Response of Adult Largemouth Bass and Aquatic Plants to Small-scale Applications of Aquathol K in Lake Seminole, Georgia

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Abstract: We examined the effects of an aquatic herbicide (Aquathol K) applied prior to largemouth bass spawning to reduce the exotic submersed macrophyte hydrilla *(Hydrilla verticillata)* and promote establishment of native submersed plants on largemouth bass *(Micropterus salmoides)* population metrics. Density and biomass of adult (>250 mm) largemouth bass were determined between 2000 and 2003 using a catch-depletion technique in a cove that had been periodically treated with herbicides. Also, catch-per-effort for both number and weight were compared in 2002–2003 between a treated and untreated hydrilla-infested cove. In the cove where catch-depletions were conducted, herbicide applications reduced hydrilla between 2000–2003 and abundance of native plants increased. Coincident with these changes, largemouth bass density and biomass increased 50% to 120%. Over time, the size of fish captured increased in this cove, but temporal changes in relative weight were not evident. In another cove treated with herbicides, native plant abundance was maintained but did not increase, hydrilla was the dominant plant, and catch-per-effort for number and weight was about twice as great than in an untreated cove (100% hydrilla coverage). No differences in size distributions or relative weight were observed between the treated and untreated coves. The application of Aquathol K to coves 2 to 3 months prior to largemouth bass spawning and periodic treatments after spawning was associated with either neutral or positive impacts on population metrics and also resulted in maintenance or an increase in native submersed plants.

Key words: Largemouth bass, herbicides, aquatic plants, biomass

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Anglers fishing for largemouth bass *(Micropterus salmoides)* generally prefer to fish in vegetated areas and typically desire a substantial amount of vegetation in water bodies where submersed plants become established (Wilde et al. 1992, Slipke et al. 1998). However, excessive levels of submersed aquatic plants can hinder other recreational and industrial uses of water bodies, and either mechanical, biological, or chemical control methods must be used to reduce or eliminate aquatic plants. Most fishery biologists agree that some intermediate level of aquatic vegetation is desirable, not only for largemouth bass fisheries, but for other fish species and fisheries (Engel 1995, Henderson 1996, Hoyer and Canfield 2001).

Previous research on the effects of vegetation removal on adult largemouth bass populations and fisheries have primarily focused on whole water body responses to some manipulation (Bettoli et al. 1992, Bettoli et al. 1993, Maceina 1996, Wood and Dugas 2002, Sammons et al. 2003). For adult largemouth bass, very limited data have been published on the effects of small-scale or area specific vegetation reduction or removal, particularly when herbicides are used to manage excessive levels of submersed plants (Bain and Boltz 1992, Boyer 1994).

Largemouth bass anglers have been skeptical of both the short and long-term effects of aquatic herbicides on fish movement and behavior, and potential changes in habitat utilization exposed fish may display (Schupp 1997). Since the 1990s, lake managers have been attempting to replace exotic submersed macrophytes such as hydrilla *(Hydrilla verticillata)* and Eurasian milfoil *(Myriophyllum spicatum)* with native aquatic plants primarily by reducing the abundance of exotic plants with aquatic herbicides. Native plants are then planted or become reestablished via the seed bank (Smart et al. 1996). The objectives of this project were to determine if adult largemouth bass density, biomass, relative abundance, relative weight, and length-structure changed in relation to successive treatments of Aquathol K (dipotassium salt of endothall; 7-oxabicyclo[2.2.1]heptane-2,3-dicarboxylic acid) and associated changes in aquatic vegetation in small treatment coves (<10 ha) to control hydrilla.

