State of Michigan's

Status and Strategy for Starry Stonewort (*Nitellopsis obtusa* (N.A.Desvaux) J.Groves) Management

Scope

Invasive starry stonewort (*Nitellopsis obtusa* (N.A.Desvaux) J.Groves, hereafter SSW) was collected from Lake St. Clair, St. Clair River, and Detroit River in 1983, but was only recently discovered as an aggressive nuisance in inland lakes in southern Michigan (Schloesser 1986; Pullman and Crawford 2010). This document was developed by Central Michigan University and reviewed by Michigan Departments of Environmental Quality and Natural Resources for the purposes of:

- Summarizing the current level of understanding on the biology and ecology of SSW.
- Summarizing current management options for SSW in Michigan.
- Identifying possible future directions of SSW management in Michigan.

This document used the current information available in journals, publications, presentations, and experiences of leading researchers and managers to meet its goals. Any chemical, company, or organization that is mentioned was included for its involvement in published, presented, or publically shared information, not to imply endorsement of the chemical, company, or organization.

Biology and Ecology

I. Identification

Starry stonewort is a macroalgae that resembles true plants with "stems" composed of a few long cells, "nodes" of small cells that branch off with longer cells, and root-like rhizoids that produce star-shaped bulbils, where it gets its name (Figure 1). These bulbils can reach 0.2 in (4 mm) across and are produced at any part of the macroalgae, but are usually concentrated near the substrate. It also produces orange oocysts, from which eggs develop, that are visible to the naked eye (Figure 2). Starry stonewort has been observed in Michigan to reach 7 ft (2 m) long and

Figure 1. Starry stonewort (*Nitellopsis obtusa*) is a macroalgae that produces star-shaped bulbils most often seen in late fall and early spring. Photograph by Progressive AE

grow at depths up to 29 ft (9 m; Pullman and Crawford 2010).

Species that are often mistaken for SSW include other types of macroalgae: *Chara* spp. *Nitella* spp. and *Nitellopsis* spp. Aside from the distinctive star-shaped bulbils, SSW has a more irregular branching pattern, can grow longer and at greater depths than other species, forms dense pillows or mats of irregular height, and lacks a musky or garlic odor of other macroalgae. Although SSW itself lacks odor, other odorous algae species have been known to grow with it, so identification should not be based on odor alone.

Figure 2. Starry stonewort (*Nitollopsis obtusa*) can reproduce by orange oospores. Photograph from Pullman and Crawford (2010)

One test that may be used to distinguish SSW from *Chara spp.* is the "squeeze test." In SSW, the protoplasm will pop out of the cell when squeezed. The remaining cell wall becomes a limp straw (G. Douglas Pullman, Aquest Corporation, *personal communication*). In *Chara* spp., the protoplasm does not separate easily from the cell wall.

II. Detection

Starry stonewort is less conspicuous than many other problematic invasive plant species. The star shaped bulbils are a clear identifying characteristic for identification and are present for a large part of the growing season (Bharathan 1987). They are most abundant in late fall or early spring (Pullman and Crawford 2010). The squeeze test can be employed for identification at any time of year.

Starry stonewort may be a candidate for detection with eDNA, but no research has been conducted in this area. If it is possible to detect SSW with eDNA, this could improve the distinction of SSW from other species when the star-shaped bulbils are not present or when it is growing in an inaccessible portion of a lake.

Submerged aquatic vegetation at water depths greater than 15.7 in (40cm) cannot be distinguished using remote sensing technology at this time even when processed with object-based image analysis (Visser et al. 2013). Water absorbs the wavelengths commonly used to remotely sense vegetation (i.e. visible and near infrared). Aerial photographs have been used with plant or local experts to distinguish submerged aquatic vegetation, but these studies did not have repeatable procedures and required experts of unspecified training (e.g. Husson et al. 2013).

