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Abstract: Aquatic plants are an important component of well functioning lake ecosystems. Plant abundance is influenced by sediments, nutrients and water clarity. Given the dominance of agriculture in Iowa, nutrients and soil lost from "leaky" watersheds combine to create ideal habitat for growth of aquatic plants in lakes and ponds and hasten eutrophication. Under these conditions, plant growth can become a nuisance and reduce recreation, especially shoreline angling and boating. These nuisance growths present special problems to lake managers and those interested in lake-based recreation. Given the complexity of the aquatic vegetation often found in lakes, there is no one long-term solution to their management although grass carp and herbicides have been used with that goal. The best solution to a lake's specific vegetation problem will be a combination of preventative, physical, biological and chemical options tuned to that specific lake's environmental conditions and fishery needs. Development of a strategy to address the control of nuisance aquatic vegetation with the ultimate goal of producing a set of BMPs is needed to manage plants in Iowa's ponds and lakes. This information will provide lake managers with the best methods and techniques to sample, assess, and manage nuisance aquatic vegetation. Plans developed from these strategies will link critical watershed characteristics, lake bathymetry, water quality, and density and diversity of aquatic plants to management options that benefit fish and fishing. Considerations will include the cost and benefit of various alternatives and the likelihood for success. This project was initiated July 2006 and continues through June 2009.

Key Words: aquatic, BMPs, management, vegetation

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Introduction

Many different aquatic plants, phytoplankton to rooted vascular plants, inhabit lentic systems. Aquatic plants are an important component of well functioning lake ecosystems producing oxygen, food, and cover for fish and other aquatic organisms. Plant abundance is influenced by sediments, nutrients and water clarity (Cooke et al. 1993). Given the dominance of agriculture in Iowa, nutrients and soil lost from "leaky" watersheds combine to create ideal habitat for growth of aquatic plants in lakes and ponds and hasten eutrophication that can cause these plants to become a nuisance to anglers as well as other users of the aquatic resource.

Although numerous studies have documented the importance of aquatic vegetation to the health and well-being of fish (Crowder and Cooper 1979, Savino and Stein 1982, Durocher et al. 1984, Paukert and Willis 2002), other reports have shown the detrimental effect of excessive vegetation upon fish and fishing (Mitzner 1977, 1978; Bettoli et al. 1993). Inclusion of important indices of aquatic plant communities will greatly benefit public efforts to manage lakes at the ecosystem level for the benefit of anglers and other lake users.

One of most fundamental tools needed by lake managers is a standard sampling protocol for aquatic plants that is efficient in time expended and quality of data generated; presently, such a protocol is not available. Measurements of aquatic plant communities include both qualitative and quantitative surveys. Qualitative measurements note the presence or absence of specific taxa as well as estimated percentage cover. Although qualitative surveys are economical, they provide little data that can be used in statistical analyses.

Quantitative measurements include measurements of biomass, density, and relative abundance. Mitzner (1978) established 10 stations randomly placed near shore in an Iowa reservoir. Monthly samples were obtained by scuba-equipped divers who collected all vegetation from a 0.25-m^2 enclosure. It is obvious that given the labor involved on this one project, this technique has limited applicability to a state-wide vegetation assessment program.

Several protocols have been used to sample plants found in multiple lakes, some requiring less labor. Madsen (1999) described the use of point intercept and line intercept methods for assessment of aquatic plants in lakes. Both methods can be accomplished at a lower cost than biomass sampling, are adaptable to larger lakes, are sensitive to species diversity, but less sensitive to annual variations of plant abundance.

Methods and technology used to manage growths of aquatic plants have included consideration of lake bathymetry, biological control (grass carp, *Ctenopharyngodon idella*), dredging to remove excessive sediments and deepening of shallow water near shore, the use of labeled aquatic herbicides, and physical removal of plants. More recently, reduction in rates of lake sedimentation has also greatly benefited vegetation management in lakes; increased light penetration has allowed for increased plant growth.

Lake Bathymetry

The shape and depths of a lake or pond has a direct effect primary and secondary production, water chemistry, and subsequent management options (Cooke et al. 1993). There is an inverse relationship between lake depth (Cole 1975, Wetzel 1983) and the ratio of mean to maximum depth (Carpenter 1983 as cited by Cooke et al. 1993).

