoylov)**
- *Nitzschia biacrula* Hohn et Hellerman
- *N. dissipata* (Kützing) Grunow
- *N. dissipata var. media* (Hantzsch) Grunow
- *N. dissipata var. oligotraphenta* Lange-Bertalot
- *Nitzschia sociabilis* Hustedt
- *N. recta* Hantzsch

**Complex 2 (Presented by D. Winter)**
- *Nitzschia amphibia* Grunow
- *N. amphibia f. frauenfeldii* (Grunow) Lange-Bertalot
- *N. amphibioides* Hustedt
Complex 3 (Presented by W. Cody)

*Nitzschia tropica* Hustedt
*N. fonticola* Grunow
*N. fossilis* Grunow

Complex 4 (Presented by R. Lowe)

*Nitzschia frustulum* (Kützing) Grunow
*N. inconspicua* Grunow

Complex 5 (Presented by K. Ponader)

*Nitzschia palea* (Kützing) Smith complex

An electronic version of the above list was sent to workshop participants. They were asked to choose a complex and prepare a presentation including the historical background of the taxa, different views in the literature as to their taxonomic position, affinities with closely related entities, features used for identification, and relevant ecological information that might be helpful in the characterization of the taxa. Each presentation was to last 30 minutes and be followed by brief discussions. In addition to the complexes listed above, Dr. M. Potapova prepared a presentation entitled: “Some unknown *Nitzschia* taxa in NAWQA databases” in which she discussed the taxonomy of some nitzschioid diatoms reported as unknowns in counts of NAWQA material.

Also, prior to the workshop, Dr. E. Morales compiled lists of samples containing high abundances of the taxa above and he (with the collaboration of E. Hagan and M. Schadler from the Phycology Section) sent acid cleaned material to P. Hamilton for SEM analysis. Participants were asked to communicate directly with P. Hamilton in order to discuss SEM related issues of the taxa included in their complexes. A sizable amount of SEM photographs were taken from 10 samples and some are included in this report. The full set of SEM photographs are contained in the electronic version if this report.

During the workshop, laboratory sessions were held following sets of presentations. These concentrated on examination of NAWQA permanent slides from the ANSP Diatom Herbarium. For each of the complexes, a group of participants (with the participant in charge of that complex as the leader) collected digital images and documented them in an EXCEL spreadsheet. Intensive discussion and literature search led in many cases to the application of correct names to problematic taxa, or to the conclusion that more research was needed in order to be confident about the identity of certain species and their varieties. During observation of ANSP Diatom Herbarium slides and laboratory discussions, Dr. Charles W. Reimer’s participation was very helpful.

In addition to the presentations of the complexes, three lectures were presented during the workshop. The first lecture was presented by P. Hamilton and it was entitled: “*Nitzschia*: General aspects of its Biology and Ecology.” Many aspects of the morphology of nitzschioid groups were highlighted in this presentation with emphasis on the construction of the canal raphe and its implications for the taxonomy of species in this genus. Both light microscopy (LM) and
scanning electron microscopy (SEM) were considered. A Microsoft Power Point presentation of this lecture is included in the electronic version of this report.

The second presentation, by Dr. S. Spaulding, was entitled: “Origin of the canal raphe: one or many?” Dr. Spaulding concentrated on the evolution of the canal raphe in different groups of diatoms possessing such a structure, including *Nitzschia*. Likewise, a Power Point presentation containing this lecture is presented in the electronic version of this report.

The third lecture, presented by Dr. P. Siver, was: “*Nitzschia* species (and other diatoms and chrysophytes) from selected localities in the Cape Cod, MA Region.” Dr. Siver talked about the biogeography and distribution of some diatoms and chrysophytes from Cape Cod, and discussed some difficulties in the identification of nitzschioid diatoms from that area. His Power Point presentation is included in the electronic version of the report.

The present report also includes the outcomes of discussions arranged by taxonomic complex with supporting plates. These plates were made using pictures drawn from participant’s presentations, pictures taken by participants during the workshop and additional pictures taken by the senior author of this report. The plates presented herein should be used by NAWQA taxonomists as a reference during routine counts. Morphological terminology used in this report follows Barber and Haworth (1981) and Cox (1996).
In her presentation of this complex, K. Manoylov pointed out that the most conspicuous problem with this group is in distinguishing the nominal variety of *N. dissipata* from the variety *media*. It is also difficult to recognize the variety *oligotraphenta*, which appears only in recent reports in the literature (e.g., Cantonati, 2001) and the taxonomy of which still requires further study. She stated that the taxonomy of *N. biacrula*, *N. recta* and *N. sociabilis* is not particularly difficult, but some recommendations must be made about how to separate these taxa from *N. dissipata*.

*N. dissipata* has a lanceolate to fusiform shape with subrostrate or apiculate ends (Plate 1, Figs. 1-13). The raphe is in an eccentric position; it runs to one side of the longitudinal axis of the valve instead of along the valve margins, and the fibulae are massive structures that do not flare. That is, they do not extend laterally as they come in contact with the valve face interior. This taxon has a clear canopeum, which is easily recognizable under LM as two parallel lines, each running along the canal raphe.

Under SEM, *N. dissipata* can be seen to have a large canopeum with two rows of punctae, each on one side of the raphe fissure (Plate 2, Figs. 1 and 2). The fibulae are thick and form distinct clear areas at their junction with the canal raphe and the valve face interior. There is no contact between contiguous fibulae and they are widely, but irregularly spaced along the canal raphe. The areolae are clearly visible and their density corresponds to that of the punctae on the canopeum.

*N. dissipata var. media* (Plate 1, Figs. 14-18) has the same characteristics as the nominal variety, except that the valve size is larger and the apices of the valves are consistently subrostrate. Another characteristic feature of this taxon is that the raphe is more eccentric than in the nominate variety (Krammer and Lange-Bertalot, 1991).

*N. biacrula* can be distinguished from *N. dissipata* by its sigmoid valve shape and rostrate bent ends (Hohn and Hellerman, 1963). The raphe is also eccentric, but to a lesser degree than in *N. dissipata*. The fibulae do not flare as they come in contact with the valve face. The canopeum is also clearly visible in this taxon. The type slide of *N. biacrula* was examined during the workshop (G.C. 44466) and only one specimen (circled and reported as the type specimen) of this taxon was found on the entire slide (Plate 1, Figs. 19-21). What is more, this
type specimen is tilted and it is not clearly seen due to mounting problems. A very large population of this taxon has been reported during analysis of NAWQA material from Indian Creek (GS024253, SANT 1998) (Plate 1, Figs. 22-26). Additional populations have been reported from elsewhere in the United States, hence, this taxon should be kept separate from N. dissipata or any other taxon in this complex. The expansion of the protologue based on material found for NAWQA is recommended.