III. Life History and Spread/Dispersal

In its native climate (Figure 3), SSW is an annual alga that dies off in the winter, or sometimes persists in mild winters. The SSW in the Detroit River was documented to emerge in early July but could emerge as late as August (Nichols et al. 1988). The biomass increased until September, remaining constant until the ice broke up in February. In mid-March, SSW died back until July (Schloesser 1986; Nichols et al. 1988; Pullman and Crawford 2010). In some Michigan inland lakes, SSW has been observed to grow in cool waters through the fall, winter, and spring and die back during the summer months (Pullman and Crawford 2010).

Starry stonewort forms a dense, vertically thick, mono- or oligoculture mat that completely covers the lake bottom. As the mat grows, it forms “pillows” of different heights instead of mats of uniform heights like other macroalgae. When the growth of SSW hits its yearly decline, circular patches will appear in the mat, dubbed “Swiss cheese” pattern. Other species may grow in these holes.

In North America, SSW can overtake other aquatic vegetation in three years: Crawford (2011) described the establishment of SSW in waters 2 – 4 ft (0.6 – 1.2 m) deep, but it may establish itself in deeper waters where there is minimal competition from other macrophytes. In subsequent years the monoculture mat of SSW encroaches into deeper and shallower waters where fish like rock bass and large sunfish spawn. These mats outcompete almost all other aquatic macrophytes, including the invasive Eurasian water-milfoil (*Myriophyllum spicatum* L.) and curly-leafed pondweed (*Potamogeton crispus* L.; Nichols et al. 1988; Pullman and Crawford 2010).

Starry stonewort is dioecious and reproduces sexually via dark orange oospores (Figure 2), asexually via star-shaped bulbils (Figure 1) and possibly fragmentation. Mature oospores are usually produced only under eutrophic conditions and have a mandatory dormant period before germination (Bharathan 1987). Oospores easily attach to fur and feathers, and it is believed that animals facilitate the dispersion of SSW between inland lakes (Pullman and Crawford 2010).

Bulbils can be found on SSW at any point during the year, but they are most plentiful in the fall. Bulbils can sprout in 3 – 5 days under the right conditions (Bharathan 1987).

