Diatom (*Stephanodiscus binderanus*)
Ecological Risk Screening Summary

U.S. Fish & Wildlife Service, February 2014
Revised, March 2016, March 2017, June 2017
Web Version, 6/22/2018

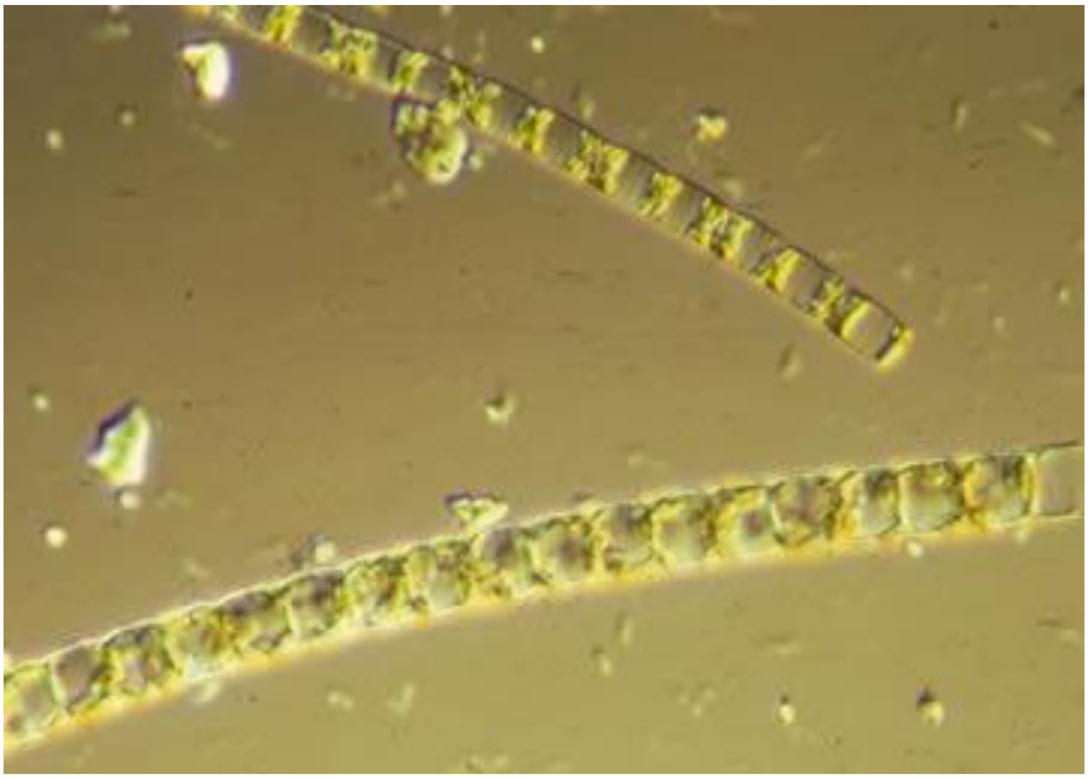

Photo: Rex Lowe, GLANSIS (Kipp et al. 2014). Available: https://nas.er.usgs.gov/queries/GreatLakes/FactSheet.aspx?SpeciesID=1687.

1 Native Range and Status in the United States

Native Range
From Kipp et al. (2014):

"*Stephanodiscus binderanus* was first described from the Baltic Sea and is considered a Eurasian species (Mills et al. 1993). However, it has expanded its range within Eurasia to places where it was not previously recorded."

Status in the United States

From Kipp et al. (2014):

"*Stephanodiscus binderanus* was first recorded from Lake Michigan in 1938. However, sediment samples indicate that it could have occurred by 1930 in Lake Erie and by around the late 1940s to early 1950s in Lake Ontario. It also now occurs in Lake Huron and the Cuyahoga River, which is part of the Lake Erie drainage (Mills et al. 1993, Stoermer et al. 1996, Stoermer and Yang 1970, Williams 1972)."

"*Stephanodiscus binderanus* populations in Lake Erie and Lake Michigan have fluctuated over time. From the 1930s to 1960s, both lakes experienced eutrophication and, as a result, *S. binderanus* increased in abundance. By the end of that period, the density of *S. binderanus* in Lake Michigan ranged from 98 cells/mL to 1617 cells/mL, accounting for 14.6% of lake biomass. Spring blooms were associated with the excursion of the spring thermal bar and were limited to eutrophic nearshore areas in Lake Michigan, but occurred in both nearshore and offshore waters in Lake Erie and Lake Ontario (Danforth and Ginsbur 1980, Makarewicz 1981, Stoermer and Ladewski 1976). As anthropogenic inputs to the lakes began to be addressed in the 1970s and 1980s, these systems returned to more oligotrophic-mesotrophic conditions, and *S. binderanus* concentrations plummeted. In the 1980s, the maximum density *S. binderanus* in Lake Erie was 1,549 cells/mL, accounting for only 0.56% of the total cells collected. However, in the early 1990s, *S. binderanus* increased again in abundance in Lake Erie, only to drop to low levels by the end of that decade (Barbiero et al. 2006, Danforth and Ginsburg 1980, Makarewicz 1993, Makarewicz and Baybutt 1981, Stoermer et al. 1975, Stoermer et al. 1996, Tarapchak and Stoermer 1976)."

"Established where recorded."

