U.S. Fish & Wildlife Service

Starry Stonewort (*Nitellopsis obtusa*)
Ecological Risk Screening Summary

U.S. Fish & Wildlife Service, June 2021
Revised, July 2021
Web Version, 8/11/2021

Organism Type: Plant
Overall Risk Assessment Category: Uncertain

Photo: Jim Grazio, PA DEP. Licensed under Public Domain. Available: https://nas.er.usgs.gov/queries/FactSheet.aspx?SpeciesID=1688 (July 2021).

1 Native Range and Status in the United States

Native Range

From Kipp et al. (2020a):

"Nitellopsis obtusa is native to Eurasia, from the west coast of Europe to Japan (Mills et al. 1993, Soulie-Marsche et al. 2002)."

From Larkin et al. (2018):

"Known populations of *N. obtusa* have a disjointed distribution through Occidental and Central Europe and Asia and are absent from Africa. There is some evidence of recent changes in the native range of the species during the last three decades, concurrent with accelerated climate warming. Krause (1985) reported that *N. obtusa* was expanding in Europe. In France, its range has shifted from west to east (Bailly and Schaefer, 2010) and it has been discovered in southern France in seven new localities since 2012 (Mouronval et al., 2015). New localities have also been recorded since 2006 in the Wielkopolska region of Poland (Gąbka, 2009) and in newly dug ponds in floodplains in Germany (Korsch et al., 2008). In Switzerland, *N. obtusa* has expanded into large, moderately eutrophic lowland lakes (Dienst et al., 2012; Auderset Joye and Rey-Boissezon et al., 2015; Rey-Boissezon and Auderset Joye, 2015). It has also recently colonized two lakes in the Swiss and French Jura Mountains at elevations of 850 and 1004 m, respectively (Bailly et al., 2007)."

Status in the United States

From Kipp et al. (2020a):

"Established in Indiana, Michigan, Minnesota, New York, Pennsylvania, Vermont, and Wisconsin."

"Great Lakes Nonindigenous Occurrences: First U.S. occurrence was in 1978 along the St. Lawrence River (Geis et al. 1981; Mills et al. 1993), although *N. obtusa* was likely present in North America since 1974 based on DNA analysis from a liquid-preserved specimen collected in Québec (Karol and Sleith 2017). Present range includes much of the Great Lakes Region, and parts of the Upper Mississippi-Crow-Rum Basin, the Rock Basin, the Upper Illinois Basin, the Allegheny Basin, the Upper Susquehanna Basin, and the St. Francois River Basin:

- Indiana - Initially discovered in 2008 at Lake Wawasee near Syracuse (Edgell 2011; Aquatic Weed Control 2015). Currently in 8 lakes in northeastern Indiana (Edgell 2011; Pearson 2015; Aquatic Enhancement & Survey, Inc. 2015).
- Michigan - First found in 1983 at Lake St. Clair, along the St. Clair and Detroit Rivers (Schloesser et al. 1986). Now occurs at lakes in all Lower Peninsula basins and in Millecoquins Lake of the Upper Peninsula (Pullman and Crawford 2010; Michigan State University 2015; Bagley 2015). Michigan has the most reported occurrences of any state.
- Minnesota - First confirmed occurrences in 2015 at Mud Lake and Lake Koronis, two connected basins (MN DNR 2015). Starry stonewort was confirmed in seven lakes in 2016 and two in 2017.
- New York - First spotted in 1978 along the St. Lawrence River (Geis et al. 1981; Mills et al. 1993), and later in 1981 at Lake Ontario (iMapInvasives 2015). Since 2005, starry stonewort was found at Oneida, Chautauqua, Otisco, Otsego, and Cayuga Lakes (iMapInvasives 2015).
- Pennsylvania - Only occurrence was at Presque Isle Bay near Erie; first seen in 2009 (EnviroScience, Inc. pers. comm. 2009) and confirmed in 2012 (Jim Grazio, PA DEP pers. comm. 2015).
- Vermont - Discovered in 2015 in a small cove at southeastern Lake Memphremagog (FLOW 2015).

- Wisconsin - Found in 2014 at Little Muskego Lake (WI DNR 2014). Additional starry stonewort was spotted in 2015 at Silver, Long, Pike, Big Muskego, and Bass Bay Lakes (WI DNR 2015)."

From Indiana Public Media (2018):

"Indiana has banned the sale and distribution of two invasive aquatic plant species — starry stonewort and water soldier."

From Minnesota Department of Natural Resources (2021):

"The first occurrence in the United States was in 1978 along the St. Lawrence River. It was first confirmed in Minnesota in August 2015, in Lake Koronis and connected Mud Lake (Stearns County). Only 13 lakes in Minnesota are listed as infested with starry stonewort."

"Starry stonewort (*Nitellopsis obtusa*) is a prohibited invasive species (/invasives/laws.html) in Minnesota, which means it is unlawful (a misdemeanor) to possess, import, purchase, transport or introduce this species except under a permit for disposal, control, research or education."

From Larkin et al. (2018):

"The oldest published record of *N. obtusa* in North America was in the St. Lawrence River in New York's Jefferson and St. Lawrence counties in 1978 (Geis et al., 1981). […] In 1983, *N. obtusa* was recorded in the St. Clair-Detroit River system in Michigan (Schloesser et al., 1986; Griffiths et al., 1991). And in 2005, it was reported from Upper Little York Lake in interior New York (Sleith et al., 2015). By 2012, reports began to rapidly increase and expand to Pennsylvania, Indiana, and interior Michigan […]. *Nitellopsis obtusa* was confirmed in Wisconsin in 2014. In 2015, there were first records for Minnesota and Vermont."

According to EDDMapS (2021), *Nitellopsis obtusa* is found on the following invasive listing sources: Michigan's Prohibited and Restricted Species, New Jersey Invasive Species Strike Team 2017 Invasive Species List, Pennsylvania Department of Conservation and Natural Resources Invasive Plants, Pennsylvania's Field Guide to Aquatic Invasive Species, and Wisconsin's Invasive species rule – NR 40.