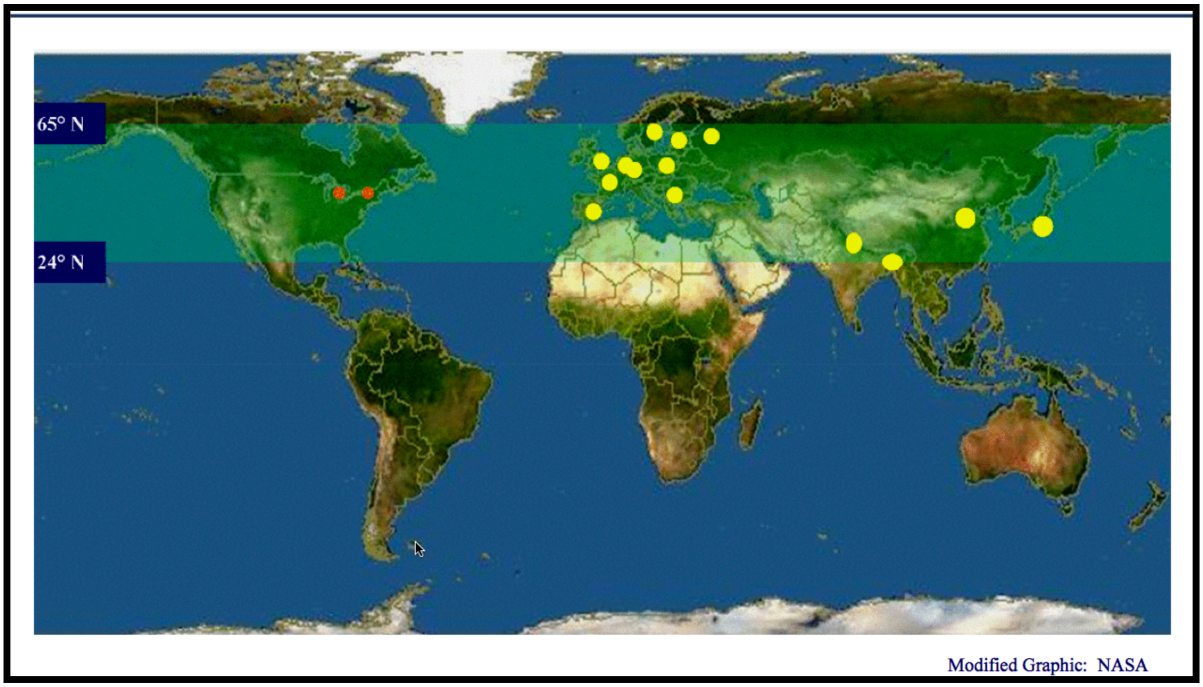

Figure 3. Global extent distribution of starry stonewort (*Nitellopsis obtusa*) as mapped by Brown (2014). Yellow dots indicate areas where starry stonewort is considered native. Red dots indicate areas where starry stonewort is considered invasive

IV. Habitat

Starry stonewort distribution is limited globally between 24° and 65°N latitude (Figure 3). It is native to Europe and parts of Asia. It is in decline in parts of Europe and endangered in the UK, which has produced detailed documents promoting the conservation of stonewort habitat throughout the country (Stewart 2004; Gołdyn 2009). SSW was declared extinct in the wild in Japan in 1994 before it was rediscovered in 2005 (Kato et al. 2005). In the United States it is present in the St. Lawrence Seaway, Lake Oneida, New York, and Michigan (Mills et al. 2007).

Although it has established invasive populations in over a hundred Michigan inland lakes, little data has been published regarding the ideal environmental conditions or nutrient levels that promote invasive SSW growth in lake ecosystems (Brown 2014). Most of what is known comes from observations.

Starry stonewort grows in a variety of conditions. High dissolved calcium levels appear to be important in supporting growth, though no testing has been done to quantify critical levels (Pullman and Crawford 2010). It can tolerate moderate fluctuations in salinity, but cannot survive and reproduce in water bodies with salinity consistently higher than 5 PSU (Practical Salinity Units; Winter 1999). In the St. Lawrence River SSW was found growing at a current velocity of 11.3 cm s^{-1} or lower (Schloesser 1986).

Lake colonization depth depends on a combination of lake bathymetry and water clarity. Starry stonewort has been found most often in Michigan lakes with oligo-mesotrophic or mesotrophic trophic states (Brown 2014). The absence of SSW from eutrophic water bodies

is consistent with populations worldwide, and the general trend of anthropogenic eutrophication in fresh water may be one reason SSW and other stonewort species are becoming scarce in their native ranges (Bennett et al. 2001; Stewart 2004).

V. Effects from SSW

a. Negative Effects

In favorable Michigan habitats, SSW outcompetes virtually all other aquatic macrophytes, including other invasive species. The dense growth makes it difficult for most other aquatic plants to push through.

Heavy infestations of SSW can form rings of vegetation stretching the entire circumference of a lake. These rings may change in depth during the course of the growing season, appearing to have ceased growth but actually moving deeper on the substrate. During the warmest part of the growing season SSW often undergoes large die-offs that leave open sediment for other invasive species to colonize (Brown 2014).

Starry stonewort mats have been observed to negatively affect fish reproductive behavior by compromising nesting and feeding habitat. Removal of the SSW will restore breeding behavior, but is not a permanent solution if adjacent SSW populations remain and recolonize the area (Pullman and Crawford 2010).

Starry stonewort is also a favorable substrate for zebra mussel (*Dreissena polymorpha* (Pallas)) colonization, but SSW's relationship with zebra mussels has not been fully investigated (Crawford 2011).

Laboratory testing established that SSW has an allelopathic effect on cyanobacteria, but field-testing has not been performed to confirm that it happens in natural settings. No allelopathic effects were observed against eukaryotic cells (Berger and Schagerl 2004).

b. Positive Effects

In some lakes where SSW is already established, lake managers have used it to control other aquatic invasive species like Eurasian water-milfoil. Starry stonewort grows below the surface of the water and can be less disruptive to recreational activities than other invasive plant species. If it reaches a nuisance level, SSW can be treated with herbicide to kill the top few inches of the mat (Pullman and Crawford 2010).

