2.7 Starry Stonewort

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Nitellopsis obtusa (Desvaux in Loiseleur) J. Groves, submerged macro-alga in the Characeae family

Native to Europe and Asia, introduced to North America in the St. Lawrence River, presumably in ballast water of trans-oceanic ships. Currently found in inland aquatic ecosystems in the midwest and northeast US and Ontario, Canada

Introduction and spread

Nitellopsis obtusa (starry stonewort) is an invasive green macro-alga native to Europe and Asia and records indicate that it was introduced to North America in the St. Lawrence River in the 1970s. It is likely that starry stonewort was transported to the Great Lakes in North America in the ballast water of a trans-oceanic shipping vessel. There was an apparent lag in expansion of starry stonewort until the 2000s, several decades after its introduction. This may be due in part to a lack of awareness or systematic search efforts, coupled with the difficulty of identifying this alga and its ability to initially "hide" among other algae and vascular plants. In 2005, starry stonewort was reported from Upper Little York Lake in New York and had expanded into Pennsylvania, Indiana and interior Michigan by 2012. The first population of starry stonewort was identified in Wisconsin in 2014, followed by the discovery of populations in Minnesota and Vermont in 2015. Star-shaped bulbils of starry stonewort were found in Lake Simcoe (Ontario) in 2009 and the species was reported in Presqu'ile Bay (Lake Ontario) and Lake Scugog (Ontario) in 2016. At the time of this writing, starry stonewort is present in North America in Ontario, Canada and seven Great Lakes states in the northern US.

Almost all spread of starry stonewort is attributed to human-mediated transport on boats and boating equipment, indicated primarily by the preponderance of new infestations around watercraft access points such as boat ramps. For example, a study of lakes in New York revealed that starry stonewort was not present in 20 lakes that lacked boat launches, even though those lakes were within the most heavily starry stonewort-invaded region of New York. It is unlikely that starry stonewort has reached the full extent of its potential range in North America and several attempts have been made to predict regions of the US that could be susceptible to new invasions. One study that used a climate-based ecological niche model predicted that large portions of the mid-Atlantic, intermountain

West and Great Plains regions of North America could provide habitat for starry stonewort, although the species has not yet been reported in these regions. Likewise, a water chemistry-based model identified areas of the northeastern US, including eastern New York and western Vermont, as suitable regions. There is no reason to expect that starry stonewort will not colonize much of the eastern and midwestern states of the US.

Description of the species

Starry stonewort is a robust Characean macro-alga and is a relative of the common native algae genera *Chara, Nitella* and *Tolypella*. In its introduced range, starry stonewort grows in a manner similar to rooted, submersed perennial macrophytes. The main "stem" or thallus (plural: thalli) of starry stonewort is slender (up to 1/12 inch in diameter) and emerges from the sediment, where it is anchored by a network of rhizoids (colorless root-like structures). Thalli have branchlets that are arranged in whorls of 5 to 8 around nodes, which can give rise to further branchlets. Starry stonewort forms dense, monotypic stands with a disorganized appearance and will grow to just below the water's surface.

New growth of starry stonewort is easily confused with its Characean relatives, especially species of *Chara*, and starry stonewort is often misidentified as "super-chara". However, starry stonewort is smooth to the touch, in contrast to the rough or crunchy texture of *Chara*; it has no odor, whereas *Chara* often smells like garlic or onion; and starry stonewort produces bulbils (clonal seed-like reproductive structures), while *Chara* does not. Starry stonewort's common name is derived from its unique star-shaped bulbils, which can be found attached to rhizoids in the sediments around populations of starry stonewort.

Reproduction

In its native range of Europe and Asia, starry stonewort reproduces using both sexual (oospores) and asexual/vegetative (bulbils and fragmentation) means. However, only male reproductive structures have been found to date in North American populations of starry stonewort, which results in reproduction entirely by vegetative means in the US. New growth of the species emerges from sediment in mid- to late spring; peak biomass typically occurs between late June and late August, depending on latitude, and starry stonewort can grow until November in some regions. Bulbils appear to be most prevalent in early spring (when the alga is starting to emerge from the sediment) and in the late summer and fall (prior to the onset of winter and accompanied by natural senescence of the population). Bulbils seem to be short-lived but likely remain viable for at least 6 months.

Problems associated with starry stonewort

Starry stonewort grows entirely underwater as a submersed alga and its growth potential appears limited primarily by wave action and the depth of light penetration. Starry stonewort is commonly found at depths of 5 to 15 feet but has

been found in water as deep as 30 feet. This ability to colonize water that is deeper than most native submersed species can tolerate may allow it to obtain a foothold before spreading into the shallower margins of lakes where most native plants colonize. Although starry stonewort is an alga, dense populations can cause problems similar to those associated with invasive aquatic plants, such as reducing light and oxygen availability and interfering with human uses of infested waters. Given starry stonewort's capability for vigorous growth and rapid spread, in many aquatic ecosystems it may only take a few years for a seemingly benign colony of the species to become a wide-spread and problematic infestation.