From Taylor and Bothwell (2014):

"The effort required to detect a rare diatom taxon in sediment cores is seldom put forth, which may lead to erroneous conclusions about the diatom's absence. An example that may be analogous to *D. geminata* blooms comes from the lake diatom *Stephanodiscus binderanus*, which was initially identified as a nonnative invasive introduced to the Great Lakes from Eurasia; however, recent lake core data show that this species was present in nearby (less than 50 kilometers away) Lake Simcoe since at least the seventeenth century (Hawryshyn et al. 2012). The recent increase in abundance of this species in the Great Lakes has been attributed to changing environmental conditions—namely, eutrophication— which makes it appear to have been recently introduced."

Means of Introductions in the United States

From Kipp et al. (2014):

"*Stephanodiscus binderanus* was very likely introduced to the Great Lakes basin in ships' ballast water (Mills et al. 1993)."

Remarks

From Kipp et al. (2014):

"*Stephanodiscus binderanus* was first recorded in the St. Lawrence River near Montreal in 1955 (Mills et al. 1993). *Stephanodiscus binderanus* is synonymous with *Melosira binderana*. Alternate spellings sometimes found in the literature are *S. binderianus* and *M. binderiana*.
A recent study conducted by Hawrshyn et al. (2012) in Lake Simcoe, Ontario found historical microfossils of *S. binderanus* dating back the 17th century. This discovery brings the status of *S. binderanus* as a nonindigenous species in the Great Lakes basin into question. *Stephanodiscus binderanus* may be better classified as a range expander rather than as a nonidigenous species."

2 Biology and Ecology

Taxonomic Hierarchy and Taxonomic Standing

From ITIS (2014):

"Kingdom Chromista
  Subkingdom Chromista
    Division Bacillariophyta
      Class Coscinodiscophyceae
        Order Zingiberales
          Family Stephanodiscaceae
            Genus *Stephanodiscus*
              Species *Stephanodiscus binderanus*"

"Taxonomic Status: Current Standing: accepted"

Size, Weight, and Age Range

From Kipp et al. (2014):

"Volume is approximately 830 cubic microns"

Environment

From Kipp et al. (2014):

"*Stephanodiscus binderanus* often reaches high abundance in eutrophic and/or slightly brackish conditions. It is very tolerant of osmotic variability. […] In the Great Lakes, it usually occurs in eutrophic areas in the thermal bar region. It is most abundant in colder seasons but may persist in relatively polluted areas throughout summer. Resting cells are typically triggered to reinitiate growth by changes in temperature, nutrients, and other abiotic conditions (Kling 1998, Laugasta et al. 1996, Mills et al. 1993, Round 1972, Sicko-Goad et al. 1989, Sommer 1984, Stoermer et al. 1975, Stoermer and Ladewski 1976, Stoermer and Yang 1970, Tarapchak and Stoermer 1976)."

"Highest abundance in nearshore areas typically occurs at water temperatures around 8–9°C (Lauer 1976, Round 1972, Stoermer and Ladewski 1976). […] In the Cuyahoga River, *S. binderanus* has been known to occur at temperatures of 26°C (Williams 1972). It has also been recorded in the north channel of the St. Lawrence estuary at biovolumes over 50% in salinities of 1–5.5 psu (Winkler et al. 2003)."

"In the former USSR, *S. binderanus* tends to be a eurythermal species that blooms around 15–16°C in the spring and 19–20°C in the summer, and typically occurs in large lakes and reservoirs."

"*Stephanodiscus bineranus* thrives in phosphorous rich and silica depleted waters."

Climate/Range

From Kipp et al. (2014):

"This species grows best in 12 hours of light and 12 hours of dark (Holopainen and Letanskaya 1999, Knisely and Geller 1986, Sicko-Goad and Andersen 1991, Sommer and Stabel 1983)."

Distribution Outside the United States

Native

From Kipp et al. (2014):

"*Stephanodiscus binderanus* was first described from the Baltic Sea and is considered a Eurasian species (Mills et al. 1993). However, it has expanded its range within Eurasia to places where it was not previously recorded. (Also see Remarks. [in source material])"

Introduced

No records were found that clearly indicated a non-native introduction of *Stephanodiscus binderanus*. Records of the presence of *S. binderanus* were found that did not indicate if it was part of the native range or a non-native introduction, those are detailed below.

Distribution Records without Indication of Native or Introduced Status

From Kling (1998):

"[…] and the diatoms (*Aulacoseira ambigua*, *A. granulata*, *A. islandica*, *S. binderanus*, and *S. niagarae*) were abundant in the upper sediments and changes after 100 cm can be interpreted as the effects of human impact. These taxa indicative of increase eutrophication, in addition to *S. agassizensis*, *Melosira varians* and *Cyclostephanos dubius*, are representative of present day plankton [in Lake Winnipeg, Canada]."

From Laugaste et al (1996):

"*A. granulata* (Ehr.) Sim. and *Stephanodiscus binderanus* (Kutz.) Krieger prevail in summer and autumn, the latter being most abundant in the southern part [of Lake Peipsi-Pihkva, Estonia and Russia]."

From Edlund et al. (1995):

"This diatom [*Strephanodiscus binderanus*] has been reported from Lake Baikal since the 1930's (Skvortzow, 1937)."

"Zone 3 is represented by a single depth (20-21 cm) and is uniquely characterized by an abundance peak of *Stephanodiscus binderanus* that had begun in Zone 4. This depth has been dated c. 1780's A.D., and may indicate that anthropogenically-induced changes occurred in Lake Baikal during early settlement and development in the southern basin."

From Berthon et al. (2013):

"A comparison of the species relative abundances in the limnological data and alaeolimnological data [for Lake Geneva, France] highlighted some differences: *Asterionella formosa*, *Cyclotella costei* and *Diatoma tenuis* relative abundances were higher in limnological data, and, in contrast, *Stephanodiscus binderanus* and *S. minutulus* had lower relative abundances than in the palaeolimnological data (between 1989 and 1996)."