*N. dissipata* var. *borneensis* was also treated during the laboratory session dealing with this complex. It is possible that *N. biacrula* is a synonym of the variety *borneensis*. The latter taxon was not formally described by Hustedt, however, since a type specimen was not designated. Simonsen (1987) suggested a possible lectotype, but he cautioned that it might not represent the actual taxon that Hustedt had in mind when he first published this name. Until this taxonomic issue is clarified, the name *N. dissipata* var. *borneensis* must not be used by NAWQA analysts. If a similar taxon is found, an unknown designation should be applied to it.

*N. dissipata* var. *oligotraphenta* has a fusiform shape and conspicuously capitate valve ends (Cantonati, 2001, Lange-Bertalot and Metzeltin, 1996). The width of the valves is much smaller than that of *N. dissipata* or any of the varieties mentioned above. Also, the raphe is markedly more eccentric than in *N. dissipata*. The fibulae are much smaller, they do not flare, and the canopeum is visible. This taxon has not been reported in NAWQA counts, but special attention should be paid to it, for its occurrence might indicate slightly different ecological conditions than the nominal variety. Lange-Bertalot and Metzeltin (1996) should be used to identify this taxon.

*Nitzschia recta* has long valves with parallel margins and rostrate to subcapitate ends. The raphe is not eccentric, but runs along the valve margin (Plate 1, Figs. 32-37). The fibulae are wide and do not flare. The canopeum is visible under LM as a hyaline area that runs along the canal raphe. There are no major issues with the identification of this taxon in NAWQA samples. Special attention should be paid to the identification of smaller representatives of this taxon which might be confused with larger representatives of *N. dissipata* and *N. dissipata* var. *media* and *N. rectiformis*.

Under SEM, *N. recta* is similar to *N. dissipata*, but much larger and always has a “nitzschoid” keel (Plate 3, Figs. 1-6). The keel, which is always along the valve face-mantle, has a well developed conopeum with a distinct set of enlarged (sometimes elongated) punctae running from apex to apex. These punctae align with the areolae on the valve face (ca. 40 per 10um). The raphe is situated on an elevated ridge separate from the keel and does not appear to have central raphe endings. The canopeum completely covers the valve face at the apices. Smaller specimens in NAWQA samples start to appear like *Nitzschia rectiformis* Hustedt, but the general shape is that of *N. recta*.

*N. sociabilis* has fusiform valves with acute ends (Plate 1, Figs. 27-31). The canal raphe runs along the margin of the valve. The fibulae are conspicuous and they flare at the bottom as they meet the valve face. The bases of these fibulae, and as a result of their flaring, meet forming a visible (even under LM) rim that runs parallel to the valve margin. This characteristic
gives the fibulae a block-like aspect. The canopeum is absent. There are no problems with the identification of this taxon in NAWQA material. Special attention should be paid to the identification of larger specimens of this taxon, which may be confused with *N. dissipata*. Observation of the shallow girdle views are helpful during identification of specimens of *N. sociabilis* (Plate 1, Fig. 31). Frustules of *N. dissipata* are much deeper and the canopea of both valves can be clearly seen.

In SEM, *N. sociabilis* has a flat external valve face with a rounded keel, which is raised from the valve face and mantle (Plate 4, Figs. 1-8). The raised keel dominates the apex regions with reflected raphe ends towards the valve face. Even from the external view in SEM, the interconnected nature of the fibulae is visible. The striae are continuous across the valve face and onto the keel.

**Complex 2 (Presented by D. Winter)**

*N. amphibia*

*N. amphibia* f. *frauenfeldii*

*N. amphibioides*

In her presentation of this complex, D. Winter highlighted some of the difficulties in the identification of these taxa. Some of the crucial issues discussed involved the determination of the boundaries between *N. amphibia* and the form *frauenfeldii* and between *N. amphibia* and *N. amphibioides*. As a result of her studies of NAWQA samples, D. Winter included the taxon *Denticula kuetzingii* and *D. kuetzingii* var. *rumrichae* in this group.

*Nitzschia amphibia* has parallel to convex valve margins with narrowly rostrate ends, although the latter feature varies and therefore cannot be used reliably (Plate 5, Figs. 1-15). The canal raphe runs along the valve margin and a central nodule is not always conspicuous. The fibulae are conspicuous and prolong well into the valve face narrowing into a single point (pointed or arrow-like fibulae). These fibulae do not flare. The striae are composed of puncta that can be seen clearly.

In SEM, this taxon has heavily silicified valves with well spaced areolae (Plates 6 and 7). Sometimes volae can be observed in well-preserved specimens. The canopeum is absent. The valve face typically slopes towards the keel (Plate 6, Figs. 1-6). The keel is rounded and clearly elevated from the valve face and mantle with 2 small punctae associated with each striae. Internally, the fibulae are attached to one or two interstriae on the mantle (Plate 7, Figs. 1-8). The continuation of the fibula onto one interstria on the valve face gives the “pointed” or arrow-like fibular project used in the identification of this species.

*N. amphibia* f. *frauenfeldii* has much longer (with a higher length to width ratio) valves with widely rostrate apices (relative to the width of the valve) (Plate 5, Figs. 16-22). There is a conspicuous central nodule formed by the separation between fibulae located at that area. The
fibulae usually appear to be more box-shaped than in *N. amphibia* and they do not flare, but their extensions onto the valve face are considerably shorter than in *N. amphibia*.

Under SEM, intermediate forms were found between *N. amphibia* and *N. amphibia f. frauenfeldii* in a sample from the Caloosahatchee River, Southern Florida Study Unit (1998). The same basic ultrastructural features are present in both taxa (Plate 8, Figs. 1-8).

*N. amphibioides* has coarser valves with coarser features (Plate 5, Figs. 23-41). The fibulae of the canal raphe are larger, thicker and fewer in number than in *N. amphibia*. These fibulae are of unequal length throughout the entire valve face. The last two fibulae located at each apex usually cross the valve face from side to side. The areolae composing the striae are much wider and clearly visible under LM.

