J. Aquat. Plant Manage. 23: 59-63

Effects of Harvesting on Aquatic Vegetation and Juvenile Fish Populations at Saratoga Lake, New York

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ABSTRACT

Mechanical harvesting conducted in June and August of 1981 and 1982 only reduced total plant biomass initially, relative to control areas. Regrowth of the predominant species, Eurasian watermilfoil (*Myriophyllum spicatum* L.), reached pre-harvest levels within 30 days after both June and August harvestings. Total plant biomass in harvested areas peaked later than control area vegetation both years. The ratio of the average annual biomass of the harvested area to the control area was the same both years (0.73), despite significant decreases in overall average total plant biomass in 1982. The harvesting operation removed primarily bluegill sunfish (*Lepomis macrochirus*) and to a lesser degree, largemouth bass (*Micropterus salmoides*), yellow perch (*Perca flavescens*) and pumpkinseed sunfish (*Lepomis gibbosus*). Harvesting effectively removed approximately 3% of the total standing crop of juvenile fish in both June 1981 and 1982, and approximately 2 to 8% in August of both years.

Key words: macrophytes, harvesting, *Myriophyllum, Lepomis, Micropterus.*

INTRODUCTION

The short-term effectiveness of aquatic vegetation removal by harvesting has been well documented (10, 13, 14). The immediate effect of harvesting is to reduce recreational use impairment by creating access lanes to lake areas where vegetation is less dense, to create open areas where anglers' access to sport fish is improved, and to create open shoreline areas for swimming. Additionally, when all other controllable sources of nutrient input are reduced, the removal of vegetation could have a positive effect on the total nutrient pool available for vegetative production. However, the results of several studies on the latter theory have been variable (13)[2]. While the total reduction in nutrient availability may be insignificant in many cases, the plant biomass reductions observed during subsequent growth periods were significant, and may be related to sediment/plant nutrient interactions (2, 6, 12, 9, 5, 4).

The objectives of this study were to investigate the effectiveness of mechanical harvesting, commonly used to control nuisance aquatic vegetation and to document the effects of this technique on the juvenile fish populations associated with the nuisance vegetation.

MATERIALS AND METHODS

This study was conducted in Saratoga Lake approximately 48 km north of Albany, New York, in central Saratoga County. It is a dimictic lake 1630 ha in surface area with a mean depth of 8 m. However, over 25% of the surface area is less than 3 m deep. High developmental pressure and recreational use in the 1960's to 1970's have resulted in degraded water quality and impairment of all recreational uses. Municipal wastewater treatment plant effluents were diverted from the watershed in 1977. Since then, water quality, measured by nutrient levels, Secchi depth and chlorophyll *a* concentrations have improved significantly[3]. Concurrently, two species of rooted macrophytes, Eurasian watermilfoil (*Myriophyllum spicatum* L.) and curly-leaf pondweed (*Potamogeton crispus* L.), have shown dramatic increases in areal and depth distribution. In 1982, the entire lake surface area to the 4 m contour was impacted. While sport fishing for walleye (*Stizostedion vitreum*), northern pike (*Esox lucius*) and bass (*Micropterus salmoides* and *Micropterus dolomieui*), is still excellent, all recreational uses at Saratoga Lake have been severely impaired[4].

An area on the northwest side of Saratoga Lake, Manning's Cove, was chosen for the study. A transect was harvested in early June and early August of 1981 (Table 1). The size of the area was 48 m by 3 m. The transect was cut in the 1 to 2 m depths, using a commercial barge-type mechanical harvester (Aquamarine, Inc.). The harvester had a cutting bar 1.2 m wide and 1.5 m long and a maximum cutting depth of 1.5 m. In August, half of the site was reharvested as well as another transect of similar dimensions in an adjacent area that had not been harvested in June. In 1982, harvesting was again conducted in Mannings's Cove in early June and again in early August. In August 1982, half of the June plot was reharvested and another adjacent plot was harvested for the first time. Depths of the harvested plots were the same in 1982 as 1981.

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[2]Bedrosian, A. J. 1982. The evaluation of macrophyte harvesting at Lake Noquebay, Wisconsin, for the period of May thru December 1981. Wisc. Dept. Natural Resources Rept.

[3]Hardt, F. W., G. Hodgson and G. F. Mikol. 1983. Saratoga Lake diagnostic-feasibility study and management plan. Clean Lakes Program Phase I Report to U.S.E.P.A., 236 p.

[4]Mikol, G. F. 1982. New York State lake classification and inventory annual report. NYSDEC Bureau of Water Research Rept., Albany, NY, 159 p.

TABLE 1. AQUATIC VEGETATION HARVESTING COMPARISONS FOR 1981 AND 1982 TRANSECTS.

	COLLECTION DATES			
	6/13/81	8/21/81	6/7-8/82	8/13/82
Area harvested (ha)	0.031	0.023	0.20	0.175
Total wet weight removed (kg)	201	105	1228	1600
Total dry[1] weight removed (kg)	34	18	208	272

[1]Approximate; based on average of 17% dry weight/wet weight of oven dried sub-samples.