Means of Introduction Outside the United States
No records were found that clearly indicated a non-native introduction of *Stephanodiscus binderanus*.

Short Description
From Kipp et al. (2014):

"This diatom is an obligate colonial species that occurs in filaments. Valve faces are flat but may exhibit some concentric undulation and occur at right angles to valve mantles. Valve spines are forked. On occasion some cells exhibit occluded or slit-shaped areolae. Thick pores occur in a ring on the mantle. Vacuoles comprise around 40% of cell volume (Round 1972, 1982; Stoermer and Sicko-Goad 1985). In Saginaw Bay, Lake Huron, the cell volume of *S. binderanus* is around 830 µm3 (Sicko-Goad et al. 1977)."

Biology
From Kipp et al. (2014):

"*Stephanodiscus binderanus* also sometimes occurs at river outlets into lakes. It requires silicon for growth, but populations can persist in low silicon conditions until this resource increases in abundance. Filaments are frequently grazed efficiently by zooplankton in native regions."

"Blooms are typically recorded in spring and fall in many water bodies, although there are also some records in summer."

"In Lake Michigan, blooms of *S. binderanus* have been recorded both in spring and fall. […] In Lake Erie, peaks in abundance have been recorded in spring, which is the largest peak, and also around November/December. In Lake Ontario, abundance typically reaches a maximum after the thermal bar spring excursion and declines sharply in summer. In Lakes Erie and Ontario, blooms typically occur in offshore and often central regions (Barbiero and Tuchman 2001, Round 1972, Stoermer and Ladewski 1976)."

"It was historically limited to northern regions of the USSR and only a few more southerly locations, but this changed with the building of more reservoirs in southern regions. It is likely that this species requires sediments to overwinter, which often accumulate well in larger lakes and reservoirs (Priymachenko 1973). In Lake Baikal, where it is not endemic, its presence is associated with increasing anthropogenic impacts (Edlund et al. 1995)."

Human Uses
Information about human uses of *Stephanodiscus binderanus* was not found.

Diseases
Information about diseases of *Stephanodiscus binderanus* was not found.

Threat to Humans
Information on any threats to humans from *Stephanodiscus binderanus* was not found.

3 Impacts of Introductions
From Kipp et al. (2014):

"*Stephanodiscus binderanus* has a moderate environmental impact in the Great Lakes."

"Realized:
The introduction and establishment of *S. binderanus*, along with *Actinocyclus normanii* f. *subsalsa*, were accompanied by the reduction of five native diatoms (*S. transilvanicus*, *Cyclotella comta*, *C. michiganiana*, *C. ocellanta*, and *C. stelligera*) in Lake Ontario (Edlund et al. 2000, Stoemer et al. 1985). While it is unclear if these local population reductions were due entirely or in part to competition with exotic taxa, the appearance of *S. binderanus* in Lake Ontario spring diatom collections tends to be associated with the absence or rare occurrence of *C. comta*, *C. michiganiana*, *C. ocellanta*, and *C. stelligera* (US EPA 2012). These native species reappear at sample sites in summer, when *S. binderanus* is not longer [sic] found (US EPA 2012), suggesting that strong seasonal competition may drive fluctuations in native diatom abundances."

"Current environmental impacts of this species are unknown."

"*Stephanodiscus binderanus* has a moderate socio-economic impact in the Great Lakes."

"Realized:
Stephanodiscus binderanus has clogged filters at water filtration plants in both Chicago and Montreal, and has caused water taste and odor problems (Brunel 1956, Stoermer and Yang 1970,

Stoermer et al. 1996, Vaughn 1961). *Stephanodiscus binderanus* also forms surface scums and, at high abundances, reduces water quality, and negatively affects recreational uses of the affected lake (Stoermer et al. 1985)."

"There is little or no evidence to support that *Stephanodiscus binderanus* has significant beneficial effects in the Great Lakes."

"Potential:
Stephanodiscus binderanus has been used to assess historical pollution and climate conditions both in the Great Lakes and in Lake Baikal, Russia (Edlund et al. 1995, Stoermer et al. 1985)."