There is a positive relationship between SSW colonization and the growth of two aquatic macrophytes: coontail (*Ceratophyllum demersum* L.) and common bladderwort (*Utricularia vulgaris* L.). This may be related to the ability of coontail and bladderworts to grow unattached to substrate, as they have been observed lying on top of the SSW mat (Pullman and Crawford 2010). Sweet-scented waterlily (*Nymphaea odorata* Aiton.) and flat-stemmed pondweed (*Potamogeton zosteriformis* Fernald) are also capable of growing in or around SSW patches (Brown 2014).

Starry stonewort can immobilize available phosphorous in calcified structures, leading to less algal growth and higher water clarity in areas supporting large populations of SSW (Hilt et al. 2010). In parts of Europe SSW is considered an indicator species for unpolluted water (Stewart 2004).

Current Status and Distribution in Michigan

Starry stonewort was first observed in North America in the St. Lawrence Seaway in 1978 (Geis 1981). It was found dominating the macrophytes of Goose Bay, north of Alexandria Bay, New York. It was believed to have been introduced in ship ballast water (Geis 1981; Schloesser 1986). Five years later Schloesser et al. (1986) collected SSW in Lake St. Clair, St. Clair River, and Detroit River. Studies in the 1980's and 1990's found SSW growing in oligocultures of eel grass (*Vallisneria americana* Michx.), Eurasian water-milfoil (*Myriophyllum spicatum* L.), Richardson's pondweed (*Potamogeton richardsonii* (A. Benn.) Rydb.), slender naiad (*Najas flexilis* (Willd.) Rostk. & Schmidt), and common waterweed (*Elodea canadensis* L.; Geis 1981; Schloesser 1986). It wasn't until the turn of the century that SSW was perceived as a nuisance and forming monocultures in Michigan inland lakes (Pullman and Crawford 2010).

Starry stonewort is present in over half the counties in the southern Lower Peninsula (Figure 4), and it may be present in many more counties than are reported (Pullman and Crawford 2010). The highest density of reported sightings occurs in southeastern Michigan in both Oakland and Livingston Counties. Four populations that were reported as dense were in Lotus, Maceday, and Angelus lakes in Oakland County and Baker Lake in Barry County (MISIN 2014). Most confirmed sightings did not contain information on density of populations.

A single unverified sighting was reported to MISIN in the Upper Peninsula in Millecoquins Lake in 2014.

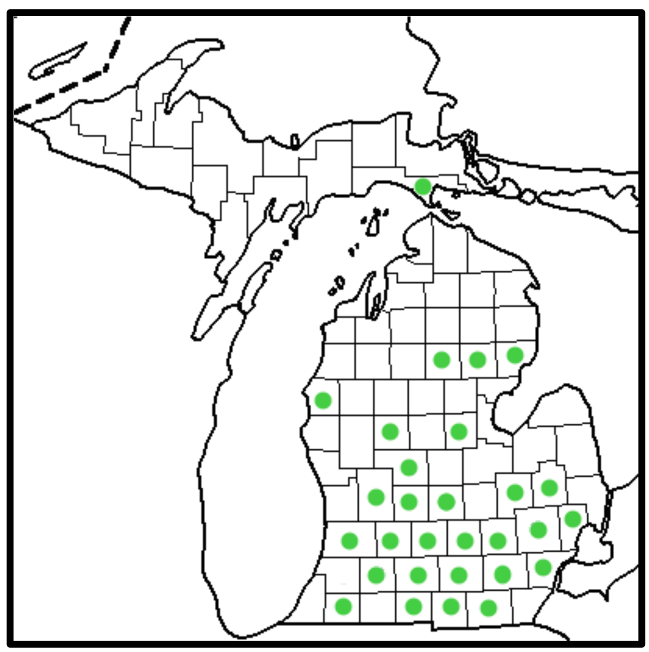

Figure 4. Green dots indicate reported presence of *Nitellopsis obtusa* on the Midwest Invasive Species Information Network (MISIN). County map was developed by Michigan Flora Online (Reznicek et. al. 2011)

Management of SSW

I. Prevention

Preventing the establishment of SSW is preferable to post-establishment management. Starry stonewort is a "Prohibited Species" in Michigan under Natural Resources and Environmental Protection act 451 of 1994. Under this act it may neither be sold nor grown in the state.