Biological Controls

Since 1963, when grass carp were first stocked at Auburn, Alabama and at Stuttgart, Arkansas, they have been the principle species stocked for biological control of aquatic vegetation (Lee et al. 1980). To date, this species has been distributed throughout most of the U.S., regardless of state-specific regulations regarding their use in aquatic plant control. Mitchell and Kelly (2006) indicate grass carp introduction was "…in keeping with a strong environmental and political mandate of that day to replace the broad use of chemicals with biological controls."

Given the previously-stated rationale for their use, several publications have concluded their use has been an asset in aquatic vegetation management. Bailey (1978) compared fish populations before and after grass carp stockings into Arkansas lakes and found their introduction did not improve or harm fish populations; a highly variable dataset was blamed for the conflicting results. Mitzner (1978) investigated the effect of stocking grass carp at 17 fish/ha in a deep-sided 29-ha reservoir in south-central Iowa; this reservoir contained an extensive growth of aquatic plants that included *Potamogeton*, *Najas*, *Ceratophyluum*, and *Elodea*. Over a 4-year post stocking period, grass carp reduced plant biomass 91% with the result of substantially improving shoreline fishing success.

In 1981-82, grass carp were stocked into an 8,094-ha Texas reservoir, 74 fish/ha (Bettoli et al. 1993); aquatic plants consisted primarily of *Hydrilla*, which covered 40% of the total surface area. The majority of aquatic vegetation was eliminated within 1 year post-stocking of the grass carp. The results of vegetation removal on the fishery was mixed, with largemouth bass (*Micropterus salmoides*) and white and black crappies (*Pomoxis annularis* and *P. nigromaculatus*) experiencing greater growth rates (Bettoli et al. 1992), while some prey species (e.g., brook silversides, *Labidesthes sicculus*), were negatively impacted (Bettoli et al. 1991).

Given the well-established database of the utility of grass carp to eliminate aquatic vegetation, some authors have recommended caution in their use. In a Florida study on four lakes, grass carp stocked at 49 fish/ha effectively controlled the problematic aquatic vegetation, but all four lakes had elevated turbidity, although chlorophyll did decrease significantly in three of the four lakes. The other lake had no significant effect (Leslie et al. 1983). Three of these lakes had long-term increases in nutrient-related variables, e.g., Kjeldahl nitrogen and phosphorus compounds. In a similar study, Hansson et al. (1987) suggest that grazing fish serve to release nutrients contained in macrophytes, thereby causing other primary producers to respond and accelerate the eutrophication process of that aquatic system. In an Indiana study, grass carp use resulted in increased turbidity and potassium levels; potassium level was used as an indicator of vegetation consumption by grass carp (Lembi et al. 1978).

Other than the direct negative impact on water turbidity and enrichment, there have also been concerns related to the actual impact of vegetation removal on the fish communities. Durocher et al. (1984) noted that the standing crop of largemouth bass is directly related to the percent submerged vegetation (up to

20%) in Texas reservoirs. Guy and Willis (1991) also determined a positive relationship between aquatic vegetation and largemouth bass in small South Dakota Lakes. Crowder and Cooper (1979) indicated that aquatic macrophyte control was often done with limited thought to secondary effects on the system. Given the fact that grass carp are long-lived and often experience low rates of annual mortality (2.0 - 7.7%) (Hill 1986), many lake managers have discontinued their use.

Since grass carp often completely eliminate aquatic vegetation, other studies have investigated stocking at lower densities. Kirk (1992) reported on a 3-year study where triploid grass carp were stocked as a replacement to herbicides; stocking rates were 12, 25, and 50 fish/ha. All stocking densities failed to achieve the desired 70% decrease in aquatic vegetation biomass.

Blackwell and Murphy (1996) stocked triploid grass carp into small impoundments at 4-7.5 fish/ha; the goal was to maintain 10-40% vegetation coverage. The stocking rate of 4 fish/ha failed to adequately control the vegetation, while the 7.5 fish/ha rate eliminated all aquatic vegetation. The authors suggested a combination of grass carp chemical treatment might produce the best treatment results.