4 Global Distribution

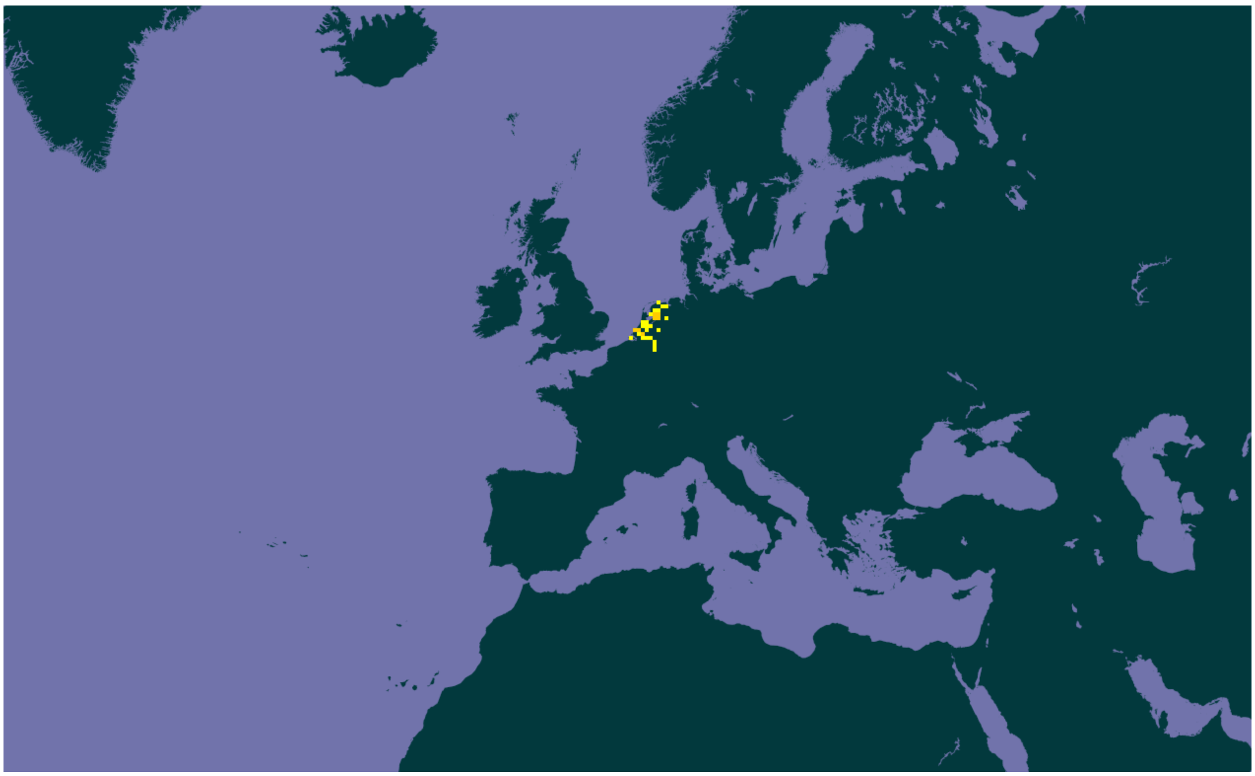

Figure 1. Known global distribution of *Stephanodiscus binderanus*. Locations are in northern Europe. Map from GBIF Secretariat (2016).

GBIF Secretariat (2016) does not record any locations in the United States. Those locations are provided in more United States focused databases and outlined in Section 5, below.

Records of this species were also found for Lake Winnipeg, Canada (Kling 1998), Lake Peipsi-Pihkva, Estonia and Russia (Laugaste et al. 1996), Lake Geneva, France (Berthon et al. 2013), and Lake Biakal, Siberia (Edlund et al. 1995). While no geographic coordinates were given, the site descriptions were detailed enough to be used as source points for the climate match.

5 Distribution Within the United States

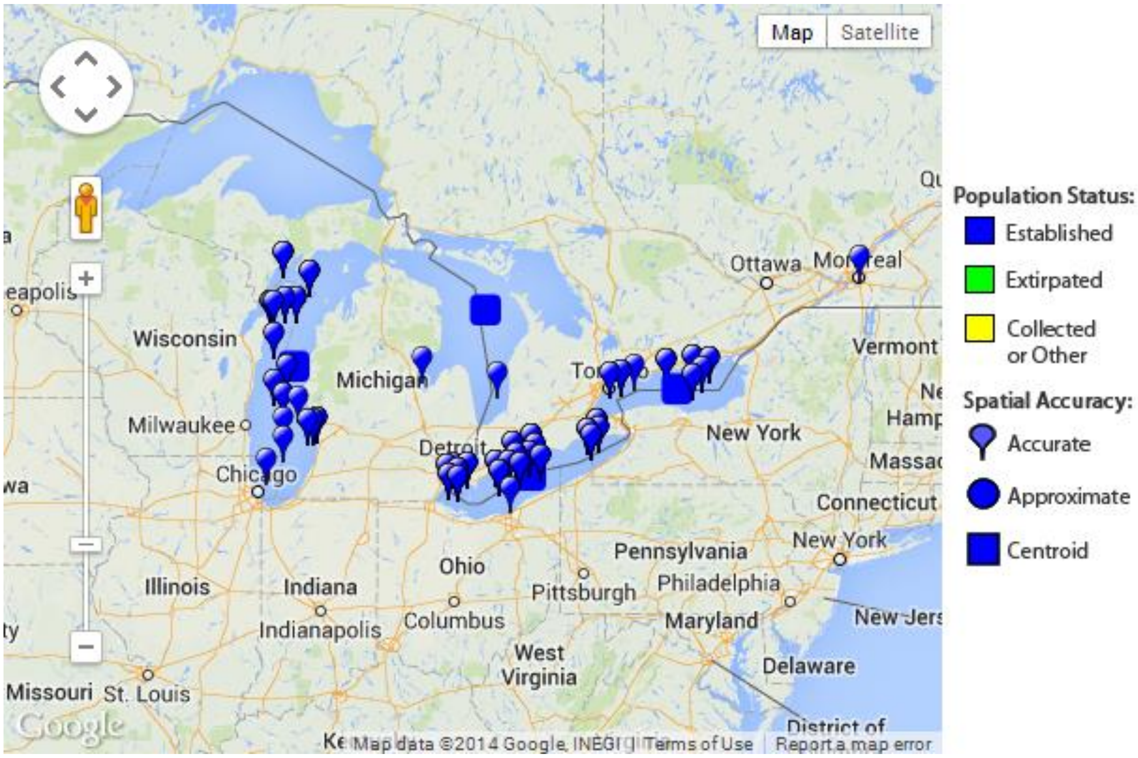

Figure 2. Known distribution of *Stephanodiscus binderanus* in the Great Lakes Region as reported by Kipp et al. (2014).

