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Indian Ponds Association
c/o Chip King, Alexena Frazee and Greg Cronin

Dear IPA Friends:

I am writing to summarize current issues with regard to *Hydrilla verticillata* (hydrilla) in Mystic Lake, having been involved with this invasive plant species problem from the start at Mystic Lake and having knowledge of control efforts in other lakes. I hope that my perspective as a lake manager for over 35 years will help all parties move toward a solution. Most of the work that needs to be done can be done by IPA members or commercial plant control firms, so I am seeking no paid project work from the control of hydrilla in Mystic Lake. However, I know that with multiple interest groups involved, it can be difficult to overcome institutional inertia. If the hydrilla problem is to be solved, action is needed, and all parties need to understand the situation and their respective roles. Here I try to inform and clarify; this summary can be disseminated to anyone involved or interested in the control of hydrilla on Cape Cod. Further discussion will be needed.

Hydrilla background

Hydrilla verticillata is not native to the United States and is mostly known as a subtropical species. It survives in colder climates, however, and is ecologically well suited to establishing and maintaining populations in Massachusetts lakes. To date, about a dozen lakes have become infested with hydrilla. There are two strains of hydrilla, monoecious and dioecious, the former having male and female parts on the same plant and the latter having separate male and female plants. The more extensive southern infestations are dioecious hydrilla, while virtually every infestation north of about Virginia on the east coast is monoecious hydrilla. This has ecological implications, and one must be careful when interpreting case histories from the south for possible application in the north.

Hydrilla reproduces mainly by turions and tubers, which tend to appear very similar and fill the same function. Turions are formed off the stem at the base of leaves, while tubers are formed on the roots. Formation and germination of turions and tubers are dependent mainly on light and temperature, and is therefore weather dependent. This limits predictability, but it appears that there are two main periods of production, early and late in summer. Tubers and turions can be very abundant, with densities of up to 3000 per square meter observed, with germination of over 90% of collected turions and tubers, so the potential to spread quickly from these propagules is high. Turions and tubers typically do not germinate in the year of formation (they seem to need an annual photoperiod or temperature cycle to trigger germination), but remain viable for multiple years after formation.

For the most part, hydrilla dies back each winter in northern climates, functioning as an annual plant and re-establishing from turions or tubers the following spring. In Mystic Lake, growths are not typically observed until June and do not become dense until July, with biomass peaking in early autumn and die back by mid-November. Earlier or later growth may be possible with warmer or colder seasonal weather, creating year to year variation. Climate change may be a factor in the arrival and success of hydrilla in Massachusetts. Overwintering in a vegetative form is possible at warmer temperatures, but even our mildest winters appear too cold for hydrilla to survive as mature plants.

The depth to which hydrilla grows is a function of light, and it does not tolerate low light as well as many plants, so 10-12 feet of water depth is about the limit for this species. In Mystic Lake it has been most common in 3-8 feet of water. It can form a dense canopy if it reaches the lake surface and shades out other species. In many southern reservoirs it becomes the dominant plant and impairs habitat, water supply and recreation, but in northern reservoirs its annual habit and late start on spring growth tend to keep it from completely eliminating other plant species. However, control efforts have been practiced in the majority of lakes where hydrilla has occurred in New England, so we do not really know what would happen if hydrilla was left unchecked.

Growths of hydrilla in Mystic Lake have been expansive but have not generally resulted in topped out canopies. This may be more due to attempted control from the earliest discovery, which appears to have started within a year after introduction. Prompt action by the IPA minimized the rate of spread, but hydrilla is a very difficult plant to control. Topped out growths have been observed in other lakes, including Long Pond in Barnstable, so lack of control can be expected to result in problem conditions.

Hydrilla can move among lakes by flow (upstream to downstream where a connection exists), boats (the most common means of invasive plant movement, but not proven to be a major factor with hydrilla) and birds (suspected of being the primary vector, with viable turions passing through digestive tracks of birds that eat hydrilla). The initial infestation in Mystic Lake appears to have been near the Linxholm beach. Residents place canoes and kayaks there, but these watercraft rarely go anywhere else. Birds use the dock and swim platform, however, and the largest growth discovered in 2010 was just off that swim platform. About a dozen smaller patches were found around the lake, and these could have come from birds or movement of turions with water currents.

There is still more to be learned about basic hydrilla ecology, especially the monoecious form, but those who want to learn more about what we do know can find a technical summary online at **http://www.nyis.info/user_uploads/files/Monoecious%20Hydrilla%20Lit%20Review%20-%20Final.pdf**.