Prevention of SSW spread is difficult. It is thought that animals act as a primary vector for transporting SSW between lakes because oocytes readily attach to fur or feathers, but vegetation attached to recreational boats is also a potential

means of spread (Pullman and Crawford 2010). Nearly 75% of Michigan's inland lakes are suitable for SSW colonization (Brown 2014). The following actions may prevent and limit the dispersal of SSW:

- Build a coalition of local, statewide, and Great Lakes regional partners to monitor for SSW and other aquatic invasive species
- Build a coalition of states that have classified SSW as a restricted or prohibited species
- Provide boat washing stations for high-traffic public lake accesses
- Develop and sustain a sustainable water recreation vehicles and trailers inspection program
- Identify water bodies of high-risk of infestation using known distribution and dispersal knowledge

II. Management/Control

Although presented separately here, a management plan developed by integrating ecological knowledge, several management techniques, monitoring, and plan adaptation over time – called integrated pest management – is the most effective approach to controlling invasive species. Starry stonewort has not been a concern in many locations outside the Great Lakes Basin, and small infestations can be treated easily with several different algaecides. High density SSW growth may prevent herbicide treatments from reaching the lower levels of the SSW mat, so only the first few inches respond to chemical treatment (Pullman and Crawford 2010).

Some managers have used infestations of SSW to manage other invasive macrophytes. Recolonization has also occurred post-treatment: years after populations are thought to be reduced or eliminated, dormant spores and/or bulbils can repopulate an area (Kato et al. 2005; Hilt et al. 2010).

Starry stonewort is not a problematic invasive in locations outside of the St. Lawrence seaway, Michigan, New York, and Indiana. Little has been published regarding management and control of the species. The following management section is covered in a publication by Pullman and Crawford (2010).

a. Chemical

Starry stonewort is highly sensitive to copper and endothall chemical treatments. If growing in a dense mat, only the top layer will die back with a standard treatment. Cooling herbicides or algaecides prior to application facilitates penetration into the dense benthic mats (Pullman 2014). Chemical treatments mixed with chelated agents may also be used to treat deeper into the mats (Pullman and Crawford 2010).

b. Physical or Mechanical Control

Mechanical harvesting has been carried out on SSW populations. Starry stonewort harvesting is difficult because its dense growth quickly fills harvesters, and recolonization is swift if adjacent populations remain (Pullman and Crawford 2010). Mechanical management through the use of weed rollers was effective in removing SSW from fish spawning habitat in Lake Waumega (Pullman and Crawford 2010).

Drawdown of water level where it is practical may provide effective control, but it has yet to be investigated.

c. Biological

There are no known species-specific biological controls for SSW. In its native range eutrophication and competition from other plants limits the growth of SSW (Gołdyn 2009).

III. Indirect Management

No indirect management techniques have been investigated for the control of SSW at the time of this report.

Research Needs

A review by Pullman and Crawford (2010) lists in detail many research needs to better understand SSW management in Michigan, including some of those described below: habitat requirements, spore and bulbil viability, detection of distribution, genetics, ecological impacts, relationship with zebra mussels, effectiveness and longevity of control methods, and potential recolonization of treated areas.

I. Biology and Ecology

Research regarding the viability of SSW spores and bulbils in Michigan populations would be useful in understanding management. Several studies suggested that SSW repopulated areas years after populations became scarce (Kato et al. 2005; Hilt et al. 2010). Knowledge of whether this is the case in Michigan would determine whether eradication is practical.