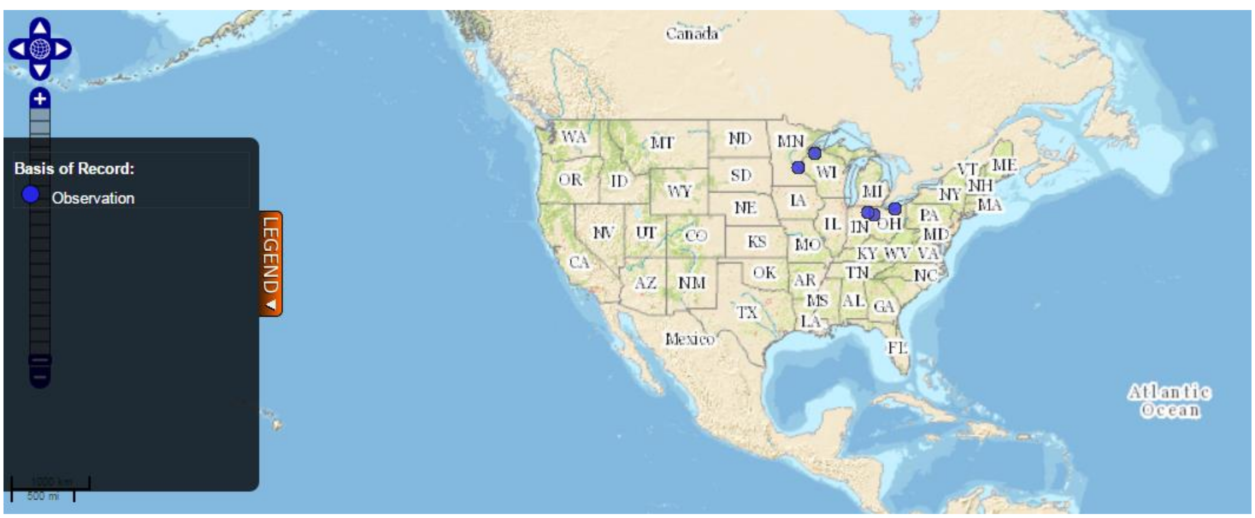

Figure 3. Known distribution of *Stephanodiscus binderanus* in the United States. Map created with data from BISON (2017).

6 Climate Matching

Summary of Climate Matching Analysis

The climate match for *Stephanodiscus binderanus* was high surrounding the Great Lakes and the northern part of the Mississippi basin. The match was medium in areas around the Great Lakes Basin and low elsewhere in the country. The Climate 6 score (Sanders et al. 2014; 16 climate variables; Euclidean distance) for the contiguous United States was 0.375, high. The following states had high individual climate scores: Arkansas, Colorado, Connecticut, Delaware, Illinois, Indiana, Iowa, Kansas, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, Montana, Nebraska, New Hampshire, New Jersey, New York, North Dakota, Ohio, Oklahoma, Pennsylvania, South Dakota, Vermont, Virginia, West Virginia, Wisconsin, and Wyoming.