*Denticula kuetzingii* is similar to *N. amphibioides*. The fibulae are also of unequal length and extend well into the valve face (almost crossing it entire width) (Plate 5, Figs. 43-49). However, the shape of *D. kuetzingii* is more elliptical with acute apices. Additionally, all *Denticula* species possess characteristic girdle bands bearing septa that cross the valves from side to side. If only the valves are found on a slide, a portion of the slide must be scanned to find the girdles bands in order to confirm identifications of *Denticula*.

*D. kuetzingii var. rumrichae* has large valves with blunt, somewhat rounded ends (Plate 5, Fig. 42). The fibulae extend only partially onto the valve face interior, and they are almost of the same length throughout the length of the canal raphe. Since this taxon has more coarse valves and the characteristic blunt ends and girdle bands with septa, it can not be confused with the *N. amphibia* group.

There seem not to be major problems with the identification of species in this complex in NAWQA samples. In future identifications, special attention must be paid to *N. amphibia f. frauenfeldii*, which appears to have a southern distribution, particularly Florida (Potapova, pers comm.).

**Complex 3 (Presented by W. Cody)**

*Nitzschia fonticola*

*N. fossilis*

*N. tropica*

In his presentation, W. Cody discussed the taxonomy of additional taxa that have similar morphology to the taxa originally listed in this complex (Table 1). The sources of the difficulties in identifying the species treated in this complex seem to be the morphological resemblance
Table 1. Morphological features of taxa in Complex 3. Morphologically similar taxa have been added for comparative purposes. Table made by W. Cody, edited by E. Morales.

<table>
<thead>
<tr>
<th>Taxon</th>
<th>Width (µm)</th>
<th>Length Fib./10 µm</th>
<th>Striae/10 µm</th>
<th>C. nodule</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>N. fonticola</strong> in L-B &amp; Simon. 1978</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>N. fonticola</strong> in K&amp;L-B 1988</td>
<td>2.5-5</td>
<td>10-65</td>
<td>9-16</td>
<td>23-33</td>
</tr>
<tr>
<td><strong>N. fonticola</strong> in Hust. 1930</td>
<td>2.5-4</td>
<td>11-30</td>
<td>12-15</td>
<td>28-30</td>
</tr>
<tr>
<td>Syn. <strong>N. romana</strong> in L-B &amp; Simon.1978</td>
<td>4-5</td>
<td>22-?</td>
<td>9.5-11.5</td>
<td>25-27</td>
</tr>
<tr>
<td><strong>N. romana</strong> in Germain 1981</td>
<td>3-5</td>
<td>13-40</td>
<td>10-12</td>
<td>26-28</td>
</tr>
<tr>
<td><strong>N. romana</strong> in Hust. 1930</td>
<td>4-5</td>
<td>22-35</td>
<td>11-12</td>
<td>23-25</td>
</tr>
<tr>
<td>Syn. <strong>N. macedonica</strong> Hust. 1945</td>
<td>3-4</td>
<td>18-42</td>
<td>14-15</td>
<td>30</td>
</tr>
<tr>
<td><strong>N. macedonica</strong> in L-B&amp; Simon. 1978</td>
<td>3-4</td>
<td>18-42</td>
<td>12-16</td>
<td>28-30</td>
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<tr>
<td>Syn. <strong>N. subromana</strong> Hust. 1945</td>
<td>4</td>
<td>27</td>
<td>12</td>
<td>28</td>
</tr>
<tr>
<td>Syn. <strong>N. manca</strong> Hust. 1957 (See Simonsen 157-26, <strong>N. frequens</strong>)</td>
<td>4-5.5</td>
<td>36-38</td>
<td>12-14</td>
<td>24-27</td>
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<tr>
<td><strong>N. lacuum</strong> L-B 1980</td>
<td>2.5-3</td>
<td>10-18</td>
<td>13-18</td>
<td>~40</td>
</tr>
<tr>
<td>Note: Hust. called it <strong>N. fonticola</strong> and <strong>N. macedonica</strong> ref. L-B 1980</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td><strong>N. bacillum</strong> Hust. in Schmidt’s Atlas</td>
<td>2-3</td>
<td>10-20</td>
<td>13-18</td>
<td>35-40</td>
</tr>
<tr>
<td><strong>N. bacillum</strong> in K&amp;L-B 1988</td>
<td>2-3.5(5)</td>
<td>12-20</td>
<td>12-16</td>
<td>27-32</td>
</tr>
<tr>
<td><strong>N. supralitorea</strong> in K&amp;L-B 1988</td>
<td>2.5-4</td>
<td>10-25</td>
<td>14-18 (20)</td>
<td>25-34</td>
</tr>
<tr>
<td>Note : Syn. <strong>N. fonticola</strong> sensu Choln. ref. K-L-B 1988</td>
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<tr>
<td><strong>N. fossilis</strong> Grun. in K&amp;L-B 1988</td>
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<td>30-85</td>
<td>7-9</td>
<td>18-21</td>
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<td>2.5-4</td>
<td>10-65</td>
<td>8-1210</td>
<td>24</td>
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<td><strong>N. tropica</strong> in K&amp;L-B 1988</td>
<td>2.5-4</td>
<td>10-65</td>
<td>8-12 (16)</td>
<td>23-25</td>
</tr>
</tbody>
</table>

**SIMILAR TAXA**

<table>
<thead>
<tr>
<th>Taxon</th>
<th>Width (µm)</th>
<th>Length Fib./10 µm</th>
<th>Striae/10 µm</th>
<th>C. nodule</th>
</tr>
</thead>
<tbody>
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<td><strong>N. acidocalina</strong> L-B-Simon. 1978</td>
<td>2-3</td>
<td>8-40</td>
<td>12</td>
<td>27-32</td>
</tr>
<tr>
<td><strong>N. incognita</strong> in K&amp;L-B 1988</td>
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<td>20-70</td>
<td>10-15</td>
<td>28-30</td>
</tr>
<tr>
<td><strong>N. radicula</strong> in K&amp;L-B 1988</td>
<td>2.5-3</td>
<td>33-70</td>
<td>10-13</td>
<td>28-30</td>
</tr>
</tbody>
</table>
among all its components, the lack of conspicuous distinguishing features, and the confusion created by misidentifications in the literature. In addition, the morphology of these taxa seems to be extremely variable, to the point that clear cut boundaries are difficult to establish.