Nitellopsis obtusa was not found to be available for sale through online aquarium retailers in the United States.

Means of Introductions in the United States

From Kipp et al. (2020a):

"*Nitellopsis obtusa* was very likely introduced in ballast water to the Great Lakes (Mills et al. 1993, Schloesser et al. 1986). *Nitellopsis obtusa* produces oocytes that can easily become attached to the fur and feathers of mammals and birds that inhabit infested areas. This mechanism is an efficient way for *N. obtusa* to spread rapidly amongst inland lakes (Pullman and Crawford 2010). The alga also spreads via fragmentation (Pullman and Crawford 2010)."

From Minnesota Department of Natural Resources (2021):

"The species was unintentionally introduced into the United States' Great Lakes through the discharge of contaminated cargo ship ballast water."

From Brainard and Schulz (2017):

"Sleith et al. (2015) conducted a survey of lakes in New York and found that *Nitellopsis* often was present in public lakes near boat launches but did not occur in many lakes characterized as undeveloped with minimal public access. This result suggests that *Nitellopsis* may be transported secondarily to new water bodies through overland 'hitchhiking' on recreational boats or trailers."

Remarks

From Larkin et al. (2018):

"The taxonomic history of *Nitellopsis obtusa* has been complex and confusing. The species was first described as a member of the genus *Chara* (*C. obtusa* Desv. in Loisel.) in 1810, but has been classified as a member of four different genera during the next 110 years: *Lychnothamnus, Nitella, Nitellopsis,* and *Tolypellopsis.* The tribal placement of *Nitellopsis* has also varied. Though accepted as a member of tribe Chareae (with *Chara*, Lamprothamnium, and Lychnothamnus), its classification relative to these three genera has been inconsistent. Wood (1962) proposed subtribe Nitellopsinae to include only *Nitellopsis*, uniting the remaining three genera in subtribe Charineae. In contrast, molecular phylogenetic work supported *Nitellopsis* as more closely related to Lychnothamnus than to *Chara* or Lamprothamnium (McCourt et al., 1996), which suggests that Charineae is paraphyletic."

"The Red List status of *N. obtusa* varies among regions: it is considered near threatened in Switzerland (Auderset Joye and Schwarzer et al., 2012), vulnerable to critically endangered in Germany (Hamann and Garniel, 2002; Kabus and Mauersberger, 2011; Korsch et al., 2012), vulnerable or regionally extinct in eastern Europe (Blaženčić et al., 2006; Caisová and Gąbka, 2009), and vulnerable in Nordic countries (Johansson et al., 2010; Koistinen, 2010). Increased occurrences of *N. obtusa* in parts of its native range have led to recent reclassifications of the species' conservation status. In Sweden, its status was lowered from endangered to vulnerable between 2005 and 2010 (http://artfakta.artdatabanken.se/taxon/1093). In Germany, *N. obtusa* is no longer considered threatened (Korsch et al., 2008; Auderset Joye and Schwarzer et al., 2012). In Asia, *N. obtusa* is present in China and was recently rediscovered in Japan, where it had been thought to be extinct (Kato et al., 2014). In the Netherlands, variation in *N. obtusa* abundance associated with changes in trophic state is synchronous with variation in breeding populations of redcrested pochard (*Netta rufina*) (van Turnhout et al., 2010). Hence, conservation of *N. obtusa* is a priority for lake restoration plans in several European regions (van den Berg et al., 1998)."

From Kipp et al. (2020a):

"Synonyms and Other Names: *Chara obtusa, C. ulvoides, C. stelligera, Lychnothamnus stelliger, Nitella stelligera, N. stelligera* var. *ulvoides, N. ulvoides, N. bertolonii, Nitellopsis aculeolata, N.*

obtusa var. *ulvoides, N. obtusa f. ulvoides , Nitellopsis stelligera, Tolypellopsis obtusa, T. stelligera, T. ulvoides"*

*"*Look-a-likes: *Chara* spp. musk-grass; *Nitella* spp. brittlewort; other *Nitellopsis* spp. stonewort. Key differences are the star-shaped rhizoid, the orange-colored oocyte, irregular branching, and lack of a garlic odor (Pullman and Crawford 2010)."

"*Nitellopsis obtusa* was thought to have been locally extirpated in some regions of its native range where it has been rediscovered—for example, in parts of Germany (Golombek 1998, Raabe 2006) and Japan (Kato et al. 2005). It is considered rare in Bremen, Germany but has recently increased in abundance in some lakes (Trapp and Kirst 1999). Populations are considered somewhat vulnerable in Sweden (Blindow 1994)."

2 Biology and Ecology

Taxonomic Hierarchy and Taxonomic Standing

From Guiry and Guiry (2021a):

"This name [*Nitellopsis obtusa* (Desvaux) J.Groves 1919] is of an entity that is currently accepted taxonomically."

From Guiry and Guiry (2021b):

"Biota > Plantae (Kingdom) > Viridiplantae (subkingdom) > Streptophyta (Infrakingdom) > Charophyta (Phylum (Division)) > Charophyceae (Class) > Charales (Order) > Characeae (Family) > *Nitellopsis* (Genus) > *Nitellopsis obtusa* (Species)"

Size, Weight, and Age Range

From Kipp et al. (2020a):

"Up to 2 m in height (Pullman and Crawford 2010); main stem up to 80 cm long (Hargeby 1990)."

From Larkin et al. (2018):

"*Nitellopsis obtusa* is a dioecious species reaching heights of 30 to 120 cm in the water column."