Methods

Study Sites

Lake Seminole is a 13,158-ha impoundment of the Chattahoochee and Flint rivers. Annual water level fluctuations in this shallow reservoir (mean depth 3.0 m) are typically < 0.7 m, and provide suitable environmental conditions for submersed aquatic macrophyte colonization. From 1985 to 1997, areal coverage of submersed macrophytes (primarily hydrilla) varied from 40% to 70% (Brown and Maceina 2002) and aquatic vegetation control methods included the application of EPA approved aquatic herbicides by U. S. Army Corps of Engineers (USACE) personnel. Prior to hydrilla infestation, Lake Seminole contained a diverse native plant community (Gholson 1984). Seed banks of these plants still exist in reservoir sediments, and in many instances, herbicide applications to reduce hydrilla has resulted in recolonization of native submersed vegetation (D. Morgan, USACE, pers. commun.).

Three coves adjacent to the Chattahoochee River channel were sampled to determine adult largemouth bass (>250 mm TL) populations metrics. Ranger Cove is 3.44 ha and at the start of this project in late 1999 was covered nearly entirely with hydrilla. It was treated four times with Aquathol K (2–3 ppm) between fall 1999 and fall 2001 (Fig. 1). Fairchild Cove (5.36 ha) was designated as a treatment cove in 2002 and 2003 and Aquathol K (2–3 ppm) was applied four times between summer 2000 and fall 2002 (Fig. 2). Paramore Cove is 8.70 ha and was an untreated control cove that contained 100% hydrilla coverage in 2002 and 2003.

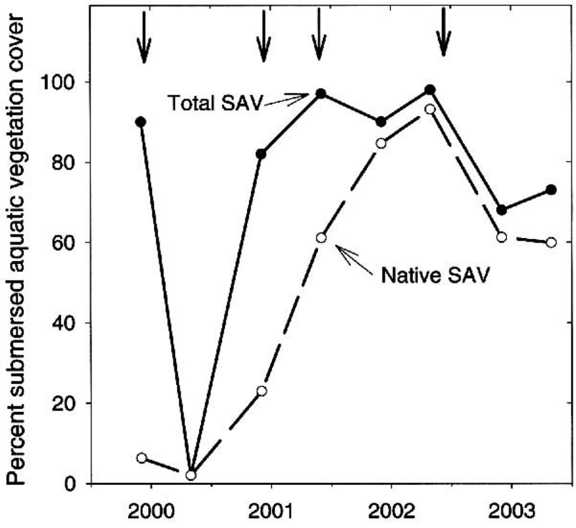

Figure 1. Total submersed aquatic vegetation (SAV) and native SAV coverages in Ranger Cove from 1999 to 2003. Bold arrows on top indicate times of Aquathol K treatments.

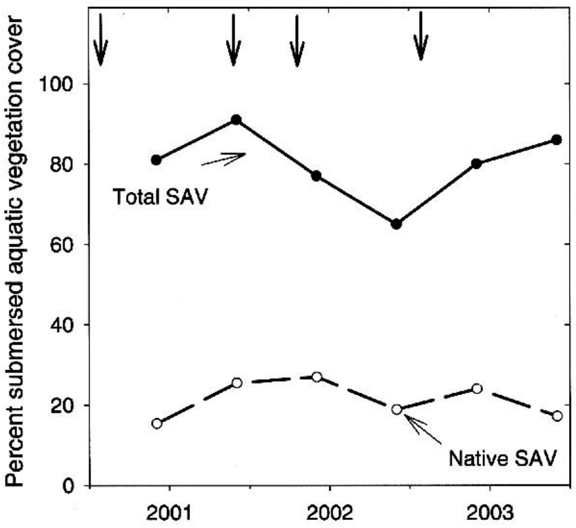

Figure 2. Total submersed aquatic vegetation (SAV) and native SAV coverages in Fairchild Cove from 2001 to 2003. Bold arrows on top indicate times of Aquathol K treatments.

Fish Collection

In late February–mid March of 2000 to 2003, prior to largemouth bass spawning (Brown and Maceina 2002), adult largemouth bass (>250 mm TL) density and biomass were estimated in Ranger Cove with a DC electrofishing catch-depletion method developed for coves (Maceina et al. 1995). Three to four passes that encompassed 1 h each of electrofishing pedal time were necessary to adequately deplete fish and thus, estimate population density. Following each pass, fish were measured (TL, mm) and weighed (1 g), then released outside the cove. A net across the cove prevented reentry. Size-selection for consecutive passes was not evident, hence biomass was estimated by multiplying density by average weight.