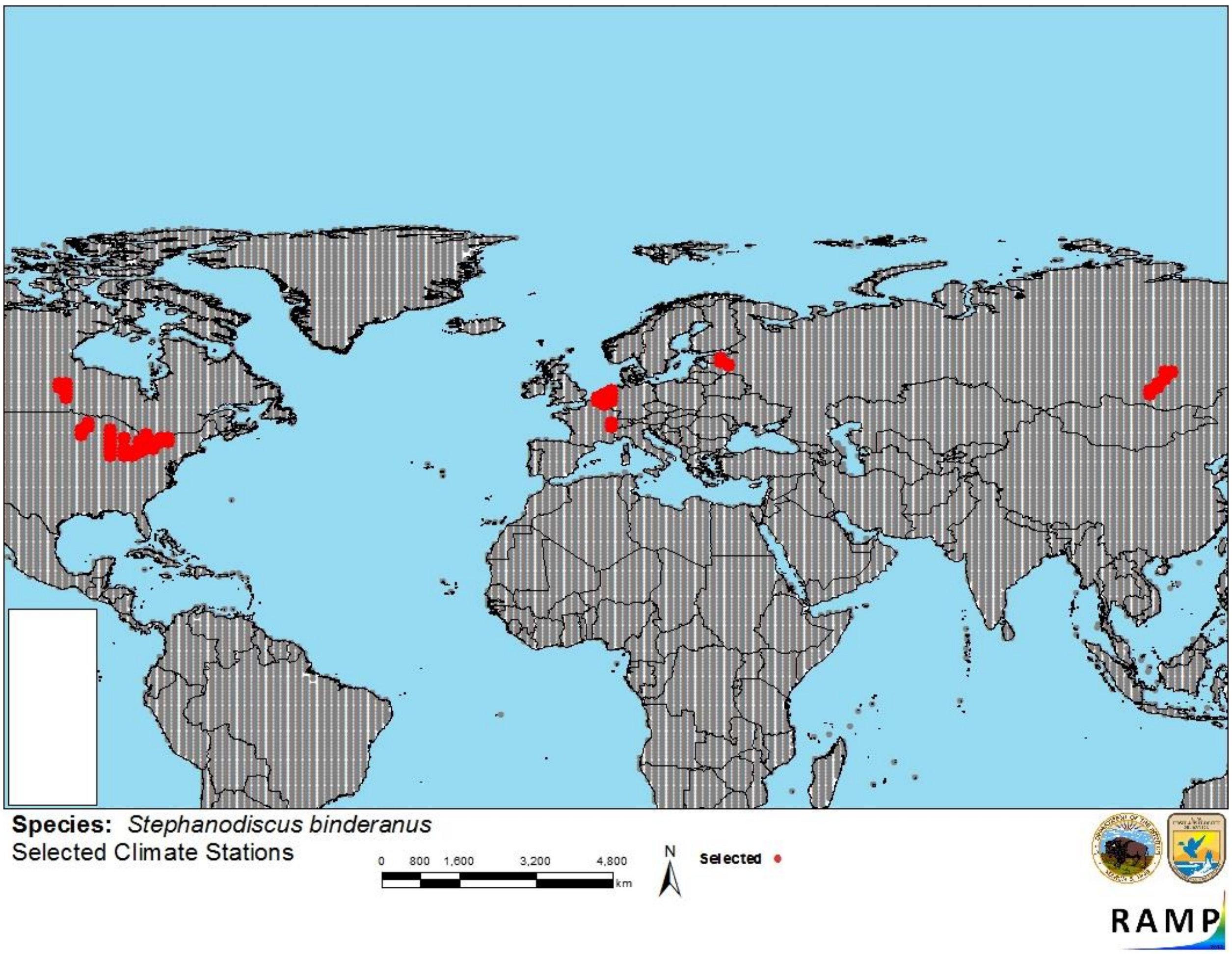

Figure 4. RAMP (Sanders et al. 2014) source map showing weather stations selected as source locations (red) and non-source locations (grey) for *Stephanodiscus binderanus* climate matching. Locations from Edlund et al. (1995), Laugaste et al. (1996), Kling (1998), Berthon et al. (2013), Kipp et al. (2014), GBIF Secretariat (2016), and BISON (2017).

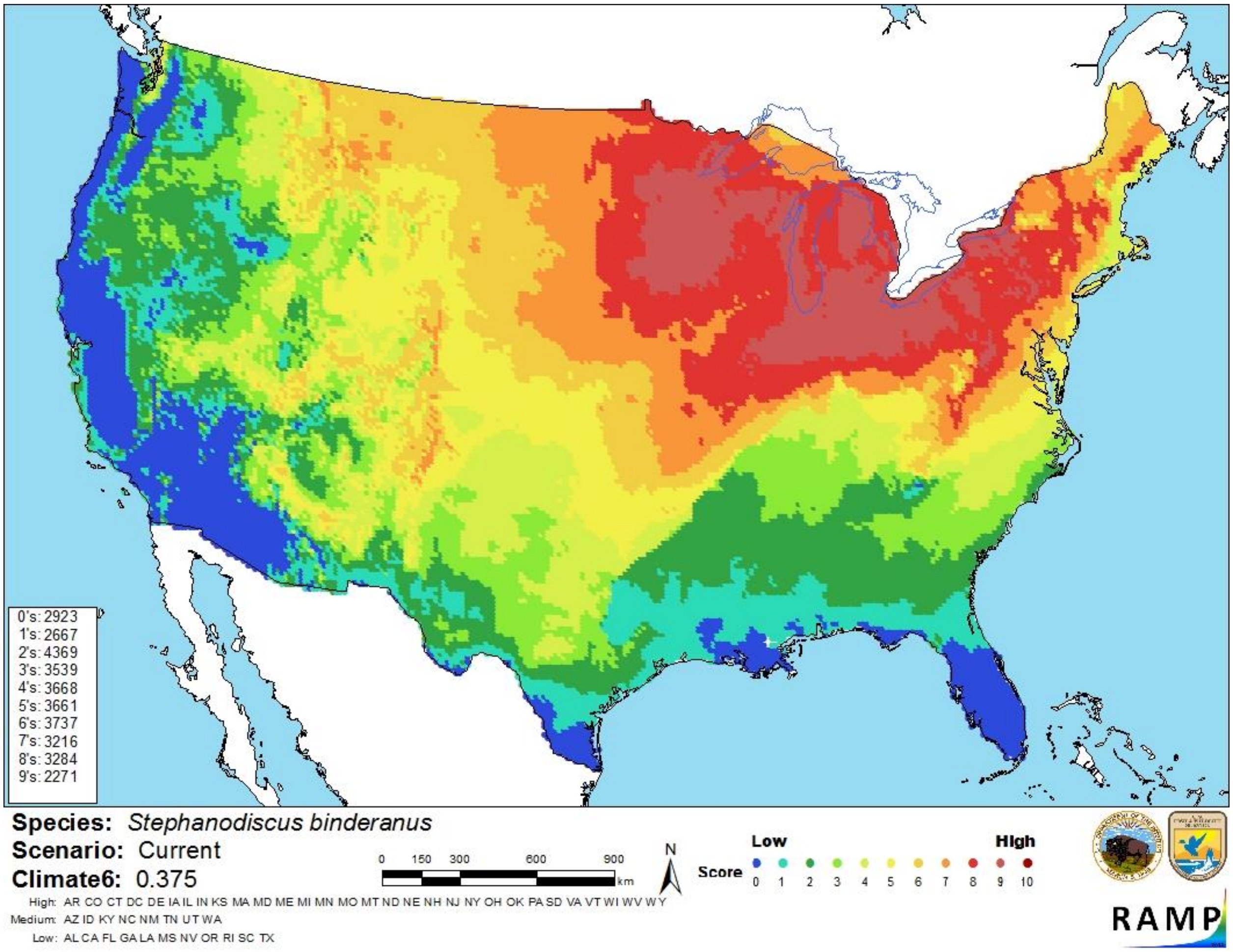

Figure 5. Map of RAMP (Sanders et al. 2014) climate matches for *Stephanodiscus binderanus* in the contiguous United States based on source locations reported by Edlund et al. (1995), Laugaste et al. (1996), Kling (1998), Berthon et al. (2013), Kipp et al. (2014), GBIF Secretariat (2016), and BISON (2017). 0 = Lowest match, 10 = Highest match.