Although it has established invasive populations in over a hundred Michigan inland lakes (Brown 2014), little data has been published regarding the ideal environmental conditions or nutrient levels that promote SSW growth in lake ecosystems. A presentation given by Scott Brown, executive director of Michigan Lake and Stream Associations, looked at where SSW occurs and the conditions in those lakes (Brown 2014), but quantitative growth studies would be useful for informing monitoring and management techniques.

The lack of known SSW invasiveness outside of the St. Lawrence Seaway, Michigan, New York, and northern Indiana populations is puzzling. Genetic studies comparing SSW populations in Michigan inland lakes to that in Lake St. Clair would determine if the

aggressive SSW is a the same or a hybrid or mutant colonizing form. Genetic research may also provide clues regarding primary dispersal pathways.

In general, there is a lack of literature on specific ecological and economic impacts of a specific aquatic invasive plant species. Most impacts are grouped by growth forms of the species, but the impacts are not quantitatively measured. It is more difficult to justify management of an invasive species when quantitative impact data is lacking.

Additional research is necessary to assess the ecological impacts of SSW on aquatic flora and fauna during SSW booms and crashes. Determining the effects of SSW on fish populations and vegetation during SSW fluctuations could provide insight into the positives and negatives of SSW presence. Crawford (2011) observed that zebra mussels have readily colonized SSW mats. If this is commonly the case, it could have implications for the management of both species.

II. Monitoring

A better understanding of the true range of SSW in Michigan will inform decisions to limit its spread. Starry stonewort's superficial resemblance to native *Chara* ssp. may result in a false sense of security for lake managers. Once the true distribution is known, high-risk water bodies can be monitored more intensely for invasion. Detection of SSW with eDNA may be possible.

Monitoring SSW and documenting variation in abundance from year to year could help identify trends and determine the best treatment type and time based on the site.

III. Management

In terms of control research, examination of the treatment relationship between Eurasian water-milfoil and curly-leafed pondweed could improve comprehensive and long-term management plans. Understanding the relationship between co-occurring invasive species could aid in determining the best time and strategy method in treating SSW. An investigation of the observed enhanced growth of certain species after treating SSW with fluriodone has yet to be conducted.

Investigation of the effects of herbicide temperature on treatment could improve treatment effectiveness. The application of cooled herbicide has been shown to penetrate dense SSW mats to a greater depth than traditional application, but repeatable studies have yet to be conducted.

No research has been published on potential biological controls, and the little that has been published regarding mechanical or chemical management comes primarily from one document (Pullman 2010). Techniques such as drawdown of water level or shading may limit SSW growth, but have yet to be examined. Research is ongoing at Clemson University on the management of freshwater algae like SSW, though they have been delayed in starting due to difficulty growing SSW in a laboratory setting (G. Douglas Pullman, Aquest Corporation, *personal communication*).

Future Directions for Michigan and SSW Management

Starry stonewort is an aquatic macroalgae native to Europe and Asia, where it is considered a desirable and/or endangered species confined to unpolluted waters. It has established aggressive invasive populations in many Michigan inland lakes, but is not known to aggressively outcompete other species in any other part of the world.

Michigan is in a unique position to discover why SSW has become so invasive here while being considered benign or beneficial elsewhere. It is possible that SSW has already invaded other water bodies in Michigan and the U.S., but has not yet been positively identified. The submersed growth form and difficulty some have with identifying macroalgae makes documentation of the species difficult until it has already formed large exclusive mats, by which time restoration of habitat can be difficult.

Prevention – Prevention of new colony establishment is the most cost effective approach to SSW management. Until the current distribution is known, prevention of spread will be difficult. Believed pathways of SSW dispersal are natural waterways and attachment of oospores, bulbils, and fragments to animals and boats, but there is little research in this area. The development of a sustainable boat washing or inspection program could also aid the reduction of the spread of this species.