Fairchild and Paramore coves were too large to conduct catch-depletion estimates for density, hence catch-per-effort for both number and weight were determined. Three consecutive 15-min transects were conducted in each cove in March 2002 and 2003. Largemouth bass (>250 mm) were measured (TL mm), weighed (1 g), and given a fin clip to note if a recapture occurred during second or third collection period. Catch was computed as number per hour and weight (kg) per hour. We assumed equal catchability of fish between coves as bottom depth at transects never exceeded 2.5 m, we used DC current for collecting, and in March in Paramore Cove, hydrilla was about 0.5 to 1.0 m below the surface.

Aquatic Plants

Submersed aquatic plants were sampled in Ranger Cove twice a year from fall 1999 to spring 2003, each November and April using a recording fathometer (Maceina and Shireman 1980) and a global position system (GPS). Frequency of occurrence of plants was determined from 75 to 125 systematic locations with a plant rake and recorded with GPS. All species of plants observed for each sample were recorded. Waypoints and their associated vegetation attributes were imported into ArcView (ESRI, Redlands, California) to create vegetation cover polygons and estimate percent areal coverage. In Fairchild and Paramore coves, the same procedures were used except plant sampling in these coves was initiated in November 2001.

Data Analysis

In Ranger Cove, density and associated 95% confidence intervals were computed using maximum likelihood estimates (Seber 1982) from depletion data with the software provided by Deventer and Platts (1989). Weights of fish did not vary within a year among passes; thus, average weight each year was multiplied by density to estimate biomass. To test for differences in catch-per-effort for number and weight between Fairchild and Paramore coves, we conducted two-way log-linear analysis of variance (Kimura 1988) which partitions the variation due to year and cove. Length distributions among years in Ranger Cove and between Fairchild and Paramore coves (2002 and 2003 pooled) were compared with Wilcoxon Sign Rank tests. Relative weights (W_r) were computed using the standard weight equation (Anderson and Neumann 1996) for quality (30–38 cm) and preferred (38–51 cm) length fish and

Table 1. Density (*N*/ha) and biomass (kg/ha) of adult largemouth bass (>250 mm TL) estimated from Range Cove February–March 2000 to 2003. N_o and W_o refer to density and biomass estimates. 95% lower bound (LB) and upper bound (UB) confidence intervals are presented. Mean lengths and weights of fish collected each year are given and mean values annotated by the same letter were not significantly different ($P > 0.05$).

	Density			Biomass				
		95% CLM			95% CLM			
Year	No	LB	UB	Wo	LB	UB	TL (mm)	Weight(kg)
2000	12.2	11.1	13.3	9.5	8.7	10.4	360[b]	0.78[b]
2001	15.4	9.8	21.0	9.2	5.9	12.6	329[bc]	0.60[b]
2002	20.9	16.3	25.5	18.8	14.7	23.0	380[ab]	0.90[ab]
2003	18.3	12.4	24.2	21.2	14.4	28.1	402[a]	1.16[a]

compared among years for Ranger Cove and between Fairchild and Paramore Coves (2002 and 2003) using one-way analysis of variance (ANOVA; Student-Newman-Keuls mean separation test) and *t*-tests, respectively.

Results

Aquatic Plants

In Ranger Cove, Aquathol K treatments successfully reduced hydrilla abundance, and native submersed plants dominated by fanwort *(Cabomba caroliniana)* and to a lesser extent coontail *(Ceratophyllum demersum)* became established (Fig. 1). By late 2001, native plants dominated the flora and with the exception of spring 2000, total coverage of submersed aquatic vegetation (SAV) in the cove exceeded 60%. In Fairchild Cove, hydrilla reduction between 2001 and 2003 did not occur, total SAV coverage fluctuated between 60% and 90%, but native submersed plants, co-dominated by Illinois pondweed *(Potamogeton illinoensis)* and stonewort (*Nitella* sp.) remained established in Fairchild Cove (Fig. 2). In Paramore Cove, which was not treated with Aquathol K, hydrilla covered the entire cove (100%) from 2001 to 2003.