*N. fonticola* has lanceolate valves with subcapitate to rostrate ends (Plate 9, Figs. 1-38). Valves are slightly sigmoid and the margin of the valve is concave at the apex on the side opposite to the canal raphe. The latter runs along one of the margins of the valve and a central nodule is often (although not always) present. There is a slight indentation on the valve margin at the central nodule, but this is not always conspicuous. The fibulae have a square shape under LM and under SEM they bifurcate as they connect with the valve face (Plate 10, Figs. 1-8). The striae are conspicuous under LM and under SEM they are arranged in slightly depressed rows between thickened interstriae. Four punctae per striae are present on the canal raphe exterior surface. These punctae are arranged in a box-like pattern, but in some instances only three punctae may be present and form a triangle. Externally, the keel is a round and flattened extension from the valve face and mantle. The raphe is positioned in the “flattened” region of the keel and is elevated on a ridge. The central raphe endings are enlarged, sometimes tear-drop shaped and easily observed when tilting the valve.

Archibald (1983) states that the slide that Grunow used for some of his original illustrations of the taxon contain a range of valve shapes from slightly linear to lanceolate with -and some without- a central area, although the lack of a central area seems to be of rare occurrence (Plate 9, Figs. 1 and 2). The same author points out that Hustedt’s concept of *N. fonticola* is somewhat different from that presented by Grunow in the original description. The discrepancy is evident in the lack of a space in the central fibulae (therefore, a lack of a noticeable central area) in the population described by Hustedt (from Africa). Further studies are needed to clarify the relationship between Grunow’s and Hustedt’s concepts. Krammer and Lange-Bertalot (1991), have a much wider concept of *N. fonticola*. They include forms with and without clear central areas. Furthermore, they synonymize a number of taxa that evidently (as shown in the pictures they presented of type material of these taxa) have similar features to those present in the type population of *N. fonticola*.

Several populations of *N. fonticola* have been reported by NAWQA analysts from different parts of the U.S. (Plate 9, Figs. 6-16 and 23-38). All the populations seem to fit the description and figures presented by Krammer and Lange-Bertalot (1991), with the exception of a population from Deer Creek, CA (Sacramento Basin; SACR 1996), which larger representatives tend to be slightly narrower than other specimens of comparable size from other regions of the country (Plate 9, Figs. 17-22).

*Nitzschia fossilis* has much coarser valves, which are linear-lanceolate (parallel sides) with rostrate to subcapitate apices (Krammer and Lange-Bertalot, 1991; Rumrich et al., 2000). The raphe runs along the margin of the valve and the fibulae are square-shaped, but much wider than in *N. fonticola*, they also seem to bifurcate as they touch the valve face interior. Under the LM, individual areolae on a stria can be distinguished. This is not possible in the case of *N. fonticola*. Thus far, the only population has been reported in NAWQA is in material from the Upper Illinois River Basin (UIRB 2000) (Plate 11, Figs. 1-8).
In SEM *N. fossilis* has a rounded keel with a weakly elevated ridge for the raphe (Plate 11, Figs. 1-8). The central raphe fissures are evident as poorly developed enlarged central pores, while the terminal raphe fissures appear to be deflected down the apex mantle. A single large areola is situated at the edge of the keel, representing the last areola of the striae sequence adjacent to the keel. Internally, the fibulae are thickened structures that attach to one or two interstriae. No lateral siliceous projections are present, although sometime “frontal” siliceous projections are observed on the internal valve face.

*Nitzschia tropica* has linear valves with strongly-tapered slightly rostrate apices. There is also a slight concavity in the valve margin at the apices on the opposite side of the canal raphe. The latter runs along one side of the valve and may or may not present a conspicuous central nodule, but there is always a small separation between the central fibulae. The central nodule is evident by a strong indentation of the valve margin. The striae are clearer than in *N. fonticola* under LM. Several reports of this taxon appear in NAWQA. However, none of the reported populations fit descriptions given in the literature (Krammer and Lange-Bertalot [1991] and Rumrich et al. [2000]). Such populations correspond to either *N. fonticola* (UTEN 1996: GSL00093), *N. gessneri* (Plate 9, Figs. 49-57; LINJ 1998: GS028733, GS028743, GS028753), or an unknown taxon reported here as: *Nitzschia* sp. 30 NAWQA EAM (NADED 48574) (Plate 9, Figs. 39-48; ACAD 1998: GSN01116). Appropriate changes to the above forms must be made.

*N. gessneri* has linear valves with subcapitate to capitate ends. The canal raphe runs along the margin of the valve and a clear central area may or may not be present. In any case, there is slight indentation at the central nodule. This taxon can be confused with *N. fossilis*, but the striae count is much higher in *N. gessneri* (26-29, even 30 per 10 µm, in specimens depicted in Plate 9, Figs. 49-57; *N. fossilis* has 18-21 striae per 10 µm).

**Complex 4 (Presented by R. Lowe)**  
*N. frustulum*  
*N. inconspicua*  

In his presentation of this complex, R. Lowe discussed the nomenclatural history of both species and some of their varieties. The varieties included were *N. frustulum* var. *bulhemianna* and *N. frustulum* var. *subsalina*. A short comment on the occurrence of the taxon *N. frustulum* var. *perminuta* has been added here by E. Morales.

The main problem in this complex seems to be the existence of transitional forms between *N. frustulum* and *N. inconspicua*. The problem is deepened by the ecological overlap between these two species. The distinction of smaller forms of *N. frustulum* from *N. inconspicua* is very difficult under LM (but see Plate 9, Fig. 68). However, latest SEM information allows the separation of the two taxa.

*N. frustulum* has linear valves with strongly tapered, apiculate (somewhat produced) ends (Plate 9, Figs. 58-63). Tapering of the apices is not gradual (in contrast to *N. acicularis*, for
instance), but rather abrupt. The canal raphe runs along one of the margins of the valve and the fibulae are square-shaped and massive at their junction with the valve face interior. As one focuses up and down on the canal raphe, the fibulae have the shape of the letter “X”. There is a clear central area marked by the separation of the two central fibulae. In some specimens this separation may not be as clear, but the central fibulae remain separated to a certain degree. The striae are clear under LM, but the individual areolae are difficult to discern.

In SEM, the structural form is surprisingly similar to *N. amphibia* and *N. fonticola* (Plates 12 and 13). The keel is rounded and elevated from the valve face. The raphe is on an elevated ridge on the keel with easily distinguished poroid central raphe fissures and terminal fissures that deflect either onto the valve face or down the mantle. Two distinct punctae are positioned on the edge of the keel at the end of each striae. The striae are located in a slight depression between interstriae ridges. The external areolate apertures are not covered by volae. Internally, each fibula is an “X” shaped thickening, which attaches to one or two interstriae. Lateral silica projections off the fibulae are not present or very weakly expressed. This species is separated from *N. fonticola* and *N. fossilis* by general shape, keel structure, striae density, and the number of punctae on or immediately adjacent to the keel.