Control of hydrilla

Whether or not to control hydrilla is a matter of perceived impact and cost. In the south, where most waterbodies are manmade reservoirs with no native plant communities, hydrilla has taken over in many cases and impeded lake use. Certainly where there are extensive shallow areas valued by people (e.g, swimming areas, cranberry bog ditches), the threat of impairment by hydrilla is very real. Out in the deeper areas of lakes, it is not at all certain that hydrilla will represent a major impairment of lake use. Most groups choose to address hydrilla if they can afford it. Even if much of their lakes are too deep for hydrilla to become a problem, the impact to shallow areas could be severe, and the potential for other lakes to become infested is very high. Note that in a Midwest study it was found that intensive control effort in an Indiana lake took 7 years to yield the desired benefits, but that no lake in a 75 mile radius was infested. In Minnesota, lack of control led to problems not just in the initially infested lake, but in about 30% of the lakes within a 75 mile radius. The need for control therefore goes beyond just the lake under consideration when an infestation occurs.

Cost is a very real issue. Many of our ponds are officially Great Ponds, a statutory designation under Commonwealth law that makes any lake larger than 10 acres in its natural size the property of the Commonwealth. Mystic Lake and the connected Middle Pond, and indeed most of the kettlehole ponds on Cape Cod, are Great Ponds. Yet Massachusetts has not shared in active management of most Great Ponds in many years. The MA DEP used to have an active lake management program, but it was transferred to the MA DCR in the mid-1990s. The DCR has limited staff, but that small group has labored valiantly to address aquatic invasive plant problems in Massachusetts. However, with a very small budget and a mandate to give priority to lakes in state parks or with major public boat ramps, attention to lakes like Mystic and Middle is minimized.

The Town of Barnstable has been very supportive financially. Barnstable is one of the better towns in the Commonwealth when it comes to recognizing the value of its water resources and getting involved in their management. Yet there are processes to be followed, and response to problems is not always as rapid as desired. Budget cycles and priorities are a fact of town management, and planning ahead is difficult when it comes to invasive species.

Beyond funding, there is a problem with the permitting system in Massachusetts, particularly as relates to the Wetlands Protection Act which is administered by the town and overseen by DEP. Lake management was specifically recognized and encouraged in the original law and regulations, but repeated revisions have led to less emphasis on lake management. Most lake management projects are now treated like development projects, with no recognition of the benefits and focus on any negative impact to any of the 8 interests of the WPA. There are inconsistencies in the regulations and with the latest revision in late 2014, there is no provision for rapid response to a new invasion. The latest regulations set up a 3-4 month process for approval of any action, effectively precluding "rapid response". The initial harvesting of hydrilla was delayed by the normal meeting schedule and approval process of the Barnstable Conservation Commission, which is the standard approach prescribed by regulation for all commissions. The newer regulations would have lengthened that delay and must be considered when planning future actions.

Actual control options are limited. There is no biological control applicable in Massachusetts. Grass carp have been used to control hydrilla in other states, and seem to prefer hydrilla in their diet. I myself have a hydrilla control project involving grass carp in Virginia. However, grass carp are not legal to introduce in Massachusetts, so this is not a viable option, and success translates into more frequent and severe algae blooms anyway (the plant nutrients are converted into forms available to algae). No insect, bacteria or other biological controls are proven or commercially available for monoecious hydrilla. This leaves physical and chemical control methods for this invasive species.

Physical controls include drawdown, hand harvesting (with or without suction aids), mechanical harvesting, benthic barriers and dredging. Drawdown will dry and freeze plants, but for seed (or turion) producing annual species, this will not provide population control and there is no effective way to lower the water level appreciably for kettlehole lakes like Mystic or Middle. Dredging is the most effective way to set a lake back in time, removing accumulated sediment and associated plants, propagules, nutrients and other contaminants. Unfortunately, dredging removes a lot of other desirable items, like protected mussels, and is very expensive. Dredging is therefore not a realistic option for invasive plant control in most situations, and certainly not for Mystic Lake or Middle Pond. This leaves harvesting methods and benthic barriers, both of which have been implemented in Mystic Lake. The hand harvesting effort and placement of benthic barriers has been successful at slowing the spread of hydrilla in Mystic Lake, but has not eliminated hydrilla or even substantially reduced it. The population has gone from a few small patches to a much more expansive but diffuse growth pattern. Benthic barriers and hand pulling are still used, but are becoming less effective, as the area impacted is too large for either to be applied in a timely manner.

Chemical controls include mainly herbicides, although hydrilla is not tolerant of saltwater and could be controlled in a marginally estuarine area by increased tidal flushing. Herbicides include contact and systemic formulations, the former killing only the part of the plant with which they come in contact and the latter being taken into the plant and translocated to all attached parts, potentially killing the whole plant. Contact herbicides tend to require less exposure time to work and are less persistent in the lake, but longer term control is less likely as root systems survive. Systemic herbicides are intended to kill the entire plant, and do a more thorough job than contact herbicides, but the percentage of target plants killed is never 100%, so repeat application is to be assumed if eradication is the goal.