Lake Deepening

Removal of sediments is one method used to deepen lakes, and this technique has two direct effects. First, the actual removal of the sediments can directly increase water depths near shore, whereby the littoral zone is more limited (Wetzel 1983). Next, since the sediments themselves serve as a reservoir of excess nutrients, sediment-regenerated phosphorus can account for almost 50% of the phosphorus loading in the lake (Cooke et al. 1993).

A technique related to dredging, but more often used as a management technique for Iowa lakes, is shoreline deepening (jetty construction). The lake level is lowered and bottom material is pushed to form a jetty. In the process, the water depth near shore is deepened. The technique results in an increase in shoreline development, reduces growth of nuisance growth of aquatic vegetation near shore, and improves shoreline access. The technique is also less expensive than lake dredging.

Chemical Controls

Today's aquatic vegetation management protocols often include the use of herbicides and algaecides. As with the biological controls, application of a herbicide is best viewed as short-term control of the problem, as the causes of the weed infestation (e.g., sedimentation) are not addressed (Moore and Thornton 1988).

The application of certain chemicals may entail restrictions related to water use, fishing, irrigation, and swimming, as well as the possible need for cautionary signs advising the public. In addition, many herbicides are selective for specific plant taxa, and application rates often vary with water temperature and water chemistry. These factors make the successful use of chemicals rather complicated and dictated by the specific factors encountered at the time of application.

Compared to the relatively low costs of grass carp, estimated at \$5 - \$6 each, application costs for herbicides can be quite expensive. For instance, the use of copper sulfate is estimated at \$15 - \$32/ha, while Aquathol K costs \$3,100/ha (2004 prices, Wisconsin Department of Natural Resources). Although the copper sulfate application costs appear to be low, this chemical is often repeated every 2-3 weeks throughout the plant growing season. In addition, regular applications of copper sulfate have been found to negatively effect the benthic populations of lentic systems (Hanson and Stefan 1984). Whole-lake treatments with herbicides are not considered as long-term control measures; aquatic vegetation sometimes needs to be retreated over a growing season, or it may be effective only until the following season (Pothoven and Vondracek 1999). Instead, they might be best used for treating small areas of lake, e.g., fishing lanes and boat docks.

Physical Removal of Plants

Aquatic plants (e.g., filamentous algae) may be physically removed using a seine (Heinen et al. 1988), cutters and rakes (McComas 1993), or by simply pulling on the plant. These techniques are often useful in situations where there is a need to maintain fishing lanes or access to boat launches. Moderate plant removal, by mowing a series of numerous, narrow channels in the vegetation, was considered very effective in largemouth bass and bluegill fisheries (Trebitz et al. 1997).

Objectives

1. Perform literature review of methods used to assess aquatic plants in lakes and implement a standardized methodology to monitor temporal and spatial changes in plant communities.
2. Evaluate physical, chemical, biological, and mechanical methods used to manage aquatic plants, include cost comparisons and their efficacious use.
3. Prepare a procedures manual of BMPs and a comprehensive approach to vegetation management in Iowa.

Progress

In a combined effort between Iowa State University and Iowa Department of Natural Resources staff, this project was initiated in July 2006. Thirteen lakes, varying in size from 13 to 163 ha, are located through out the state of Iowa; grass carp have been stocked into 8 of these lakes (Table 1). A protocol using transect lines have been established in all lakes for use in determining aquatic vegetation abundance; zooplankton and larval fish sampling stations have been established along these same transects in each lake.

Initial field collections indicate the relative abundance of larval fish in vegetated areas. Although it was our original goal to use beach seines to collect the larval fish samples, this was not possible due to the soft sediments as well as the vast vegetation mats, which combined to limit our use of seines. Instead, a hand-held DC shocking unit has been found to be quite effective in collected young-of-the-year fish.

In addition to investigating the biotic components of these lakes, water samples are being collected. Both nitrogenous and phosphorus variables as well as physical-chemical assessments are obtained on a bi-weekly basis.

Literature Cited

Bailey, W. M. 1978. A comparison of fish populations before and after extensive grass carp stocking. Transactions of the American Fisheries Society 107:181-206.