Environment

From Kipp et al. (2020a):

"*Nitellopsis obtusa* is sometimes found in deep, slow moving water where other plants are scarce, typically near docks and marinas (Midwood et al. 2016). *Nitellopsis obtusa* is known to maintain permanent populations in freshwater or brackish water with salinity up to 5%. It can tolerate salinity fluctuations up to 17% for around 1 week. Under high salt loading or unfavorable environmental conditions, it has the ability to shift cells from a high-energy state to a state of passive permeability. It experiences suppressed growth at water temperatures of 30°C. In such conditions, apical cells no longer form and some plant cells may die (Marchyulenene et al. 1982, Moteyunene and Vorob'ev 1981, Winter et al. 1999)."

"*Nitellopsis obtusa* occurs at depths of 1–3.5 m in relatively protected zones of the St. Clair-Detroit River system at water velocities of 3–11 cm/s; on soft substrates such as silt, sand, and fine detritus; and where light transmittance ranges from 1–50%. […] It has been recorded in water temperatures of 0–24°C in this area. […] It occurs at an average depth of 4.8 m depth and 6% light transmittance. In its native habitat, it is typically found at depths of 3–8 m, preferring deeper habitats with low light transmittance but relatively high calcium and phosphorus content, where other stoneworts generally occur less frequently (Berger and Schagerl 2004, Nicholls et al. 1988, Schloesser et al. 1986)."

From Larkin et al. (2018):

"In its native range, *N. obtusa* has been recorded in deep and shallow lakes, abandoned gravel pits, rivers, oxbows, and secondary channels at water depths of 0.5 to > 14 m (Korsch et al., 2008; Janauer et al., 2010). It preferentially colonizes calcareous, neutral to alkaline, mesotrophic to eutrophic waters (Bailly et al., 2007; Hutorowicz and Dziedzic, 2008), generally on sediments that are calcareous and rich in nutrients and clay […]. *Nitellopsis obtusa* has also been found in brackish waters near the Baltic Sea (Langangen et al., 2002). […] In its introduced range, *N. obtusa* can be found in a variety of habitats, from bays of the Great Lakes to small inland ponds (Sleith et al., 2015). As in its native range, *N. obtusa* occurs in calcareous, neutral to alkaline, mesotrophic to eutrophic waters […]. It has been found on a variety of substrates, from rocky, sandy bottoms of the St. Lawrence River to organic-rich, mucky sediments of inland lakes (e.g., Upper Little York Lake in Cortland Co., NY). *Nitellopsis obtusa* has been reported from depths of 0.5–7m (Geis et al., 1981; Sleith et al., 2015)."

Climate

From Larkin (2018):

"It has also recently colonized two lakes in the Swiss and French Jura Mountains at elevations of 850 and 1004 m, respectively (Bailly et al., 2007)."

Distribution Outside the United States

Native

From Kipp et al. (2020a):

"Nitellopsis obtusa is native to Eurasia, from the west coast of Europe to Japan (Mills et al. 1993, Soulie-Marsche et al. 2002)."

From Larkin et al. (2018):

"Known populations of *N. obtusa* have a disjointed distribution through Occidental and Central Europe and Asia and are absent from Africa. There is some evidence of recent changes in the native range of the species during the last three decades, concurrent with accelerated climate warming. Krause (1985) reported that *N. obtusa* was expanding in Europe. In France, its range has shifted from west to east (Bailly and Schaefer, 2010) and it has been discovered in southern France in seven new localities since 2012 (Mouronval et al., 2015). New localities have also been recorded since 2006 in the Wielkopolska region of Poland (Gąbka, 2009) and in newly dug ponds in floodplains in Germany (Korsch et al., 2008). In Switzerland, *N. obtusa* has expanded into large, moderately eutrophic lowland lakes (Dienst et al., 2012; Auderset Joye and Rey-Boissezon et al., 2015; Rey-Boissezon and Auderset Joye, 2015). It has also recently colonized two lakes in the Swiss and French Jura Mountains at elevations of 850 and 1004 m, respectively (Bailly et al., 2007)."

Introduced

From Larkin et al. (2018):

"[…], a specimen dated from 1974 that was identified as "?*Nitellopsis* sp." from the St. Lawrence River was found (Karol and Sleith, 2017). The collection is undoubtedly *N. obtusa*, indicating that the alga was established in the Montreal, Québec portion of the St. Lawrence River at least four years prior to the 1978 finding by Geis et al. (1981). […] There have been few official reports from Canada but Midwood et al. (2016) recently reported *N. obtusa* from Presqu'ile Bay, Lake Ontario. There have also been unpublished reports from Lake Scugog in interior Ontario (https://scugoglakestewards. com/monitoring-in-lake-scugog-in-2015/)."

From Ginn et al. (2021):

"Aquatic plant and macroalgae (collectively, macrophyte) communities from Lake Simcoe (Ontario, Canada) were studied in lakewide, >200 site surveys in 2008, 2013, and 2018. Over this period, mean macrophyte biomass increased 5-fold, from 29.9 g (dry)/m2 in 2008 to 153.9 g (dry)/m2 in 2018, due to the arrival and expansion of invasive starry stonewort (*Nitellopsis obtusa*). First recorded in Lake Simcoe in 2009, […]"

Means of Introduction Outside the United States

From Brainard and Schulz (2017):

"The discovery of *Nitellopsis* in the St Lawrence River indicates that its introduction to North America probably was via transoceanic transport in the ballast of ships. Mechanisms of subsequent secondary spread to inland water bodies have been debated. Potential vectors include hydrochory, whereby secondary spread occurs through water currents (Sytsma and Pennington 2015). Dispersal by animals, referred to as zoochory (Honnay et al. 2010, Sytsma and Pennington 2015), may also be an important mechanism for spread of *Nitellopsis* (Pullman and Crawford 2010), mainly through waterfowl dispersal."