Turions and tubers, once formed, are not impacted by herbicides, however, so some regrowth from turions/tubers is to be expected and will require repeated treatment. Some lakes have undergone many annual treatments (as many as 10) to get control of a hydrilla infestation, including Long Pond in Barnstable (where hydrilla was unfortunately observed 3 years after the last treatment). Eradication has apparently been successful in several lakes, including one in Maine, but if the lake was infested once, it likely can be infested again, so lasting elimination of hydrilla cannot be assumed.

The most common contact herbicide active ingredients are diquat and endothall, although flumioxazin has been more recently applied. These display some selectivity based on dose and timing of treatment, but are generally expected to kill many plants in the target area. Recovery of most native species from seed or nearby populations is usually observed, but some recovery by hydrilla can be expected too. Systemic herbicide active ingredients include fluridone, imazamox, triclopyr and 2,4-D. Fluridone, most often marketed under the tradename Sonar, has been the preferred systemic herbicide as a consequence of high susceptibility of hydrilla and no significant risk to any animal life. Fluridone will kill some other plants at low concentrations, most notably *Elodea canadensis* (waterweed) and *Najas* spp. (naiad), both found in Mystic Lake, but recovery of a native plant community is almost always observed after treatment. However, as the turions and tubers that formed prior to treatment are not killed, and some small rate of vegetative plant survival is to be expected, repeat treatment must still be planned.

Additionally, resistance to fluridone was documented in Florida dioecious hydrilla, and caution has been urged in using this herbicide year after year. As it could take 5-10 years to exhaust a tuber/turion base, periodic substitution of another herbicide is recommended.

Herbicide chemistry varies by herbicide and fate and transport are affected by local conditions. Generalizations about herbicide impacts, longevity, degradation products, and related features should be avoided. Discussion should focus on a specific formulation of a specific herbicide when considering use in a lake and possible effects. Blanket statements will usually be inadequate and often misleading.

There is always some risk of a negative outcome of some kind, and characterizing the probability of any undesirable outcome and considering it within the context of all lake users is advised. In that regard, it is hoped that those who might oppose a treatment because it has some possible negative impact to their preferred lake use (e.g., permitting agencies considering protected species, cranberry growers considering crop impacts, swimmers considering use restrictions) will look at the complete picture, including the consequence of no action. Remember that no action has consequences as well, and these may be more severe than the risks associated with action. For example, protected species may be lost if hydrilla negatively impacts their habitat, cranberry irrigation ditches may be choked by expanding hydrilla, and swimming could be rendered hazardous in some areas by dense growths. Permitting agencies are often short-sighted when evaluating proposed projects, focusing on possible negative impacts specific to their jurisdiction without proper consideration of the big picture and all related consequences.

Recommendations

Hand harvesting and the use of benthic barriers remains appropriate for addressing any patches of hydrilla that show up in Mystic Lake or Middle Pond. Mechanical harvesting would not work well, as growths are not to the surface in most cases and the whole plant could not be harvested anyway. The cost would be higher and the results would be less acceptable. Suction aided hand harvesting (diver assisted suction harvesting, or DASH) may not be very appropriate either, as the turions/tubers may escape the bagging process and be spread further around the lake. If hydrilla is found everywhere it might be, this becomes less of an issue, but where hydrilla is widespread within a lake, such effort is likely too labor intensive to be practical. The applied physical controls have been demonstrated to be inadequate to reduce hydrilla abundance lakewide in Mystic Lake at the level of effort applied. That level of effort would have to increase substantially to get better results, and even then may not yield the desired condition; at this point it can only be stated that the level of effort to date has been substantial but still not adequate to minimize hydrilla growths.

Endothall has been applied in selected parts of Mystic Lake where hydrilla growth extends over a relatively large area not conducive to effective hand pulling or benthic barrier deployment. Hydrilla growths have been killed, but regrowth the following year, presumably from deposited turions and/or tubers, has occurred. Application of fluridone has not been tried because growths were not present throughout the lake and localized use of contact herbicides was more efficient and less costly. Mystic Lake appears to have reached the point, however, where treatment of much of the lake with fluridone is appropriate. Some localization of treatment is possible with a pelletized formulation, but fluridone is very diffusive and dilution may limit effectiveness in Mystic Lake. Whole lake treatment at a low dose (<10 ppb) will be more expensive, but represents a viable approach to reducing hydrilla abundance in Mystic Lake. This is the approach used at Long Pond, and while not apparently successful at eradicating hydrilla, it did reduce it to minimally detectable levels for about 3 years (and it is uncertain if the 2015 infestation represents recovery or a new invasion).