Monitoring – Early detection would make eradication a more realistic option. Adding SSW to existing monitoring programs will assist in early detection and increase the potential of eradication of SSW. A cohesive monitoring and reporting system involving local municipalities, non-profit organizations, lake associations, recreation clubs and organization, and waterfront property owners, would increase the number of known SSW locations and enable early detection and rapid response to new colonies. Connecting waterfront property owners and boaters with resources such as MISIN could improve early detection efforts

Starry stonewort monitoring would benefit from a direct and targeted monitoring strategy. A targeted monitoring strategy would involve preparation and research, but may be the most efficient strategy in the field considering the limited known distribution of SSW in Michigan. To develop a targeted monitoring strategy, the current known distribution and predictive modeling would be used to extrapolate sites that have a high-likelihood of infestation. The likelihood of infestation of sites would be determined by evaluating potential pathways and dispersal trends of SSW, like that Abigail Fursaro and Alisha Dahlstrom Davidson (Wayne State University) are currently applying as a part of the Great Lakes Restoration Initiative to identify hot spots for new aquatic invasive species to be introduced. For SSW, water bodies could be prioritized based on the distance (Euclidean and upstream/downstream distance) from infested water bodies, density of SSW in nearby infested water bodies, environmental habitat conditions, level of recreational activity, number of public access points, and animal migration routes. More investigation into potential pathways and dispersal trends may be needed. Each potential pathway is ranked and weighted for spatial analysis. Those water bodies that score in the highest tier have a high-likelihood of infestation

Networking data – Statewide monitoring methods would benefit from creating or participating in systems that centralize and provide open access to diversity data (e.g. MISIN, Weed Map – Cooperative Weed Management Area, MiCorps Data Exchange Network – Great Lakes Commission, VertNet, Nonindigenous Aquatic Species Database - USGS, Biodiversity Information Serving Our Nation (BISON), and Global Biodiversity Information Facility (GBIF)). These databases house biological specimen or observation data including species location, verification, photographs, density, and even links to genetic data. Preliminary efforts within the state of Michigan have agencies contributing to regional databases (e.g. MISIN, Cooperative Weed Management Area, Nonindigenous Aquatic Species Database), but participation is not consistent or standard throughout programs. In addition, state databases are not always networked within an agency, across the state, throughout the region or relative to national efforts.

Participation in a national or global information network will standardize data collecting practices, produce comparable data across projects, ease data acquisition, avoid data redundancies, and promote projects with a larger scope of study than the original project for which the data was collected. Information networks that are continually linked to other resources and updated can be used to develop effective and efficient monitoring and management plans. In turn, monitoring plans can inform the resources on their findings and create an adaptive strategy to combat invasive species. When information networks are not linked or periodically synched, a person collecting information must independently identify, locate and consolidate data from separate and often difficult to access sources. The result is information is not accessed and data collection becomes redundant and inefficient.

Networking with and contributing to state, regional, national and international databases will advance research in areas that could improve the way aquatic invasive species are managed. Researchers can easily access the data and use it to model suitable habitat, model distribution, research population genetics across many spatial scales, predict new introductions, study changes due to climate change, or locate areas most beneficial for new projects or collections. The public could also use this data to know what species they may be exposed to when recreating specific water bodies.

Rapid response – The ability to rapidly respond to reports in new or high-value locations submitted by the public or through a regular monitoring strategy is essential to battling invasive species. Invasive species are easier to treat if the infestation is small. If the procedure to manage an infestation takes several years to achieve action, the infestation may have grown beyond realistic management. Maine Department of Environmental Protection has developed a rapid response protocol that attempts to treat infestations of certain aquatic invasive species within 30 days of a newly detected aquatic invasion (MDEP 2006). The workflow begins at confirmation of report, and then delineation of infestation, containment, and primary evaluation. Next steps are treatment selection, plan refinement, and implementation. The infestation should be monitored and evaluated regularly for several seasons to evaluate the treatment and control any reemerging growth. Although it is called a rapid response, it may not end rapidly.