Short Description

From Kipp et al. (2020a):

"Stem/Rhizoids: *Nitellopsis obtusa* has long, variable-length, relatively straight branches arranged in whorls that attach at acute angles to stem nodes. Internodal cells of *N. obtusa* are quite large, often on the order of a few centimeters long (Steudle and Zimmermann 1977, Yoshioka and Takenaka 1979). Most stem and branch cells are around 1 mm in diameter, while stems can reach up to 80 cm long (Hargeby 1990, Sher-Kaul et al. 1995). Heights of 2 m have been observed at a depth of 9 m in one Michigan lake (Pullman and Crawford 2010), although rate of growth is uncertain. *N. obtusa* is light green when actively growing. Creamy white bulbils may occur at the base of the main axis just below the substrate-water interface and on branches of the main axis at nodes; rhizoids are star-shaped.
Reproductive structures: Plants are dioecious. Female oogonia, with bracts on either side, form at the upper nodes of branchlets. Plants can form gyrogonites, which are calcified, spiral-shaped fructifications (Bharathan 1983, 1987, Schloesser et al. 1986, Soulie-Marsche et al. 2002). Orange to red oocytes can occur at the nodes of branches (Pullman and Crawford 2010)."

From Minnesota Department of Natural Resources (2021):

"Starry stonewort is a bushy, bright green macro-algae. It produces a characteristic star-shaped bulbil."

"Thin, bright green branchlets (branch-like structures) can be variable in length and are arranged in whorls (radiating out from a single point) around the stem. Branchlets typically extend in acute angles away from the stem nodes. Tips of the branchlets may have irregularly-lengthed forks or divisions."

"White, star-shaped bulbils (asexual reproductive structures) the size of a grain of rice form on clear threads at the base of the plant and may be found at or below the sediment surface. Small, orange spheres called antheridia (male reproductive structures) may be visible near the tips of the branchlets."

"It produces clear, root-like filaments that anchor it to the sediment."

From Larkin et al. (2018):

"The alga is bright green to dark green to brown depending on phenology and growing conditions. The main axis is slender to robust, 0.7–2 mm in diameter […]. White, conspicuous, star-shaped bulbils, which function as asexual reproductive structures and organs for hibernation (Bharathan, 1987), arise from rhizoid nodes and green bulbils arise from main axes and branchlet nodes. Branchlets are 5–8 per whorl, up to 9 cm in length, and composed of 2 to 3 segments. Gametangia [an organ or cell in which gametes are produced] are formed on all branchlet nodes, solitary or in pairs. Mature antheridia are orange to bright red, 800–1500 µm in diameter. Oogonia (not yet observed in North America) are nearly spherical, bright red to light green, and have a very small five-celled coronula […]. Oospores are ellipsoidal with truncated bases; calcified oospores (gyrogonites) are inverted-pear shaped to sub-cylindrical (Groves, 1919;

Corillion, 1957; Krause, 1997; Bailly and Schaefer, 2010; Mouronval et al., 2015; Kabus, 2016; Boissezon et al., 2017)."

Biology

From Kipp et al. (2020a):

"*Nitellopsis obtusa* is sometimes found in deep, slow moving water where other plants are scarce, typically near docks and marinas (Midwood et al. 2016)."

"In areas of dense vegetation, *N. obtusa* forms "pillows" of various heights; as growth slows, these pillowed mats may develop circular clearings (Pullman and Crawford 2010). Under eutrophic conditions, it often produces oospores (Bharathan 1987)."

"In this system, it first appears around July and reaches highest biomass levels in September, gradually declining until March of the following year, when it decomposes."

From Minnesota Department of Natural Resources (2021):

"Starry stonewort is a macro-algae, meaning it does not have a vascular system like true plants. Each branchlet or stem is a single cell. Native populations consist of both males and females, but all known introduced populations in North America are male. Bulbils are present throughout the growing season, but become most obvious and plentiful in late summer. Starry stonewort may form a dense carpet of material in shallow areas."

From Larkin et al. (2018):

"Characeae are able to reproduce both sexually and vegetatively. Extant populations of *N. obtusa* in its native range reproduce primarily through vegetative propagules (fragments and bulbils) and low sexual fertility was reported as early as the late 1800s (Migula, 1897). However, with colonization of shallower waters, there appears to be a shift toward increased sexual fertility (Krause, 1985). The influence of water temperature on growth and fertility of *N. obtusa* was studied by Willén (1960) and Boissezon et al. (2017); both found that development of gametangia could be triggered by a warm, sunny growing season.

Bulbils serve as organs for hibernation and clonal multiplication in permanent habitats (Bociąg and Rekowska, 2012). They are consistently produced on *N. obtusa* rhizoids and thalli (main axes). But clonality may be a less effective reproductive strategy in shallow habitats where viability of fragments and bulbils is limited by winter freezing or summer drying. Allocation of resources to sexual reproduction may be a strategy to ensure that long-lived, resistant propagules are produced (Boissezon, 2014). Oospores within sediments, particularly gyrogonites, can persist for long periods in a dormant state in sediment and be transported by waterfowl to distant waterbodies (endozoochory). In contrast, bulbils are short-lived and can only be transported over short distances (van den Berg et al., 2001; Bonis and Grillas, 2002; Boedeltje et al., 2003)."

Human Uses
From Kipp et al. (2020a):

"There is little or no evidence to support that *Nitellopsis obtusa* has significant beneficial effects in the Great Lakes.
Potential:
Nitellopsis obtusa is becoming regarded as the most aggressive invasive species in inland lakes and has been recorded replacing other nonnative and nuisance species, including Eurasian watermilfoil (*Myriophyllum spicatum*), fanwort (*Cabomba caroliniana*), and curly leaf pond weed (*Potamogeton crispus*) (Pullman and Crawford 2010). Hilt et al. (2010) suggested that *N. obtusa* could be an effective means of restoration for deep lakes in its native range.

Nitellopsis obtusa has a significant stratigraphical account that extends back to the early Quaternary and can be useful in biogeographical research, and well as in tracing evolutionary lineages (Soulie-Marsche et al. 2002).

In European regions, this species can be a good substrate for epiphytes, even though it is frequently covered in marl, which is a byproduct of photosynthesis formed when bicarbonate is used (Brindow 1987). It is known to have allelopathic properties towards cyanobacteria (Berger and Schagerl 2004). *Nitellopsis obtusa* increases in the Netherlands have been associated with increases in populations of red-crested pochards (*Netta rufina*), which feed preferentially on this species, possibly because it is a good source of calcium and sulfur (Ruiters et al. 1994)."