Largemouth Bass Population Metrics

Largemouth bass density in Ranger Cove increased from 12/ha in 2000 to 18–21/ha in 2002 and 2003 (Table 1). Lower bound 95% confidence intervals computed in 2002 and 2003 did not overlap with the density estimate from 2000, nor did upper bound confidence intervals computed for density in 2000 overlap with density estimates in 2002 and 2003 (Table 1). Similarly, biomass increased from 9–10 kg/ha in 2000–2001 to 19–21 kg/ha in 2002–2003 (Table 1). Respective lower and upper bound confidence intervals for biomass did not overlap with estimates computed in 2000–2001 and 2002–2003.

Greater biomass computed in 2002–2003 in the Ranger Cove was due in part to

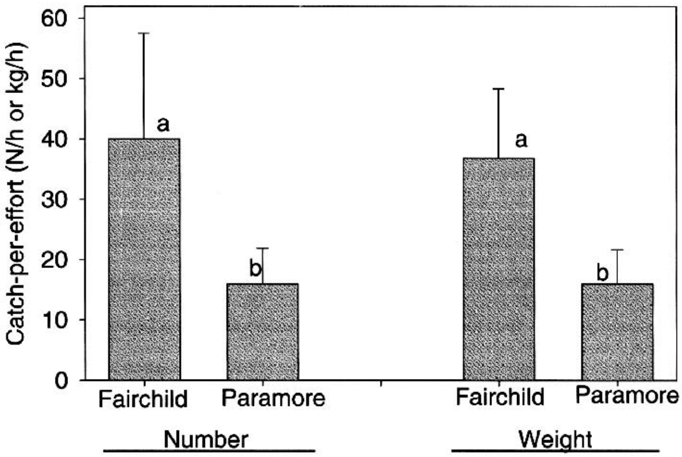

Figure 3. Mean catch-per-effort for number and weight of adult largemouth bass collected from Fairchild and Paramore coves in 2002 and 2003. Error bars indicated standard deviations, and mean values for number and weight annotated with the same letter are not statistically different ($P > 0.05$).

higher estimated densities and to larger fish collected in 2002–2003. Fish length was greater ($F = 6.71$; $P < 0.01$) in 2003 than in 2000–2001 and weight was highest ($F = 4.99$; $P < 0.01$) in 2003 compared to other years (Table 1). Wilcoxon Rank Scores also indicated length frequency distributions differed among the four years ($X^2 = 21.76$; $P < 0.01$), with the largest fish collected in 2003.

Log-linear ANOVA indicated that catch-per-effort was higher ($F > 16.5$; $P < 0.01$) for both number and weight in Fairchild Cove treated with Aquathol K than the control area, Paramore Cove (Fig. 3). Average catch for number and weight was about twice as great in Fairchild compared to Paramore. Lengths and weights of largemouth bass were similar ($F < 0.08$; $P > 0.5$) between coves for data pooled in 2002–2003. Lengths averaged 379 mm in both coves, and fish averaged 0.91 and 0.96 kg in Fairchild and Paramore coves, respectively. In addition, Wilcoxon Sign Rank test indicated no difference ($X^2 = 0.07$; $P > 0.5$) in length-frequency distributions.

In Ranger Cove, no consistent temporal trends were evident for W_r as hydrilla declined and native plants became more predominant. For quality length fish, average W_r was 95 and 96 in 2001 and 2003 respectively, and were significantly ($F = 4.25$, $P < 0.01$) greater than W_r's in 2000 and 2002 (average 88 and 89, respectively). For preferred length fish, W_r's averaged 104, 103, and 101 in 2000, 2003, and 2001, respectively, and were higher ($F = 5.19$, $P < 0.01$) than W_r's observed in 2002 (average 94).