Bettoli, P. W., M. J. Maceina, R. L. Noble, and R. K. Betsill. 1992. Piscivory in largemouth bass as a function of aquatic vegetation abundance. North American Journal of Fisheries Management 12:509-516.

Bettoli, P. W., M. J. Maceina, R. L. Noble, and R. K. Betsill. 1993. Response of a reservoir fish community to aquatic vegetation removal. North American Journal of Fisheries Management 13:110-124.

Bettoli, P. W., J. E. Morris, and R. L. Noble. 1991. Changes in the abundance of two atherinid species after aquatic vegetation removal. Transactions of the American Fisheries Society 120: 90-97.

Blackwell, B. G., and B. R. Murphy. 1996. Low-density triploid grass carp stockings for submersed vegetation control in small impoundments. Journal of Freshwater Biology 11:475-484.

Carpenter, S. R. 1983. Lake geometry: implications for production and sediment accretion rates. Journal of Theoretical Biology 105:273-286.

Cole, G. A. 1975. Textbook of Limnology. The C. V. Mosby Company, St. Louis, MO. 283 pp.

Cooke, G. D., E. B. Welch, S. Peterson, and P. Newroth. 1993. Restoration and Management of Lakes and Reservoirs, Second Ed. Lewis Publishers, CRC Press, Boca Raton, FL. 560 pp.

Crowder, L. B., and W. E. Cooper. 1979. Structural complexity and fish-prey interactions in ponds: a point of view. Pp. 2-10 *in*: D. L. Johnson and R. A. Stein (Eds.), Response of Fish to Habitat Structure in Standing Water. American Fisheries Society, North Central Division, Special Publication 6, Bethesda, MD.

Durocher, P. P., W. C. Provine, and J. E. Kraai. 1984. Relationship between abundance of largemouth bass and submerged vegetation in Texas reservoirs. North American Journal of Fisheries Management 1984(4):84-88.

Guy, C. G., and D. W. Willis. 1991. Relationship between environmental variables and density of largemouth bass in South Dakota ponds. Proceedings of the South Dakota Academy of Science 70:109-117.

Hanson, M. J., and H. G. Stefan. 1984. Side effects of copper sulfate treatment of Fairmont Lakes. Minnesota Water Resources Bulletin 20:889-900.
Hansson, L., L. Johansson, and L. Persson. 1987. Effects of fish grazing on nutrient release and successession of primary producers. Limnology and Oceanography 32:723-729.
Heinen, J. M., G. C. G. Fornshell, and P. J. Foley. 1988. Removal of floating filamentous algae from ponds with a shallow seine. The Progressive Fish-Culturist 50:197.
Hill, K. R. 1986. Mortality and standing stocks of grass carp planted in two lakes. North American Journal of Fisheries Management 6:449-451.
Kirk, J. P. 1992. Efficacy of triploid grass carp in controlling nuisance aquatic vegetation in South Carolina farm ponds. North American Journal of Fisheries Management 12:581-584.
Lee, D. S., C. R. Gilbert, C. H. Hocutt, and R. E. Jenkins. 1980. Atlas of North American Freshwater Fishes (Publication of the North Carolina Biological Survey). Patricia Ledlie Bookseller Inc., Buckfield, ME. 854 pp.
Lembi, C. A., B. G. Ritenour, E. C. Iverson, and E. C. Forss. 1978. The effects of vegetation removal by grass carp on water chemistry and phytoplankton in Indiana ponds. Transactions of the American Fisheries Society 107:161-171.
Leslie, A. J., L. E. Nall, and J. M. Van Dyke. 1983. Effects of vegetation control by grass carp on selected water-quality variables in four Florida lakes. Transactions of the American Fisheries Society 112:777-787.
Madsen, J. D. 1999. Point intercept and line intercept methods for aquatic plant management. Aquatic plant control technical note MI-02. Army Engineer Waterways Experiment Station, Vicksburg, MS. 16 pp.
McComas, J. 1993. Lake Smarts: The First Lake Maintenance Handbook. Terrene Institute, Alexandria, VA.
Mitchell, A. J., and A. M. Kelly. 2006. The public sector role in the establishment of grass carp in the United States. Fisheries 31(3):113-121.
Mitzner, L. 1977. Evaluation of biological control of nuisance aquatic vegetation by white amur. Federal Aid to Fish Restoration Completion Report, Iowa Conservation, Fisheries Section, Des Moines, IA. 43 pp.
Mitzner, L. 1978. Evaluation of biological control of nuisance aquatic vegetation by grass carp. Transactions of the American Fisheries Society 107:135-145.
Moore, L., and K. Thorton. 1988. Lake and Reservoir Restoration Guidance Manual. North American Lake Management Society, Madison, WI.
Paukert, C. P., and D. W. Willis. 2002. Seasonal and diel habitat selection by bluegills in a shallow natural lake. Transactions of the American Fisheries Society 131:1131-1139.
Pothoven, S. A., and B. Vondracek. 1999. Effects of vegetation removal on bluegill and largemouth bass in two Minnesota lakes. North American Journal of Fisheries Management 19:748-757.
Savino, J. F., and R. A. Stein. 1982. Predator-prey interaction between largemouth bass and bluegills as influenced by simulated submersed vegetation. Transactions of the American Fisheries Society 111:255-266.
Trebitz, A., S. Carpenter, P. Cunnningham, B. Johnson, R. Lillie, D. Marshall, T. Martin, R. Narf, T. Pellet, S. Stewart, C. Storlie, and J. Unmuth. 1997. A model of bluegill-largemouth bass interactions in relation to aquatic vegetation and its management. Ecological Modeling 94:139-156.
Wetzel, R. G. 1983. Limnology. Sanders College Publishing, Philadelphia, PA. 767 pp.