Diseases
According to Guiry and Guiry (2021a), *N. obtusa* is a host of the parasite *Calcinus latens* (Randall, 1840).

Threat to Humans
From Kipp et al. (2020a):

"There is a large economic investment from inland lake communities to manage and control invasions of *N. obtusa*. This is both to protect boat owners from potential damage to their vessels, as well as to maintain economically important recreational fishing and swimming areas (Pullman and Crawford 2010). Moreover, *N. obtusa* poses a risk of entanglement to swimmers, who also are displeased with this alga's rough texture (R. Sturtevant , pers. comm.)."

3 Impacts of Introductions
From Kipp et al. (2020a):

"*Nitellopsis obtusa* has a moderate environmental impact in the Great Lakes.
Realized:
When it was first reported, *N. obtusa* was the ninth most frequently collected macrophyte in the St. Clair-Detroit River system (Mills et al. 1993, Nicholls et al. 1988). It was recorded at a peak biomass of 259 g m-2 in September, when many other macrophytes were declining, giving it a

competitive advantage (Nicholls et al. 1988, Schloesser et al. 1986). Once established in inland lakes, *N. obtusa* forms dense mats of vegetation that completely cover the lake bottom. Mats of *N. obtusa* can act like a commercial benthic barrier and lead to the accumulation of phytotoxins that could create redox conditions; these conditions have a reduced impact on the rootless *N. obtusa* as compared to native species (Pullman and Crawford 2010).

Mats of *N. obtusa* also correspond with a dramatic decrease in the biomass of competing species. Although specific surveys have not been conducted yet, there is serious concern for inland lake populations of native species that are dependent on lake bottom habitat, including minnows, logperch, darters, clams, and other invertebrates (Pullman and Crawford 2010). Dense mats of *N. obtusa* directly impact the habitat used by native fish for spawning. Bass and sunfish are known to regularly spawn in dense growths of native *Chara* species, but these spawning behaviors did not occur in correspondingly dense growths of *N. obtusa* (Pullman and Crawford 2010).

Nitellopsis obtusa has been associated with increased water clarity in inland lakes, which could in part be due to their association with zebra mussels (*Dreissena polymorpha*) as a favored substrate. In spite of increased water clarity from the mussels, the dense growth of *N. obtusa* actually reduces light availability for other submersed flora (Pullman and Crawford 2010).

Potential:
There is also research indicating that macrophyte species have a strong influence on phytoplankton through allelopathic interactions (Hilt et al. 2010, Mulderij et al. 2007, Pullman and Crawford 2010). In Sweden, *N. obtusa* dies off in the winter, which reduces the ability of slow colonizers like the isopod *Asellus* and amphipod *Gammarus* to establish significant populations in this habitat. As a result, it typically hosts many chironomids, while *Chara tomentosa* harbors more amphipods and isopods (Hargeby 1990).

In Lake Majcz Wielki, Poland, zebra mussels settle at densities of 1000 per m2 on *N. obtusa* and *Stratiotes aloides*, and at much lower densities on other plants (Lewandowski and Ozimek 1997).

There is no indication that *N. obtusa* is affecting Great Lakes native populations genetically, but it has been proposed that the population of *N. obtusa* in the Great Lakes represents a unique phenotype from its native population in Europe (Pullman and Crawford 2010).

Nitellopsis obtusa has a high socio-economic impact in the Great Lakes.
Realized:
There is a large economic investment from inland lake communities to manage and control invasions of *N. obtusa*. This is both to protect boat owners from potential damage to their vessels, as well as to maintain economically important recreational fishing and swimming areas (Pullman and Crawford 2010). Moreover, *N. obtusa* poses a risk of entanglement to swimmers, who also are displeased with this alga's rough texture (R. Sturtevant , pers. comm.).

As one of the filamentous algae that frequently detaches from the bottom to form a floating mat, *N. obtusa* contributes both to lake "scum" and mats that wash up on beaches (R. Sturtevant, pers. comm.).

Potential:
While *N. obtusa* negatively affects water quality for other macrophyte and phytoplankton species, there is no evidence to suggest that the quality of drinking water is significantly affected. However, there have been no studies conducted to specifically address this issue.
Nitellopsis obtusa is a relatively new invasion, particularly to the inland lakes. The long term impacts on the economic value lake property cannot yet be properly assessed."

From Larkin et al. (2018):

"*Nitellopsis obtusa* could have similar impacts as other invasive macrophytes; this warrants further study (Pullman and Crawford, 2010; Hackett et al., 2014; Brainard and Schulz, 2017). Its ability to form large, dense mats suggests that its expansion within a lake could lead to displacement of native vascular plants or algae. *Nitellopsis obtusa* is also taller than most native Characeae and can fill the water column at shallow depths; this could cause native species to become light-limited. In addition, characeans can act as ecosystem engineers, altering water chemistry and nutrient cycling through high rates of productivity and nutrient uptake and low rates of decomposition (Kufel and Ozimek, 1994; Kufel and Kufel, 2002). It is possible that large beds of *N. obtusa* might restrict nutrients available to native plants through such mechanisms, as has been shown in other invasive macrophytes (Larkin et al., 2012). Potential ecological impacts of *N. obtusa* are largely unknown due to a lack of peer-reviewed literature. However, Brainard and Schulz (2017) documented decreased native plant species richness and biomass associated with increasing *N. obtusa* abundance in four lakes in New York, U.S.A."