Use of fluridone in Mystic Lake is recommended, but its use presents several complications, some not encountered in Long Pond. Mystic Lake still harbors protected species of mussels; despite a great reduction in numbers back in 2009, possibly from a toxic cyanobloom, 3 endangered species of mussels are still represented in the lake and the Natural Heritage and Endangered Species Program must approve of the treatment. This is not expected to be an insurmountable task, but does represent a bottleneck in the permitting process and has resulted in costly, time consuming, and questionable restrictions in past Mystic Lake management efforts. Another complication is cranberry bogs, which use water from Mystic Lake at least for harvesting and possibly for irrigation. There is potential for impact on cranberry plants by fluridone, and even if there is no direct impact, the presence of detectable fluridone residue on cranberries limits sale options, especially in the international market. Any use of fluridone must therefore be carefully planned and monitored, but this is the recommended course of action. Additionally, the potential for promoting resistant species suggests that more than one herbicide should be applied in a multi-year project. Endothall has served well so far and is the logical alternative to fluridone, but it is not clear if there are restrictions for cranberry bog use or if the NHESP has issues with repeated use as relates to protected species.

Suggested treatment, related issues and safeguards

Whole lake treatment of Mystic Lake with fluridone is recommended at an initial target dose of 6-8 ppb. It will likely have to be repeated for the better part of a decade, so this is a major undertaking, and treatment with endothall should be considered instead of fluridone in years where hydrilla distribution is not widespread. Follow up hand harvesting and benthic barrier placement may be needed as well and should be planned, but those actions are not controversial or difficult to permit. The herbicide treatment will present several obstacles to be negotiated, and this letter is intended to provide some background for decision making in this regard. Consider the following:

- Concentrations of fluridone above 3 ppb for about a month should kill hydrilla. This is a low level with low risk to many but not all other plants present in Mystic Lake. The initial target concentration will be at least 6 ppb, since the half-life of fluridone under typical sunlight conditions (via photodegradation) is about a month.
- The germination period for monoecious hydrilla in New England appears to be between mid-May and early August. Turions and tubers are not formed before July, probably not before August. In Mystic Lake there is rarely any hydrilla before mid-June, so treatment with fluridone in early June and again in early July (a boost treatment based on observed concentrations) should be adequate. Examination of harvested hydrilla into August has

revealed very few turions or tubers; formation late in summer appears to be the case, and again treatment in June and July would seem appropriate.

- Fluridone is not known to negatively impact any animal life at applied levels. Doses of up to 20 ppb are allowable in water supplies, and monitoring over the last 20+ years suggests minimal risk to any insect, reptile, amphibian, fish or mammal species in treated lakes.
- Between photodegradation and uptake, the concentration would be at least halved every month, so a treatment of up to 8 ppb in early July would be expected to yield a concentration of no greater than 1 ppb in early October and would more likely be undetectable (<0.1 ppb) when the water was needed for cranberry harvest.
- Use of Mystic Lake water for cranberry bog irrigation could represent risk to cranberries. It is not known if any water from the lake is used for irrigation, only for harvest, and alternative use of wells seems plausible, but this needs to be investigated.
- Endothall would be used on a more localized basis, has a much shorter period of activity, and with dilution would not likely be detectable in any withdrawal even if applied just a few weeks before withdrawal was conducted (half-life of 7-10 days). However, the same application period would apply, with early July as the latest application period and minimal chance of any endothall being detected in early October.
- The endothall dose would likely be no greater than 3 ppm, a level at which impact to aquatic animals is not expected, especially with only a short duration (<3 weeks) exposure. Application would be to areas observed to have hydrilla, which will represent only a small portion of the lake.
- As endothall has been previously used in Mystic Lake under permit, this would not seem to represent a regulatory or cranberry bog problem, but this needs to be investigated further.

There is some level of risk to some non-target organisms with any management action, and there is certainly risk under the no action alternative. It is easy for any interested party to reject actions based on low risk tolerance, but it is essential that everyone understand that taking no action is not the same as preventing harm. Moving forward with an aggressive control program will require acquiescence by the town through its conservation commission, the Commonwealth through the DEP and NHESP, cranberry growers using Mystic Lake water and the Indian Ponds Association (representing shoreline property owners and the bulk of lake users). Opening a discussion among all parties about how to address the hydrilla issue is advised, and by that I do not mean giving each an opportunity to simply say what they don't want. If this infestation is to be successfully managed, there will need to be cooperation on a control program.

Contact me with any questions.

Sincerely yours,

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