*N. frustulum var. bulnhemiana* is much wider and coarser than the nominal variety. This taxon has been returned to species status under the name *N. bulnhemiana* Rabenhorst. The areolae composing the striae can be seen under LM. The ecology of this taxon also seems to be characteristic and restricted to highly saline waters (it was originally described from salt mines).

*N. frustulum var. bulnhemiana* has been reported in NAWQA counts, but a review of the slides suggests that names in counts for the following samples should be changed to *N. frustulum*: SOFL (1998) (GS027563, GS027603; GS027561, and GS027611) and NROK (1999) (GSN01334). The following samples for the PUGT (1998) study unit samples should be changed to *N. inconspicua*: GS030201 and GS030213. These changes mean that *N. frustulum var. bulnhemiana* does not occur in NAWQA material.

*N. frustulum var. perminuta* has been used in NAWQA to identify specimens that better fit in *N. inconspicua* (see next). Therefore, all records of *N. frustulum var. perminuta* should be corrected. The occurrence of specimens that can be identified as *N. frustulum var. perminuta* in NAWQA material is yet to be determined.

Krammer and Lange-Bertalot (1991) synonymized *N. frustulum var. subsalina* with *N. frustulum*. In the absence of a proper designation of the holotype by Hustedt, Simonsen (1987) chose a lectotype, which has a general valve structure that does not look much different from *N. frustulum*. The only subtle differences are the blunt apices and the coarser striae on the valves of the variety *subsalina*. Therefore, the identity of this taxon, remains unclear based on the literature. The great majority of the reports of this taxon in NAWQA material have been checked by M. Potapova and the decision was made (during the Third NAWQA Workshop) to change all such records to *N. frustulum*.
*N. inconspicua* has elliptical valves with somewhat rounded apices (Krammer and Lange-Bertalot, 1991; pg. 354-355, Plate 69, Figs. 6-10). This shape is maintained even in the larger specimens, in which the apices can be broadly rounded. The canal raphe runs along the valve margin and has a distinctive central nodule due to a wider separation between the central fibulae (than in *N. frustulum*). The fibulae are wider than in *N. frustulum* and also expand at their junction with the valve face. The striae are clear under LM, but individual areolae are difficult to see, since they are even smaller than those in *N. frustulum*. Under SEM, the striae do not bifurcate at their junction with the canal raphe (Snoeijis, 1993). This is probably the most decisive feature distinguishing *N. inconspicua* from *N. frustulum*.

**Complex 5 (Presented by K. Ponader)**  
*Nitzschia palea* complex

In her presentation of this complex, K. Ponader touched on aspects of the nomenclatural history of *N. palea* and closely related taxa. Concretely, she referred to the following taxa: *N. palea*, *N. palea* var. *debilis*, *N. palea* var. *temuirostris*, *N. palea* var. *sumatrana*, *N. capitellata*, *N. archibaldii*, and *N. perspicua*. However, the discussion concentrated around *N. palea*, *N. palea* var. *debilis*, *N. archibaldii*, and *N. capitellata*. Comparisons among these taxa can be found in her presentation, which is included in the electronic version of this report. The main problem in the recognition of the above taxa is the lack of distinguishing features.

*N. palea* has valves with linear to linear-lanceolate shape and narrowly rostrate ends (Plate 14, Figs 11-17). The striae are very fine and difficult to resolve under LM. The fibulae are also fine and appear as delicate dark dots along the valve margin under LM. No clear central nodule can be seen and for the most part the fibulae are spaced regularly although sometimes some wider spacing can be seen, but not necessarily at the central area.

In SEM, the valve face is flat to slightly concave (Plate 18, Figs. 1-6). The keel is round, thin and weakly developed away from the valve face. Single areola aligned with each stria are present on the lower edges of the keel. The raphe is continuous and not elevated on the keel with terminal raphe fissures that extend down the mantle. Striae are composed of fine areolae. The valve is thinly silicified and the fibulae can easily be seen in SEM on the undersurface of the valve. Internally, the fibulae are rod-like, varying from thin to wide. The fibulae do not extend far onto the valve face, but do show consistent lateral projections that do not connect with adjacent fibulae.

The lectotype of *N. palea* has been illustrated by Krammer and Lange-Bertalot (1991). However, a survey of the literature containing reports of *N. palea* reveals a great diversity of forms and shapes. Part of this diversity is shown by Krammer and Lange-Bertalot (1991), who put in synonymy a number of taxa under the common name of *N. palea*. The authors then divided *N. palea* into “sippen,” but it is highly difficult to realize for instance if each sippen has been drawn on purely morphological bases or if there are other supporting data. From an ecological perspective, however, there is a distinct possibility that each one of these
morphological groupings occupies specific niches with well-defined environmental conditions. Therefore, we recommend that each category be recognized and reported separately in NAWQA counts.

_**N. palea** var. **debilis** is a much smaller taxon. The valves are also linear, but the apices are markedly rostrate and even slightly subcapitate (Plate 14, Figs. 1-10). The striae cannot be seen clearly under LM, the fibulae are fine, and no clear central area is observed. Some irregularities can be seen in the spacing of the fibulae, but not necessarily at the central area.

In general, this taxon can be distinguished from the nominal variety by its narrower width and the characteristics of the valve apices. This taxon has been reported in NAWQA counts and it should continue to be recognized and treated separately.

_**N. archibaldii** has even narrower valves than the other two taxa above (See Plate 14, Fig. 18 for a comparison of the three taxa). Valves in _**N. archibaldii**_ have parallel sides with rostrate apices. Some representatives may be slightly subcapitate (Krammer and Lange-Bertalot, 1991; pg. 379, Plate 81, Figs. 10-12). The fibulae are seen as small dots under LM and they are much smaller than those in _**N. palea**_ and varieties.

_**N. archibaldii**_ has been identified from NAWQA material and it should be kept separate from related taxa. Krammer and Lange-Bertalot (1991) can be used as a reference for its identification. Kobayasi (1985) also presented LM and SEM data for this species and can be used as an additional reference.

_**N. capitellata**_ has linear to lanceolate valves with subrostrate to subcapitate ends; a middle constriction is clearly visible in some specimens (Plate 14, Figs. 19-27). This taxon could be confused with larger representatives of _**N. palea**_. _**N. capitellata**_ has conspicuous striae, however, and a clear central nodule can be seen in many specimens. Although the latter feature seems to vary within local populations, at least some representatives will have this feature thereby giving a hint as to their identity. The fibulae are fine as in _**N. palea**_, but in general, they seem much more regularly arranged.