From Ginn et al. (2021):

"[…] starry stonewort has greatly altered the macrophyte community, particularly in shallow (<3 m) water where it outcompeted invasive Eurasian watermilfoil (*Myriophyllum spicatum*). By 2018, starry stonewort comprised 67.6% of the total macrophyte biomass in Lake Simcoe. In shallow, mesotrophic Cook's Bay, comparison to studies from the 1980s shows an increased plant biomass due to increased water clarity, from phosphorus (P) abatement and invasive dreissenid mussels, with further increases after 2011 due to starry stonewort. Starry stonewort may continue to impact nearshore ecology, with shallow-water fish species losing habitat and refugia as the "forest-like" structure of the plant community is replaced by large, dense aggregations of starry stonewort. Recreational uses will also be impaired and landowner complaints of macrophyte wash-ups will increase, with municipalities and lake-based businesses bearing the cost of mitigation and control strategies."

4 History of Invasiveness

Nitellopsis obtusa has been introduced outside of its native range to Canada and the United States, where it has become established. Multiple negative impacts of introduction have been reported, however a majority of the impacts are potential. Without actual documented impacts of introduction, the history of invasiveness cannot be High. *Nitellopsis obtusa* is found on the following invasive listing sources: Michigan's Prohibited and Restricted Species, New Jersey Invasive Species Strike Team 2017 Invasive Species List, Pennsylvania Department of Conservation and Natural Resources Invasive Plants, Pennsylvania's Field Guide to Aquatic

Invasive Species, and Wisconsin's Invasive species rule – NR 40. No information on this species in trade was available. The history of invasiveness for *Nitellopsis obtusa* is Data Deficient.

5 Global Distribution

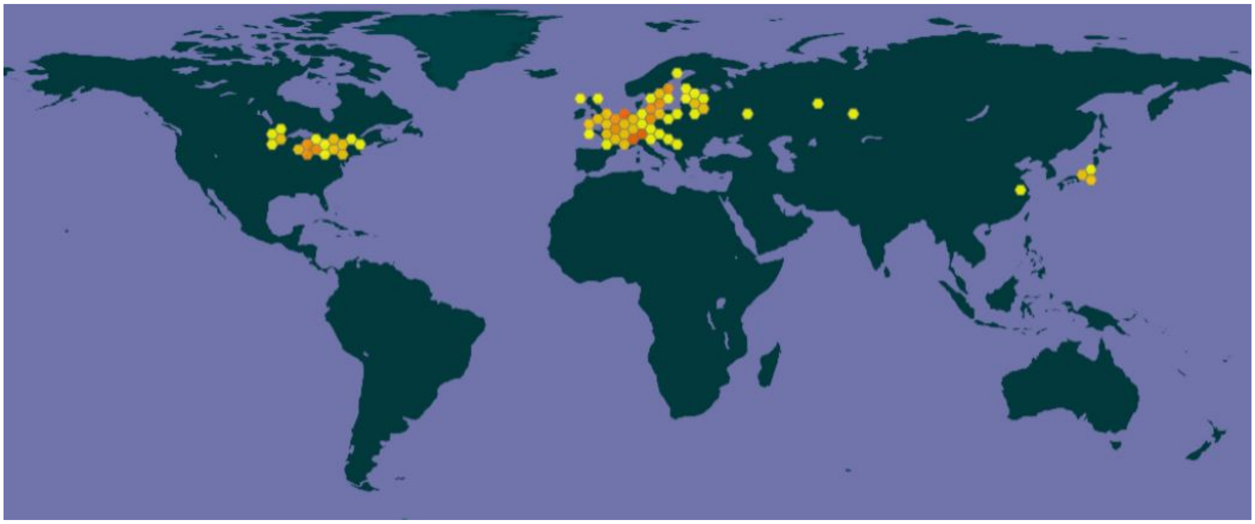

Figure 1. Known global distribution of *Nitellopsis obtusa*. Map from GBIF Secretariat (2021). Locations are found around the Great Lakes region in the United States and Canada, throughout a majority of Europe, in Russia, Kazakhstan, China, and Japan.

6 Distribution Within the United States

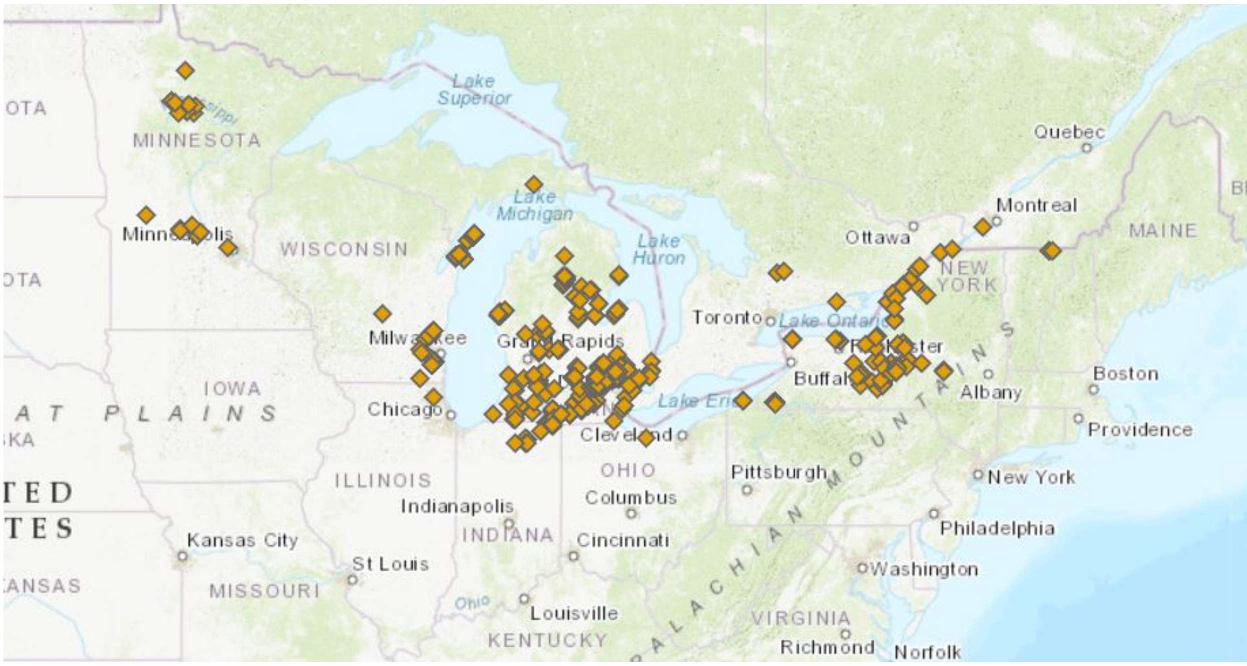

Figure 2. Known distribution of *Nitellopsis obtusa* in the United States. Map from Kipp et al. (2020b). Locations are found in Minnesota, Wisconsin, Illinois, Michigan, Indiana, Ohio, Pennsylvania, New York, and Vermont. Additional locations are found in Southern Canada.