The High, Medium, and Low Climate match Categories are based on the following table:

Climate 6: Proportion of (Sum of Climate Scores 6-10) / (Sum of total Climate Scores)	Climate Match Category
0.000≤X≤0.005	Low
0.005<X<0.103	Medium
≥0.103	High

7 Certainty of Assessment

The certainty of assessment is low. There was adequate general biological and ecological information available for *Stephanodiscus binderanus*. The current world-wide distribution is not well defined. Databases with geo-referenced observations were missing large areas that the literature indicated were part of the range of this species. There are records of this species as introduced to the Great Lakes but recent work has thrown this into question.

8 Risk Assessment

Summary of Risk to the Contiguous United States

Stephanodiscus binderanus is a diatom first described from the Baltic Sea and is considered a Eurasian species. It has been considered invasive to North America, potentially introduced to the Great Lakes basin in ships' ballast water (Mills et al. 1993). Recent work found fossils of this species in Lake Simcoe, Ontario from as early as 1700, throwing into question the invasive or native status of this species in North America. The history of invasiveness is uncertain. There are well documented impacts of *Stephanodiscus binderanus* in the Great Lakes. However, it is not certain if those impacts stem from the species being completely new to the system or a native species that experienced a population increase with the eutrophication of the Great Lakes. The climate match is high. This species is already present in the Great Lakes basin. Its worldwide distribution is not well documented in a single location but can be found haphazardly in the literature. The certainty of assessment is low. The overall risk assessment is uncertain.

Assessment Elements

- **History of Invasiveness (Sec. 3): Uncertain**
- **Climate Match (Sec. 6): High**
- **Certainty of Assessment (Sec. 7): Low**
- **Remarks/Important additional information** The native or invasive status of this species is in question in some locations.
- **Overall Risk Assessment Category: Uncertain**

9 References

Note: The following references were accessed for this ERSS. References cited within quoted text but not accessed are included below in Section 10.

Berthon, V., A. Marchetto, F. Rimet, E. Dormia, J.-P. Jenny, C. Pignol, and M.-E. Perga. 2013. Trophic history of French sub-Alpine lakes over the last ~150 years: phosphorus reconstruction and assessment of taphonomic biases. Journal of Limnology 72(3):417–429.

BISON. 2017. Biodiversity Information Serving Our Nation (BISON). U.S. Geological Survey. Available: https://bison.usgs.gov. (March 2017).

Edlund, M. B., E. F. Stoermer, and C. H. Pilskaln. 1995. Siliceous microfossil succession in the recent history of two basins in Lake Baikal, Siberia. Journal of Paleolimnology 14:165–184.

GBIF Secretariat. 2016. GBIF backbone taxonomy: *Stephanodiscus binderanus* (Kütz.) Willi Kreig. Global Biodiversity Information Facility, Copenhagen. Available: http://www.gbif.org/species/3193318. (March 2016).

ITIS (Integrated Taxonomic Information System). 2014. *Stephanodiscus binderanus* (Kütz.) Willi Kreig. Integrated Taxonomic Information System, Reston, Virginia. Available: http://www.itis.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=2329 (February 2014).

Kipp, R. M., M. McCarthy, and A. Fusaro. 2014. *Stephanodiscus binderanus*. U.S. Geological Survey, Nonindigenous Aquatic Species Database, Gainesville, Florida, and NOAA Great Lakes Aquatic Nonindigenous Species Information System, Ann Arbor, Michigan. Available: https://nas.er.usgs.gov/queries/greatlakes/FactSheet.aspx?SpeciesID=1687&Potential=N&Type=0&HUCNumber=DGreatLakes. (February 2014).

Kling, H. J. 1998. A summary of past and recent plankton of Lake Winnipeg, Canada using algal fossil remains. Journal of Paleolimnology 19:297–307.

Laugaste, R., V. V. Jastremskij, and I. Ott. 1996. Phytoplankton of Lake Peipsi-Pihkva: species composition, biomass and seasonal dynamics. Hydrobiologia 338:49–62.

Sanders, S., C. Castiglione, and M. Hoff. 2014. Risk assessment mapping program: RAMP. U.S. Fish and Wildlife Service.

Taylor, B. W., and M. L. Bothwell. 2014. The origin of invasive microorganisms matters for science, policy, and management: the case of *Didymosphenia geminate*. BioScience 64(6):531–538.

10 References Quoted But Not Accessed

Note: The following references are cited within quoted text within this ERSS, but were not accessed for its preparation. They are included here to provide the reader with more information.

Barbiero, R. P., D. C. Rockwell, G. J. Warren, and M. L. Tuchman. 2006. Changes in spring phytoplankton communities and nutrient dynamics in the eastern basin of Lake Erie since the invasion of *Dreissena* spp. Canadian Journal of Fisheries and Aquatic Sciences 63:1549–1563.

Barbiero, R. P., and M. L. Tuchman. 2001. Results from the U.S. EPA's biological open water surveillance program of the Laurentian Great Lakes: I. introduction and phytoplankton results. Journal of Great Lakes Research 27(2):134–154.

Brunel, J. 1956. Addition du *Stephanodiscus binderanus* a la flore diatomique de l'Amerique du Nord. Naturaliste Canadien (Quebec) 83:91–95.

Danforth, W. F., and W. Ginsburg. 1980. Recent changes in the phytoplankton of Lake Michigan near Chicago, USA. Journal of Great Lakes Research 6(4):307–314.

Edlund, M. B., C. M. Taylor, C. L. Schelske, and E. F. Stoermer. 2000. *Thalassiosira baltica* (Grunow) Ostenfeld (Bacillariophyta), a new exotic species in the Great Lakes. Canadian Journal of Fisheries and Aquatic Sciences 57:610–615.