_**N. capitellata**_ has been reported from NAWQA material and analysts have kept it separate from larger forms of _**N. palea**_. Analysts must be extremely cautious, however, during identification of this taxon versus _**N. solita**_. The latter taxon has a similar morphology, but lacks the middle valve constriction and a conspicuous central nodule (Krammer and Lange-Bertalot, 1991; pg. 359, Plate 71, Figs. 1-12). Also, the striae in _**N. solita**_ are much coarser and in some larger specimens the individual areolae can be seen under LM.

**Some unknown Nitzschia taxa in NAWQA databases (presented by M. Potapova)**

In her presentation, M. Potapova pointed out that a total of 493 species of the genus _**Nitzschia**_ have been reported in NAWQA counts. From these, 262 correspond to unknown species, 26% of which reached at least 1% relative abundance in quantitative counts. M.
Potapova discussed 12 unknown species and 3 additional unknowns that she encountered during the preparation of her presentation.

*Nitzschia* cf. *legleri* Hustedt CODY resembles *N. solita* and all dimensions are in accordance with data presented for the latter species by Krammer and Lange-Bertalot (1991) (Plate 16, Figs. 1-3). M. Potapova also found that some of the valves reported as *Nitzschia* cf. *legleri* Hustedt CODY actually resemble *N. palea* (Plate 16, Figs. 4 and 5). These latter specimens have finer striation and fibulae of different characteristics than those of *N. solita*. *Nitzschia* cf. *legleri* Hustedt CODY should be synonymized with *N. solita* in NAWQA databases.

*Nitzschia* cf. *solita* Hustedt CLASON also resembles *N. solita* in striae, fibulae and valve shape characteristics (Plate 16, Figs. 6-8). Smaller specimens of *Nitzschia* cf. *solita* Hustedt CLASON (e.g., Plate 16, Fig. 8) also fit Krammer and Lange-Bertalot’s (1991) data for *N. supralitorea* and *N. fonticola* var. *pelagica*. An examination of a number of valves, especially of larger specimens in the population, is required to ascribe smaller specimens of this taxon to *N. solita*. *Nitzschia* cf. *solita* Hustedt CLASON should be changed to *N. solita* in NAWQA records.

*Nitzschia* cf. *lacuum* Lange-Bertalot CODY (Plate 16, Figs. 9-10). This taxon resembles *N. lacuum*, but the striae density in *Nitzschia* cf. *lacuum* Lange-Bertalot CODY is much lower (26-28 per 10 µm). Another taxon that is closely related to *Nitzschia* cf. *lacuum* Lange-Bertalot CODY is *N. bacillum*, but the valve ends are much more acute in the latter. Although the striae density between the taxa overlap, *N. bacillum* tends to have a higher density (Krammer and Lange-Bertalot, 1997). A third taxon that resembles *Nitzschia* cf. *lacuum* Lange-Bertalot CODY is *N. liebetruthii*. The ends are blunt, however, and there is a middle constriction in the valves of the latter that is not present in *Nitzschia* cf. *lacuum* Lange-Bertalot CODY (Krammer and Lange-Bertalot, 1997). *Nitzschia* cf. *lacuum* Lange-Bertalot CODY should be changed to *Nitzschia* sp.2 ANS LLB in NAWQA databases (see below).

*Nitzschia* sp.1 ANS LLB resembles *N. fonticola* in valve shape and fibulae density (ca. 10-13 per 10 µm), but is much smaller and has finer striae (ca. 38/10 µm) (Plate 16, Figs. 11-18). *Nitzschia* sp.1 ANS LLB should be maintained as a separate taxon in NAWQA records.

*Nitzschia* sp.2 ANS LLB is identical to *N. cf. lacuum* Lange-Bertalot CODY (Plate 16, Figs. 19-21). Although both of these species resemble *N. lacuum* and *N. liebetruthii* (Krammer and Lange-Bertalot, 1997), striae density (28-31 per 10 µm) are either higher or lower than the two mentioned species, respectively. *Nitzschia* sp.2 ANS LLB should be kept separate in NAWQA records. Only one specimen of the unknown taxon *Nitzschia* sp.3 ANS LLB (Plate 16, Fig. 22) was found and it is difficult to determine if the valve depicted in Plate 16, Fig. 22 is the original taxon reported as *Nitzschia* sp.3 ANS LLB since a circle could not be found. If further specimens are found, measurements should be taken and compared with those of in the literature to determine if this is truly an undescribed taxon.
Nitzschia sp.10 ANS WRC does not resemble any taxon reported in the literature and should be kept separate in NAWQA counts (Plate 16, Figs. 25-31). The population found in Central Nebraska Basins Study Unit (GS006193, CNBR 93) shows a valve length ranging between 17-26 µm and a width of ca. 3 µm. The striae and fibulae density range between 32-34 per 10 µm, and 9-14 per 10 µm, respectively. Other reported specimens of this unknown taxon in the same CNBR study unit (e.g., GS012003) are not congruent with the above description and resemble N. archibaldii (Plate 16, Figs. 32-34). In the latter case, correction to particular counts should be made.

Nitzschia sp.1 ANS WRC was reported from Colorado (GS007121) (Plate 16, Figs. 23-24). This population seems to contain two morphs, one with a central nodule and another with similar valve shape to the first morph, but without a clear central nodule. The striae and fibulae density is similar in both morphs and resemble data presented for N. fonticola by Krammer and Lange-Bertalot (1991). Since other populations of N. fonticola from North America have been found to contain morphs with and without central nodules and because Nitzschia sp.1 ANS WRC resembles descriptions of N. fonticola in the literature, the change of Nitzschia sp.1 ANS WRC to N. fonticola is recommended.

Nitzschia sp.1 ? (Plate 17, Figs. 1-6) seems to be closely related to the N. communis-N. perspicua group. The dimensions of a population found in the Acadian-Pontchartrain Study Unit (GSN01201, ACAD 1999) are: length 13-19 µm, width 3-3.5 µm, striae density ca. 32 per 10 µm, and fibulae density 14-16 per 10 µm. Since this seems to be an undescribed species, the name Nitzschia sp. 31 NAWQA KM (NADED No. 48575) should be ascribed to it.

Nitzschia sp. OA UL NAWQA KM (Plate 17, Figs. 10-17) resembles the next unknown taxon.