Table.1. History of grass carp (GC) and aquatic vegetation management in Iowa BMPs study lakes.
W:L= Watershed to Lake Area ratio

Lake	W:L	Mean Depth (m)	Water Quality Rating	Lake Size (ha)	GC Stocking History	GC/ha	Management History	Estimated % Vegetation
Mormon Trail	11.35	4.207	Good	32.28	350 8" fish stocked in 1980. 50 fish removed in 2000 and 2001.	23.2	Beach with herbicide or mechanical removal starting 2003. Cattails treated 2004 with herbicide.	30
Greenfield	17.89	3.082	Fair	48.41	600 8" fish in 1980, 240 8" fish in 1982, and 240 8" fish in 1994	55.6	Copper sulfate treatment done by City. Lake is a public water supply.	30
Meadow	22.69	3.109	Fair	34.60	400 9" fish in 1979, 400 4"-8" fish in 1981, and 420 fish in 1982.	86	No treatment but has a significant algae bloom annually.	5
Wapello	16.99	3.943	Good	282.51	1200 fish in 1995	9.9	Herbicide treatments for access after renovation in 1993	45
Smith	25.30	1.657	Poor	56.61	90 8" fish in 2003	4	Renovated in 2001, treat beach with herbicide.	25
Hendricks	25.97	2.353	Fair	48.02	126 8" fish stock in fall of 1997	6.4	Infested with curly leaf and suffers from low D.O. levels in winter.	40
Pleasant Creek	6.14	4.96	Good	404.43	4000 fish 1980, 4000 fish 1982, and 391 fish in 1995.	51.9	Spot treat Brittle Niad. Large algae bloom in 2005.	10
Swan	5.29	1.303	Fair	100.00	300 8" fish stocked in fall 2004	7.4	Renovated in 2004 because of common carp. Historically had vegetation.	0
Silver	6.21	1.95	Poor	39.45	None stocked after renovation 2003	0	Prior to Sonar treatment in 1993 lake contained Coontail. In 2005 sago and coontail.	15
Anita	13.05	3.770	Fair	175.22	None stocked after renovation in 2003	0	Historically had vegetation, GC socked in the 70s and 1990.	30
Ahquabi	14.88	2.989	Fair	116.86	None stocked after renovation in 1994	0	Herbicide spot treatments from 1999 to 2004. Whole lake treatment for curly leaf 2005	30
Red Haw	13.01	4.437	Fair	75.68	None stocked after renovation	0	GC stocked in the 80s, not stocked after renovation.	10
Three Fires	38.38	2.516	Poor	96.58	None Stocked after renovation 2004	0	Renovated fishery because of common carp in 2004 and lake was dredged. Historically had vegetation problems.	0