Hawryshyn, J., K. M. Ruehland, M. Julius, and J. P. Smol. 2012. Absence of evidence is not evidence of absence: is *Stephanodiscus binderanus* (Bacillariophyceae) an exotic species in the Great Lakes region? Journal of Phycology 48(2):270–274.

Holopainen, A. L., and G. I. Letanskaya. 1999. Effects of nutrient load on species composition and productivity of phytoplankton in Lake Ladoga. Boreal Environment Research 4(3):215–227.

Knisely, K., and W. Geller. 1986. Selective feeding of four zooplankton species on natural lake phytoplankton. Oecologia (Berlin) 69(1):86–94.

Lauer, T. E. 1976. Principal components ordination of southern Lake Michigan, USA phytoplankton. Journal of Phycology 12(supplemental):8–9.

Laugasta, R., V. V. Jastremskij, and I. Ott. 1996. Phytoplankton of Lake Peipsi-Pihkva: species composition, biomass and seasonal dynamics. Hydrobiologia 338(1-3):49–62.

Makarewicz. 1981. [Source did not give full citation for this reference.]

Makarewicz, J. C. 1993. Phytoplankton biomass and species composition in Lake Erie, 1970 to 1987. Journal of Great Lakes Research 19(2):258–274.

Makarewicz, J. C., and R. I. Baybutt. 1981. Long-term 1927–1978 changes in the phytoplankton community of Lake Michigan at Chicago Illinois, USA. Bulletin of the Torrey Botanical Club 108(2):240–254.

Mills, E. L., J. H. Leach, J. T. Carlton, and C. L. Secor. 1993. Exotic species in the Great Lakes: a history of biotic crises and anthropogenic introductions. Journal of Great Lakes Research 19(1):1–54.

Priymachenko, A. D. 1973. Role of reservoirs in the geographic distribution of planktonic algae. Hydrobiological Journal 9(5):31–34.

Round, F. E. 1972. *Stephanodiscus binderanus* or *Melosira binderana* (Bacillarophyta: Centrales). Phycologia 11(2):109–117.

Round, F. E. 1982. Some forms of *Stephanodiscus* species. Archiv für Protistenkunde 125(1–4):357–371.

Sicko-Goad, L., and N. A. Andersen. 1991. Effect of growth and light-dark cycles on diatom lipid content and composition. Journal of Phycology 27(6):710–718.

Sicko-Goad, L., E. F. Stoermer, and J. P. Kociolek. 1989. Diatom resting cell rejuvenation and formation time course, species records, and distribution. Journal of Plankton Research 11(2):375–390.

Sicko-Goad, L., E. F. Stoermer, and B. G. Ladewski. 1977. A morphometric method for correcting phytoplankton cell volume estimates. Protoplasma 93:147–163.

Skvortzow, B. W. 1937. Bottom diatoms from Olhon Gate of Baikal Lake, Siberia. Philippine Journal of Science 62:293–377.

Sommer, U. 1984. Population dynamics of 2 planktonic diatoms in Lake Constance, Europe. Holarctic Ecology 7(3):257–261.

Sommer, U., and H. H. Stabel. 1983. Silicon consumption and population density changes of dominant planktonic diatoms in Lake Constance, West Germany. Journal of Ecology 71(1):119–130.

Stoermer, E. F., M. M. Bowman, and J. C. Kingston. 1975. Phytoplankton composition and abundance in Lake Ontario during IFYGL. National Environmental Research Center, Office of Research and Development, U.S. Environmental Protection Agency, Corvallis, Oregon.

Stoermer, E. F., G. Emmert, M. L. Julius, and C. L. Schelske. 1996. Paleolimnological evidence of rapid recent change in Lake Erie's trophic status. Canadian Journal of Fisheries and Aquatic Sciences 53:1451–1458.

Stoermer, E. F., and T. B. Ladewski. 1976. Apparent optimal temperatures for the occurrence of some common phytoplankton species in southern Lake Michigan. Great Lakes Research Division Publication 18, The University of Michigan, Ann Arbor.

Stoermer, E. F., and L. Sicko-Goad. 1985. A comparative ultrastructural and morphometric study of six species of the diatom genus *Stephanodiscus*. Journal of Plankton Research 7(1):125–135.

Stoermer, E. F., J. A. Wolin, C. L. Schelske, and D. J. Conley. 1985. An assessment of ecological changes during the recent history of Lake Ontario based on siliceous algal microfossils preserved in sediments. Journal of Phycology 21:257–276.

Stoermer, E. F., and J. J. Yang. 1970. Distribution and abundance of dominant plankton diatoms in Lake Michigan. Great Lakes Research Division, Publication Number 16, The University of Michigan, Ann Arbor.

Tarapchak, S. J., and E. F. Stoermer. 1976. Environmental status of the Lake Michigan region, volume 4. Phytoplankton of Lake Michigan. Consultants to Division of Environmental Impact Studies, U.S. Energy Research and Development Administration.

U.S. EPA. 2012. [Source did not give full citation for this reference.]

Vaughn, J. C. 1961. Coagulation difficulties of the South District filtration plant. Pure Water 13:45–49.

Williams, L. G. 1972. Plankton diatom species biomasses and the quality of American rivers and the Great Lakes. Ecology 53(6):1038–1050.

Winkler, G., J. J. Dodson, N. Bertrand, D. Thivierge, and W. F. Vincent. 2003. Trophic coupling across the St. Lawrence River estuarine transition zone. Marine Ecology Progress Series 251:59–73.