Management – When managing SSW, it is important to delimit the extent of the infestation, contain already established populations, and protect high-value sites. An integrated pest management plan is needed to manage SSW, especially considering its cyclic relationship with other invasive species. Treatments of copper and endothall have been effective in controlling SSW, but no techniques have been developed for complete lake eradication. Occasionally SSW has recolonized shortly after or many years after believed extirpation or eradication.

Most often SSW is treated after it has developed dense mats; hence chemical treatment is only affective for the top layers of the mat. Other application techniques (e.g. herbicide cooling) have yet too be shown scientifically to improve effectiveness. Educating residents on the identification, restrictions, and ecological impacts of SSW could assist in preventing new occurrences and the establishment of dense mats.

Measuring effective control: Following the treatment of SSW, the effectiveness of treatment can be quantitatively assessed through documenting any year-to-year regrowth, reduction in SSW percent cover, as well as reduction in bulbil or oospore production.

The goal of aquatic invasive species management strategies is to preserve or restore ecologically stable aquatic communities. Minimal chemical, biological, and physical controls should be required to maintain these communities. Any management plan should involve the integration of prevention and control methods that consider factors affecting the long-term ecological stability of an aquatic community

Document citation

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Table 1. Objectives, Strategic Actions, Leads, and Expected Outcomes of SSW Management

Guidance and Outreach for Starry Stonewort Management			
Objective	**Strategic Action**	**Who is leading effort in Michigan?**	**Expected Outcome**
Increase public awareness of prevention methods	• Coordinate and collaborate with local and regional partners of water bodies with an infestation or high likelihood of infestation • Educate public of identification, early-detection, and prevention	• AIS Core Team • Lake Associations • Michigan Inland Lakes Partnerships • MSU Extension	• Increase public awareness of SSW • Increase the frequency and use of boat washing programs • Protect high-value sites • Contain established populations
Provide technical guidance to those interested in SSW management	• Creation of a SSW technical guide and SSW prioritization tool.		• Increase management efforts
SSW Monitoring and Data Management			
Develop a mechanism for detecting, monitoring, and reporting AIS species	• Develop a system of identifying water bodies with high likelihood of infestation • Survey waterbodies with high likelihood of infestation • Explore detection of SSW using eDNA techniques	• AIS Core Team • MISIN • Michigan Water Corps	• Develop a more thorough and up-to-date statewide distribution of SSW • Evaluate dispersal pathways and vectors
Contribute regularly to regional, national, and global diversity information networks	• Consolidate Michigan biological and abiotic data • Standardize resources • Standardize data collection • Network existing data • Regularly synchronize data	• MISIN • Weed Map - CWMA • MiCorps • VertNet • NAS - USGS • BISON • GBIF	• Develop adaptive monitoring strategy that responds to up-to-date distribution • Promote AIS research of regional, national, and global extents • Prevent data redundancies
Educate public on identification and reporting of AIS in Michigan	• Target users of water bodies that are infested and high-likelihood of infestation	• MISIN • Michigan Water Corps • Management agencies	• Increase public awareness of AIS • Identify water bodies that need professional confirmation of AIS
Research Needs for SSW Management			
Chemical: Develop treatments to increase long-term control or eradication success	• Identify means to disperse algaecide treatments so that all portions of the mat are affected (e.g. cooling herbicide prior to application) • Investigate anecdotal association between SSW infestations after lakes were treated with fluridone	Aquest Corporation	• More complete treatment of infestation resulting in possible eradication of invasive SSW
Biological: Establish biological control methods	• Identify any potential biological control species		• Increase long-term control success
Mechanical: Evaluate effectiveness of current mechanical controls	• Long-term study of the effectiveness of mechanical controls in reducing/eliminating SSW over time		• Determine whether or not long term mechanical removal is a cost effective management approach
Possible Hybrid SSW: Increase understanding of recent aggressiveness of SSW in Michigan inland lakes	• Investigate genetics of SSW of populations in Michigan inland lakes, St. Lawrence Seaway, and native populations		• Eliminate confusion regarding invasive/native role of SSW and direct further research

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