In Fairchild and Paramore coves in 2002 and 2003, W_r's were similar ($t < 0.60$, $P > 0.3$) for both preferred and quality length fish. Quality and preferred length W_r

averaged 97 and 92 in Fairchild Cove and averaged 95 and 92 in Paramore Cove, respectively. Relative weights for preferred length fish from Ranger Cove in 2002–2003 were higher ($F = 4.76$; $P < 0.05$) than in Fairchild and Paramore coves. Relative weights for preferred length fish averaged 99, 92, and 92 in Ranger, Fairchild, and Paramore coves, respectively. No differences ($F = 2.00$; $P > 0.10$) in W_r's for quality length fish were detected among Ranger, Fairchild, and Paramore coves in 2002 and W_r's averaged 92, 97, and 95, respectively.

Discussion

Coves treated with Aquathol K were occupied by adult largemouth bass prior to spawning. We could not determine the direct effects of herbicides on largemouth bass utilization of these areas as applications were typically made in late fall, about two to three months prior to our sampling. Aquathol K has a half life of about 48 hours and is undetectable in the water column about 2–3 weeks after application (Cerexagri 2003). Aquathol K reduced hydrilla abundance in Ranger Cove, which became dominated by native submersed plants by the end of the project. Coincident with these changes, largemouth bass density and biomass increased about 50% to 120% over time.

Applications of Aquathol K did not result in a major shift in the plant community in Fairchild Cove but likely maintained the native plants that inhabited this cove. Hydrilla out-competes nearly all native aquatic plants due to its ability to photosynthesized at lower levels of light and remove available carbon from the water (Van et al. 1976). Although total SAV coverage was only slightly lower than in the untreated Paramore Cove which contained 100% coverage of hydrilla, native plants persisted and largemouth bass catch for number and weight were greater in Fairchild Cove. Relative weight or the weight:length ratio was higher for preferred length fish in Ranger Cove which had less hydrilla compared to Fairchild and Paramore coves. Clearly, applications of Aquathol K in both coves and changes in the SAV community had no detrimental effects on largemouth bass population metrics, and, in fact, increased for some metrics.

Bain and Boltz (1992) found electrofishing catch per effort, size of fish caught, and relative weight did not vary between SAV areas treated with 2,4D (2,4-dichlorophenoxyacetic acid) and control SAV areas immediately after and for 100 days after initial application. In addition, radio-tagged largemouth bass did not migrate from areas treated with herbicides as SAV coverage declined from >60% to <15% (Bain and Boltz 1992). Boyer (1994) found that largemouth bass did not vacate areas after applications of 2,4D to reduce water hyacinth *(Eichhornia crassipes)* and spraying had no short-term effect on largemouth movement or activity. In addition, recommended concentrations rates of 2,4D did not alter largemouth bass feeding behavior (Boyer 1994).

We did not determine the short-term effects of Aquathol treatments on largemouth bass habitat utilization during spawning. Aquathol K was not applied during the largemouth bass pre-spawn period because SAV abundance was typically at its lowest levels following winter, and largemouth bass generally initiate spawning in March in Lake Seminole. Bettoli and Clark (1992) found that applications of 2,4D directly on bluegill nests did not cause abandonment. In conclusion, adult largemouth bass utilized areas previously sprayed with Aquathol K. These applications were also successful at either increasing the abundance or maintaining native SAV in the two treatment coves. Largemouth bass abundance increased over time in one cove with repeated herbicide treatments which coincided with greater abundance of native plants and was also greater in another cove that had been treated with Aquathol K compared to an untreated hydrilla infested cove.

Acknowledgments

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Literature Cited

Anderson, R. O. and R. M. Neumann. 1996. Length, weight, and associated structural indices. Pages 447–481 *in* B. R. Murphy and D. W. Willis, editors. Fisheries Techniques. American Fisheries Society, Bethesda, Maryland.

Bain, M. B. and S. E. Boltz. 1992. Effect of aquatic plant control on the microdistribution and population characteristics of largemouth bass. Transactions of the American Fisheries Society 121:94–103.