Nitzschia sp. OG UL NAWQA KM is similar to Nitzschia sp. OA UL NAWQA KM and N. salinicola Hustedt (Plate 17, Figs. 7-9). This latter taxon has been synonymized with N. capitellata by Krammer & Lange-Bertalot. This lumping requires further studies, hence, NAWQA taxonomists will not accept it for now. The dimensions of Nitzschia sp. OG UL NAWQA KM in the Lower Illinois River Basin Study Unit (GSL0040, LIRB 1996) are length 30-35 µm, width 4.5-5 µm, 36-38 striae per 10 µm, and 12-16 fibulae per 10 µm. Nitzschia sp. OG UL NAWQA KM should be changed to Nitzschia sp. OA UL NAWQA KM and maintained separately in NAWQA.

Nitzschia sp. 1 ANS NAR USNK does not resemble any taxon reported in the literature (Plate 17, Figs. 15-18). A population of this unknown was reported from the Upper Snake River Study Unit (GS009333, USNK 1994). Its length varies between 27-58 µm and the width measures ca. 4 µm. The striae and fibulae density range between 38-40 and 8-10 per 10 µm, respectively. The morphologically closest relative of this taxon is N. sociabilis, but the striae density in Nitzschia sp. 1 ANS NAR USNK is much lower.

In addition to the above unknown taxa, M. Potapova found the following taxa that do not seem to match any literature descriptions and are given unknown designations:
Nitzschia sp. 32 NAWQA MP from the Upper Snake River Study Unit (GS009333, UNSK 1994) has a length ranging between 25-39 µm and a width of 4-5 µm. The striae density is ca. 34 per 10 µm, and the fibulae density is 9-10 per 10 µm (Plate 17, Figs. 19-21). This taxon has been assigned the NADED No. 48576.

Nitzschia sp. 33 NAWQA MP from the Sacramento Basin Study Unit (GS029051, SACR 1996). Only one specimen was observed. Its length and width are 14 and 2.6 µm, respectively. The striae are not clearly visible and their density is probably ca. 40 per 10 µm. The fibulae density is 18 per 10 µm (Plate 17, Fig. 22). The NADED No. 485776 has been assigned to this taxon.

Nitzschia sp. 34 NAWQA MP from the Acadian-Pontchartrain Study Unit (GSN01288, ACAD 1998). Its length ranges between 10-12 µm, whereas the width of the valve ranges between 4-4.5 µm. The striae are not clearly visible and their density is probably higher than 40 per 10 µm. The fibulae density is equal to 14-16 per 10 µm (Plate 17, Figs. 23-24). The NADED No. 48578 has been assigned to this taxon.
References


Plate 1.


Figures 27-31. *Nitzschia sociabilis*. Fig. 27. Indian Creek near Madison, AL, Lower Tennessee River Basin Study Unit. Figs. 28 and 31. Scarham Creek near Mcville, AL, Lower Tennessee River Basin Study Unit. Fig 29. Nippersink Creek, Upper Illinois River Basin Study Unit. Fig. 30. Boguefalaya River, Upper Illinois River Basin Study Unit. Figures 32-37. *Nitzschia recta*. Figs. 32-34. Scarham Creek near Mcville, AL, Lower Tennessee River Basin Study Unit. Figs. 35 and 36. Bradley Creek near Alto, TN, Lower Tennessee River Basin Study Unit. Fig. 37. Cane Creek, Lower Tennessee River Basin Study Unit. Photographs by K. Manoylov and E. Morales.
Plate 2

**Figures. 1 and 2.** *Nitzschia dissipata* (SEM). Coroico, Andes Bolivia. Fig. 1. External view.

Fig. 2. Internal view. Photographs by E. Morales.
Plate 3

Figures 1-6. Nitzschia recta (SEM). External view. Magnification 4,400X to 20,000X. Fig. 1 whole valve. Fig. 2 central valve region. Fig. 3 apex. Fig. 4 central valve region. Figs 5, 6 apex. Sand Creek at Xeon Street in Coon Rapids, MN, Upper Mississippi River Basin Study Unit. Photographs by P. Hamilton.
Plate 4


Figs 1-4 whole valve. Figs 5, 6 central valve region. Figs 7, 8 apex. Note all except Fig.1 are tilted, therefore scale bar on image is not precise. Photographs by P. Hamilton.
Plate 5


Plate 6

Figures 1-8. *Nitzschia amphibia*. External view. Magnification 6,300X to 39,000X. Figs. 1-4 whole valve. Fig. 5 apex. Fig. 6 valve central region. Figs. 7, 8 whole valve. Note: all images except Fig. 7 taken with tilt, therefore scale bar on image is not precise. Bogue Phalia Near Lealand, MS, Mississippi Embayment Study Unit. Photographs by P. Hamilton.
Plate 7

Figures 1-8. *Nitzschia amphibia*. Showing internal view. Magnification 6,000X to 25,000X.

Figs. 1-3 whole valve. Fig. 4 central valve region showing “pointed” fibulae onto the valve face.

Fig. 5 whole valve. Fig. 6 central region showing “pointed” fibulae onto the valve face. Fig. 7 whole valve. Fig. 8 whole valve. Note Figs. 2, 4, 5, 6, 8 are tilted, therefore scale bar on image is not precise. Bogue Phalia Near Lealand, MS, Mississippi Embayment Study Unit.

Photographs by P. Hamilton.
Plate 8

Figures 1-8. *Nitzschia amphibia f. frauenfeldii*. In external and internal views. Magnification 3,600X to 23,000X. Figs 1, 2 whole valve external view. Fig. 3 valve central region external view. Fig. 4 apex external view. Figs 5, 6 whole valve internal view. Fig. 7 valve central region internal view. Fig. 8 apex internal view. Note: all figures are tilted, therefore scale bar on image is not precise. Hillsboro Canal at S-6 near Shawano, Southern Florida Study Unit. Photographs by P. Hamilton.
Plate 9

**Figures 1-38.** *Nitzschia fonticola.* Figs. 1-2. Type material, Cleve & Moller # 174. Figs. 3-5. Van Heurck # 143. Figs. 6-16. Caribou Creek at South Ferguson Road, Yakima River basin Study Unit. Figs. 17-22. Deer Creek near Vina, CA, Sacramento Basin Study Unit. Figs. 23-38. Peekskill Hollow Creek, Westchester, NY, Hudson River Basin Study Unit. Photographs by Workshop Participants (Figs. 1-5) and E. Morales (Figs. 6-38). **Figures 39-48.** *Nitzschia* sp. 30 NAWQA EAM (NADED 48574). Bayou Liberty, St. Tammany, LA, Acadian-Pontchartrain Study Unit. Photographs by E. Morales. **Figures 49-57.** *Nitzschia gessneri.* Maurice River, Salem, NJ. Long Island-New Jersey Coastal Plain Study Unit. Photographs by E. Morales.