7 Climate Matching

Summary of Climate Matching Analysis

A majority of the United States had a medium or high climate match locally, with the highest matches stretching from interior New England to the northern Great Plains. There were smaller scattered areas of high match on the southeastern Atlantic Coast, on the eastern edge of the Rocky Mountains, and along the eastern shore of Puget Sound in Washington. The lowest matches were found in the Desert Southwest and on the coast in the Pacific Northwest. The overall Climate 6 score (Sanders et al. 2018; 16 climate variables; Euclidean distance) was 0.456, high (scores greater than or equal to 0.103 are classified as high). More than half of the States received high individual Climate 6 scores. The following States received medium individual Climate 6 scores: Alabama, Arkansas, Arizona, Georgia, Kentucky, Nevada, Tennessee, and Washington. California, Louisiana, Mississippi, Oregon, and Rhode Island received low individual Climate 6 scores.

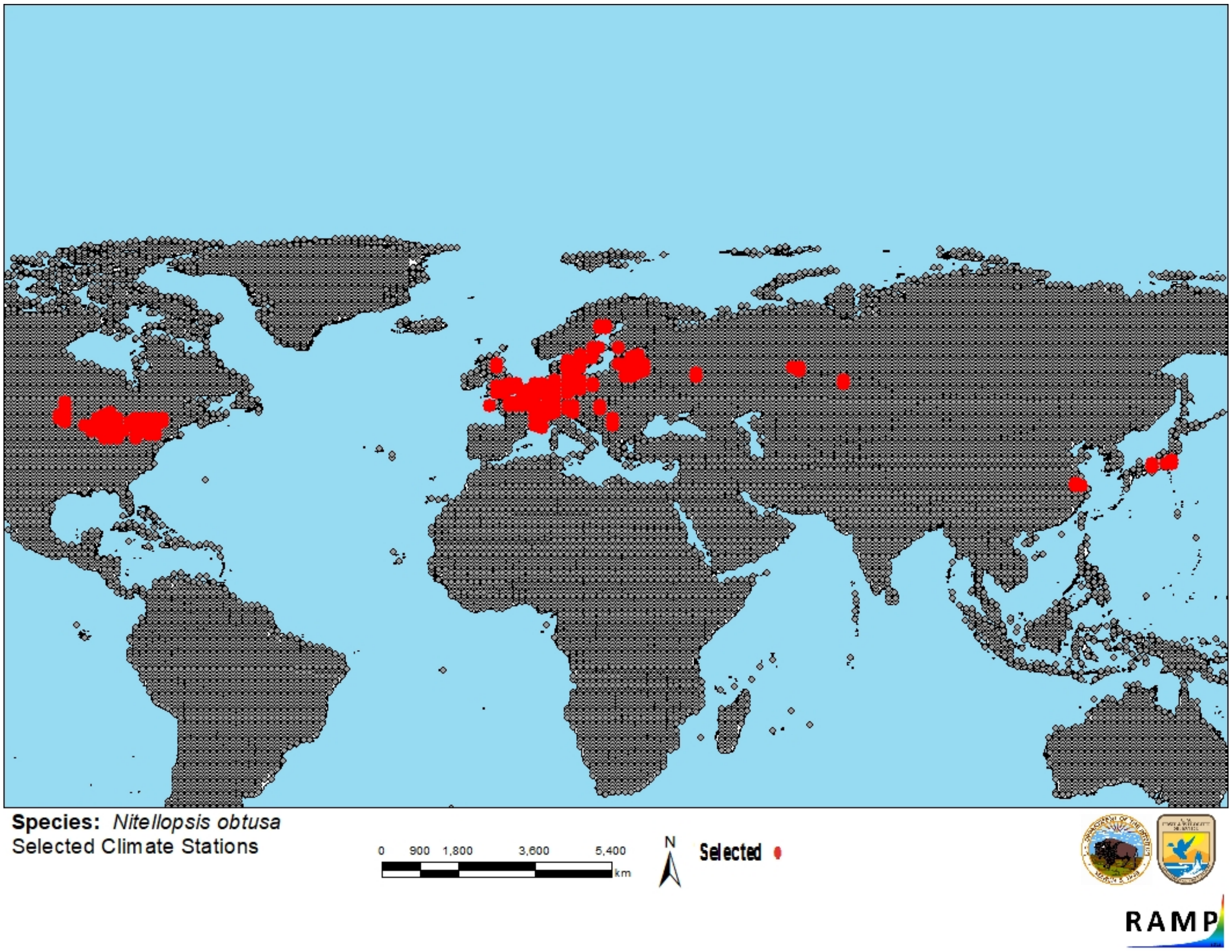

Figure 3. RAMP (Sanders et al. 2018) source map showing global weather stations selected as source locations (red; United Kingdom, France, Belgium, the Netherlands, Switzerland, Germany, Austria, Poland, Hungary, Serbia, Sweden, Lithuania, Latvia, Estonia, Finland, Russia, Kazakhstan, China, Japan, the United States and Canada) and non-source locations (gray) for *Nitellopsis obtusa* climate matching. Source locations from GBIF Secretariat (2021). Selected source locations are within 100 km of one or more species occurrences, and do not necessarily represent the locations of occurrences themselves.