Bettoli, P. W., and P. W. Clark. 1992. Behavior of sunfish exposed to herbicides: A field study. Environmental Toxicology and Chemistry 11:1461–1467.

______, 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.

______, ______, ______, and ______. 1993. Response of a reservoir fish community to aquatic vegetation removal. North American Journal of Fisheries Management 13:110–124.

Boyer, M. G. 1994. Effect of 2,4D amine on the movement and feeding behavior of largemouth bass. M.S. Thesis, University of Florida, Gainesville.

Brown, S. J. and M. J. Maceina. 2002. The influence of disparate levels of submersed aquatic vegetation on largemouth bass population characteristics in a Georgia reservoir. Journal of Aquatic Plant Management 40:28–35.

Cerexagri Inc. 2003. Product label manual (users manual and guide for pesticide use). King of Prussia, Pennsylvania.

Deventer, J. S. and W. S. Platts. 1989. Microcomputer software system for generating population statistics from electrofishing data-user's guide for Microfish 3.0. General Technical Report INT-254, U. S. Forest Service, Ogden, Utah.

Engel, S. 1995. Eurasian watermilfoil as a fishery management tool. Fisheries 20(3):20–26.

Gholson, A. K., Jr. 1984. History of aquatic weeds in Lake Seminole. Aquatics 6(3):21–22.

Henderson, J. E. 1996. Management of nonnative aquatic vegetation in large impoundments: Balancing preferences and economic values of angling and nonangling groups. American Fisheries Society Symposium 16:373–381.

Hoyer, M. V. and D. E. Canfield, Jr. 2001. Aquatic vegetation and fisheries management. Lakeline 21(3):20–22

Kimura, D. L. 1988. Analyzing relative abundance indices with log-linear models. North American Journal of Fisheries Management 8:175–180.

Maceina, M. J. 1996. Largemouth bass abundance and aquatic vegetation in Florida lakes: An alternative interpretation. Journal of Aquatic Plant Management 34:43–47.

______ and J. V. Shireman. 1980. The use of a recording fathometer for determination of distribution and biomass of hydrilla. Journal of Aquatic Plant Management 18:34–39.

______, W. B. Wrenn, and D. R. Lowery. 1995. Estimating harvestable largemouth bass abundance in a reservoir with an electrofishing catch depletion technique. North American Journal of Fisheries Management 15:103–109.

Sammons, S. M., M. J. Maceina, and D. G. Partridge. 2003. Changes in behavior, movement, and home ranges of largemouth bass following large-scale hydrilla removal in Lake Seminole, Georgia. Journal of Aquatic Plant Management 41:31–38.

Schupp, B. 1997. Lake Seminole: agonizing over hydrilla control proposals. B.A.S.S. Times 27(8):51.

Seber, G. A. 1982. The estimation of animal abundance and related parameters, 2nd edition. McMillian Publishing Inc., New York.

Slipke, J. W., M. J. Maceina, J. M. Grizzle. 1998. Analysis of the recreational fishery and angler attitudes toward hydrilla in Lake Seminole, a southeastern reservoir. Journal of Aquatic Plant Management 36:101–107.

Smart, R. M., R. B. Doyle, J. D. Madsen, G. O. Dick. 1996. Establishing native submersed aquatic plant communities for fish habitat. American Fisheries Society Symposium 16:347–356.

Van, T. K., W. T. Haller, and G. Bowes. 1976. Comparison of photosynthetic characteristics of three submersed plants. Plant Physiology 58:761–768.

Wilde, G. R., R. K. Richers, J. Johnson. 1992. Angler attitudes toward control of freshwater vegetation. Journal of Aquatic Plant Management 30:77–79.

Wood, M. G. and C. N. Dugas. 2002. Effects of aquatic vegetation removal on the trophy bass fishery of Caney Creek Reservoir. Proceedings of the Southeastern Association Fish and Wildlife Agencies 54:18–27.