Management options

Starry stonewort can be controlled relatively easily, but requires persistence to be effective. The initial step is to identify the level of infestation and to determine the management objectives (e.g., extirpation or local eradication from a water resource, maintaining access for boats, habitat improvement, protection of nearby uninvaded waters). Most starry stonewort management programs focus on two components: 1) prevention of off-site movement and reintroductions of starry stonewort propagules, and 2) control of populations within infested water resources. The specific management approach depends on the degree of invasion and the maturity of the population(s) and can be broadly grouped into four scenarios: 1) starry stonewort is absent; 2) incipient populations are present, 3) starry stonewort populations are established, and 4) widespread, mature starry stonewort populations are present.

If starry stonewort is absent, the focus is on preventing the introduction of fragments and bulbils from contaminated boat trailers and watercraft. This can be achieved by thorough inspections of boat trailers and watercraft before leaving an infested water resource, along with more intense cleaning such as pressure washing. It is important that prevention actions are coupled with routine and strategic monitoring of vulnerable areas of aquatic ecosystems. Most new infestations go unnoticed until populations reach the water's surface, so monitoring vulnerable areas (particularly

accesses or physical linkages with infested waters) can improve the chance that new infestations are quickly detected. Early detection improves the effectiveness of rapid responses to incipient starry stonewort populations (e.g., newly discovered populations in less than 5 acres), reducing management costs over the long term. Extirpation of starry stonewort may be possible at this stage and control tactics should be implemented early in the growing season when the

algae are less than 1 foot tall. Physical control tactics (Section 3.4) such as hand removal and benthic barriers can be employed and mechanical harvesting (Section 3.5) can be used if the harvesting apparatus can reach the depth at which starry stonewort is growing. Algaecide applications (Section 3.7.1) provide the most effective control of starry stonewort and can be used alone or as a follow-up treatment after physical or mechanical harvesting. Copper-based algaecides chelated with ethanolamine, used alone or in combination with endothall and/or adjuvants (Section 3.7.3), can provide effective control of starry stonewort. Flumioxazin may also be useful, although use of a herbicide to control starry stonewort may also affect nearby nontarget aquatic plants. Algaecides should be applied directly to starry stonewort, so new infestations or early season growth at the bottom of a system should be targeted with trailing hoses or injection pipes (Section 3.7.4).

Management of established populations (e.g., algae reaches the surface of the water, populations are greater than 5 acres, multiple populations are present) requires aggressive action to restore and maintain the water resource. As with incipient infestations, control tactics should begin as early in the growing season as possible (algae less than 2 feet tall), and mechanical and chemical control tactics are most applicable at this scale. If management goals are extirpation or whole-season maintenance of starry stonewort to allow boat access, multiple algaecide applications or harvesting efforts will be necessary to achieve "successful" control. Dense stands that develop throughout the growing season may require algaecide applications to the surface of the water, as dense growth may impede trailing hoses and prevent mixing of algaecide in the water column. There are currently no biological control agents (Section 3.6) are available for starry stonewort. Grass carp (Section 3.6.2) may be useful for biological control of starry stonewort but reports regarding their efficacy are lacking.

Control measures for widespread, mature populations of starry stonewort are similar to those for established populations, but management efforts may be limited by resources. For density dependent tactics such as algaecide treatments, where costs depend on the quantity of starry stonewort targeted for control, treatments should be used early in the growing season so they can be distributed over a greater area. If repeated treatments are not possible, management efforts should be timed to ensure that starry stonewort is controlled during a relevant economic, ecological, or socio-political time period. For example, if boat navigation is the most important management objective, treatments can be timed to control starry stonewort when boat traffic is the greatest, such as around summer and fall holidays. As for established starry stonewort populations, the most effective tactics for control of widespread, mature starry stonewort populations are mechanical harvesting and algaecides. The key to managing dense, mature populations of starry stonewort is persistence. Multiple algaecide applications, or mechanical harvesting of the upper portion of the population followed by an algaecide application to control the remainder, can overcome biomass limitations and restore the intended uses of a water resource.

Summary

Starry stonewort is a relatively new invasive aquatic alga in North America that has spread rapidly among inland aquatic ecosystems in the Great Lakes and Northeast regions of the US despite its inability to reproduce using sexual means. Overland dispersal is attributed to watercraft and associated equipment, making inspection and control of "hitchhikers" the first line of defense against its spread. Bulbils and fragments that escape or survive prevention efforts can colonize new aquatic ecosystems and result in new populations that have substantial ecological, economic, and socio-political impacts in invaded and connected water resources. If detected early in its colonization, it may be possible to extirpate starry stonewort from an aquatic system. If starry stonewort is allowed to persist in a water resource as a result of failure to detect the infestation or failure to initiate action early, significant resources and persistent use of control tactics will be needed to control the alga, maintain use of the water resource and prevent infestation of nearby or connected waters.

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