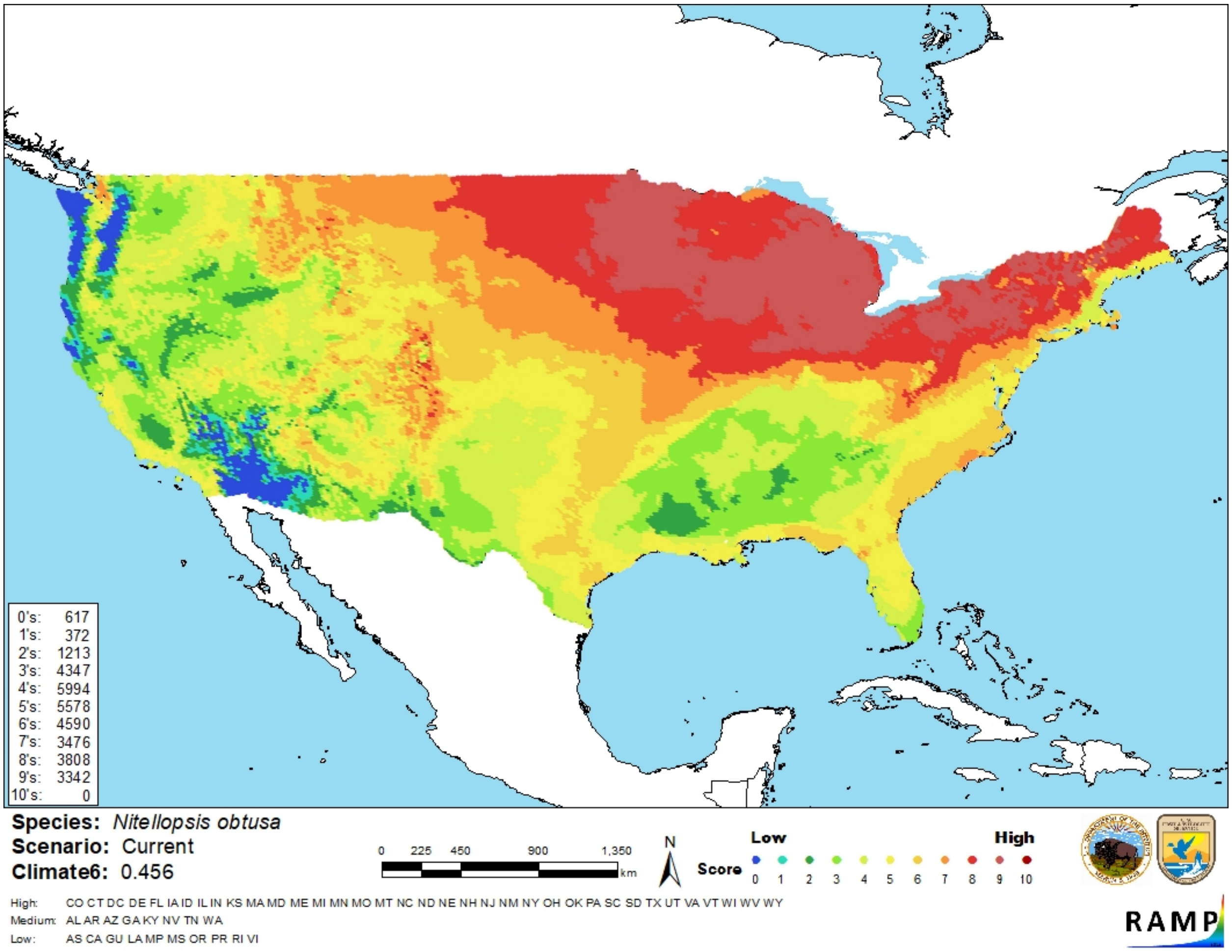

Figure 3. Map of RAMP (Sanders et al. 2018) climate matches for *Nitellopsis obtusa* in the contiguous United States based on source locations reported by GBIF Secretariat (2021). Counts of climate match scores are tabulated on the left. 0/Blue = Lowest match, 10/Red = Highest match.

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

Climate 6: (Count of target points with climate scores 6-10)/ (Count of all target points)	Overall Climate Match Category
0.000≤X≤0.005	Low
0.005<X<0.103	Medium
≥0.103	High

8 Certainty of Assessment

Information is available on the biology, ecology, and distribution of *N. obtusa*. This species has been introduced outside of native range where it has become established; however, a majority of the impacts of introduction are only potential and not actual, documented impacts. Due to limited available information on actual impacts of introduction, the certainty of assessment is Low.

9 Risk Assessment

Summary of Risk to the Contiguous United States

Nitellopsis obtusa, Starry Stonewort, is an aquatic plant species native to Eurasia, from the west coast of Europe to Japan. This species has been introduced to the Great Lakes region of the United States and Canada, where it has become established. It has since spread to the Northeast and Midwest. Multiple negative potential impacts of introduction have been reported including forming dense mats of vegetation that completely cover the lake bottom, impacting the habitat used by native fish for spawning, negatively affects water quality for other macrophyte and phytoplankton, and decreasing native plant species richness and biomass. No information on this species in trade was available. *Nitellopsis obtusa* is found on multiple State invasive species lists. The history of invasiveness is Data Deficient. The overall climate match category for *N. obtusa* is High, with the areas of highest match being found in the Great Lakes region where the species has been introduced, as well as in the Northeast and Midwest in areas with and without known populations. The certainty of assessment is Low due to limited available information on actual impacts of introduction. The overall risk assessment category for *Nitellopsis obtusa* is Uncertain.

Assessment Elements

- **History of Invasiveness (Sec. 4): Data Deficient**
- **Overall Climate Match Category (Sec. 7): High**
- **Certainty of Assessment (Sec. 8): Low**
- **Remarks, Important additional information:** No additional information
- **Overall Risk Assessment Category: Uncertain**

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