**Figures 58-63.** *Nitzschia frustulum.* North River, Franklin, MA, Connecticut, Housatonic, and Thames River Basins Study Unit. Photographs by Workshop Participants. **Figures 64-67.**

*Nitzschia inconspicua.* North River, Franklin, MA, Connecticut, Housatonic, and Thames River Basins Study Unit. Photographs by Workshop Participants. **Figure 68.** Comparison of *N. frustulum* and *N. inconspicua*, the latter is on the upper left corner of the picture. North River, Franklin, MA, Connecticut, Housatonic, and Thames River Basins Study Unit. Photographs by Workshop Participants.
Plate 10

Figures 1-8. Nitzschia fonticola. External view. Magnification 3,900X, 28,000X. Fig. 1 whole valve. Fig. 2 central valve region. Fig. 3 apex. Figs 4-7: whole valve. Fig. 8: central valve region. Note: all figures, except figs 4, 6, are tilted, therefore scale bar on image is not precise.

Deer Creek near Vina, CA, Sacramento Basin Study Unit. Photographs by P. Hamilton.
Plate 11

Figures 1-8. *Nitzschia fossilis*. External and internal views. Magnification 7,800X to 33,600X.

Fig. 1 external view whole valve. Fig. 2 internal view whole valve, Figs 3, 4 external view whole valve. Figs 5, 6 central valve region. Fig. 7 external view whole valve. Fig. 8 apex. Note: all figures, except figs 2, 4, 7, are tilted, therefore scale bar on image is not precise. Nippersink Creek, Upper Illinois River Basin Study Unit. Photographs by P. Hamilton.
Plate 12

Figures 1-6. *Nitzschia frustulum*. External view. Magnification 9,500X to 34,500X. Figs. 1-5: whole valves. Fig. 6: central valve region. Fig. 7: apex. Fig. 8: apex. Note: all figures, except Figs. 2, 6, are tilted, therefore scale bar on image is not precise. Nippersink Creek, Upper Illinois River Basin Study Unit. Photographs by P. Hamilton.
Plate 13

Figures 1-3. *Nitzschia frustulum*. Internal view. Magnification 20,400X to 21,400X. Figs. 1-3 whole valves. Note: Fig. 2 is tilted, therefore scale bar on image is not precise. Nippersink Creek, Upper Illinois River Basin Study Unit. Photographs by P. Hamilton.
Plate 14

Figures 1-10. *Nitzschia palea* var. *debilis*. Dismal River near Thedford, NE, Central Nebraska Basins Study Unit.  

Figure 11-17. *Nitzschia palea*. Dismal River near Thedford, NE, Central Nebraska Basins Study Unit.  

Figure 18. Comparison between *N. archibaldii* (upper left), *N. palea* var. *debilis* (upper right) and *N. palea* (lower right). Cattaraugus Creek at Gowanda, NY, Lake Erie-Saint Clair Drainage Study Unit.  

Figures 19-22. *Nitzschia capitellata*. San Pedro River near Hereford Road, AZ, Central Arizona Basins Study Unit.  

Plate 15

Figures 1-6. *Nitzschia palea*. External view. Magnification 6,100X to 22,800X. Figs. 1, 2 whole valve. Fig. 3 central valve region. Fig. 4 apex. Fig. 5 central valve region. Fig. 6 apex.

Note: all figures, except Fig. 1, are tilted, therefore scale bar on image is not precise.

Photographs by P. Hamilton.
Plate 16

Figures 1-3. *Nitzschia solita* (originally identified as *N. cf. legleri* Hustedt CODY). Bear Creek, South Platte River Basin Study Unit. **Figures 4-5.** *N. palea* (originally counted as *N. cf. legleri* Hustedt CODY). Bear Creek, South Platte River Basin Study Unit. **Figures 6-8.** *Nitzschia solita* (originally identified as *N. cf. solita* Hustedt CLASON). Medina River, South Central Texas Study Unit. **Figures 9-10.** *Nitzschia* sp.2 ANS LLB (originally identified as *N. cf. lacuum* Lange-Bertalot CODY). S. Platte River, South Platte River Basin Study Unit.

**Figures 11-18.** *Nitzschia* sp. 1 ANS LLB. Big Chico Creek, Sacramento Basin Study Unit.

**Figures 19-21.** *Nitzschia* sp. 2 ANS LLB. Fig. 19. Big Chico Creek, Sacramento Basin Study Unit. Figs. 20-21. Deer Creek, Sacramento Basin Study Unit. **Figure 22.** *Nitzschia* sp. 3 ANS LLB. Big Chico Creek, Sacramento Basin Study Unit. **Figures 23-24.** *Nitzschia fonticola* (originally identified as *N. sp. 1 ANS WRC*). Bear Creek, South Platte River Basin Study Unit.

**Figures 25-31.** *Nitzschia* sp. 10 ANS WRC. Eihorn River, Central Nebraska Basins Study Unit.

**Figures 32-34.** *Nitzschia archibaldii* (originally identified as *N. sp. 10 ANS WRC*). Dismal River near Thedford, NE, Central Nebraska Basins Study Unit. Photographs by M. Potapova.
Plate 17

Figures 1-6. *Nitzschia* sp. 31 NAWQA KM (originally reported as *N*. sp. 1?). Bayou Boeuf at Amelia, LA, Acadian-Pontchartrain Study Unit. Figures 7-17. *Nitzschia* sp. OA UL NAWQA KM (originally identified as *N*. sp. OG UL NAWQA KM). Sagamon River, Lower Illinois River Basin Study Unit. Figures 18-21. *Nitzschia* sp. 1 ANS NAR USNK. Devils Washbowl Spring, Upper Snake River Basin. Figures 22-24. *Nitzschia* sp. 32. NAWQA MP. Devils Washbowl Spring, Upper Snake River Basin. Figure 25. *Nitzschia* sp. 33. NAWQA MP. Deer Creek, Sacramento Basin Study Unit. Figures 26-27. *Nitzschia* sp. 34 NAWQA MP. Bayou Cane, Acadian-Pontchartrain Study Unit. Photographs by M. Potapova.