The effect of harvesting on juvenile fish was determined by counting, identifying and determining the year class of fish found in the plants harvested by the barge in June and in August of both 1981 and 1982. By enclosing a control plot of similar plant populations and depth, an estimate of the standing crop of fish was determined. The enclosed area was seined consecutively, and the population was estimated by the removal method (19). The enclosure was set up just prior to each collection. A 30.3 m x 1.2 m x 6.3 mm mesh seine was used as the enclosure wall, to enclose an area 57.8 m^2. the seine used was 7.6 m x 1.2 m x 6.3 mm mesh. The enclosure was seined until no fish were collected in two consecutive seinings. Four fish standing crop estimates were made in June, July, and August 1981 while three were made in May, June, and August of 1982.

The change in species composition of the vegetation during the growing season and biomass levels were determined at the harvested areas by randomly harvesting three to four 0.25 m^2 quadrat samples in adjacent, unharvested areas at approximately the same depths. Quadrat collections were made approximately every 19 days from the time of harvesting by SCUBA or raking within a quadrat sampler. The dry weight biomass for individual plant species collected was then determined by oven drying the samples for at least 48 hours at 70 C.

The reinfestation rate of vegetation after harvesting was determined by randomly sampling four 0.25 m^2 plots in harvested areas. The reinfestation was determined by comparing total biomass (dry weight) and species composition in the harvested areas with the unharvested areas.

RESULTS AND DISCUSSION

In 1981, the entire surface area of the study area was uniformly covered by macrophyte growth. Eurasian watermilfoil predominated, however, a band of curly-leaf pondweed reached the surface just outside the Eurasian watermilfoil affected area in approximately 4 meters of water. Approximately half the surface area of the site was harvested again in August 1981, despite the fact that the entire transect had returned to pre-harvesting levels of macrophyte densities. However, Eurasian watermilfoil at the 1981 site did not regrow to the water surface in approximately half of the transect (1.5 to 2.0 meters deep).

Harvesting in 1982 was accomplished on similar dates as in 1981. Areas harvested in 1982 were approximately six to ten times larger than in 1981. Harvesting efficiencies were lower in 1982. This could be due to the additional time required to more effectively remove plants within the plots or may be related to the actual reduced plant biomass levels noted lakewide in 1982.

The direct effects of harvesting on juvenile fish populations in the study area were different in 1981 and 1982. Only bluegill sunfish juveniles (young-of-the-year) were removed by the harvester in 1981. On June 13, 1981, the harvester removed only 44 juvenile bluegills from the transect during normal operation (Table 2).

Similar low numbers of juvenile bluegills were removed during harvesting on August 21, 1981. The 1981 harvesting operations would have removed approximately 1000 to 1400 juvenile bluegills per hectare. The fish standing crop estimates from June and August 1981 were approximately 42,000 to 44,000 juvenile fish per hectare. The estimates are similar to those determined by Haller *et al.* (11) for bluegills utilizing *Hydrilla verticillata* R. beds in Orange Lake, Florida and for total fish standing crop estimates made by Wile and Hitchin[5] for an Ontario, Canada lake infested with *Myriophyllum spicatum* L. Based on these numbers, 1981 harvesting removed approximately 2.6 to 3.4% of the total fish standing crop in this area. Bluegills comprised approximately 94% of the total standing crop in June and approximately 90% in August. Two distinct size ranges of this species were evident in June 1981 and three distinct size ranges were noted in the August 1981 collections and is probably due to multiple spawnings in the area. Largemouth bass were the next most prevalent species collected. Other fish species collected during the juvenile standing crop estimates included Northern pike, pumpkinseed sunfish, yellow perch and black crappie (*Pomoxis nigromaculatus*).

Fish removed by harvesting vegetation in June 1982 were similar to those of June 1981, despite the fact that the area harvested in 1982 was greater than the surface area harvested in 1981. Bluegill juveniles were again the predominant species collected during standing crop estimates (95 to 99%) and removed by the harvester (93 to 95%). The number of fish colleted extrapolates to standing

TABLE 2. SUMMARY OF DIRECT EFFECTS OF 1981 MECHANICAL HARVESTING ON JUVENILE BLUEGILL SUNFISH (*Lepomis machrochirus*) POPULATIONS.

	COLLECTION DATES	
	6/13/81	8/21/81
# Fish removed	44	26
# Fish removed/ha	1419	1130
Fish standing crop estimate (#/ha)	41,506	43,917
% Standing crop removed	3.4	2.6

[5]Wile, I. and G. Hitchin. 1977. An assessment of the practical and environmental implications of mechanical harvesting of aquatic vegetation in southern Chemung Lake. Ont. Ministry of the Envir., 180 pp.

TABLE 3. SUMMARY OF DIRECT EFFECTS OF 1982 MECHANICAL HARVESTING ON JUVENILE FISH POPULATIONS.

	COLLECTION DATES		
	6/7-8/82	8/13/82[1]	
		Site #1	Site #2
Total # fish removed	194	371	276
Total # bluegills removed	184	172	175
#fish removed/ha	970	7420	2226
# bluegills removed/ha	920	3440	1411
Fish standing crop estimate (#/ha)	38,954	95,411	
Bluegill standing crop estimate (#/ha)	36,530	73,883	
% standing crop (total) removed	2.5	7.8	2.3
% standing crop (bluegills) removed	2.5	4.7	1.9

[1]Site #1 was previously harvested in June 1982; Site #2 was previously unharvested.

TABLE 4. SUMMARY OF DIRET EFFECTS OF 1982 MECHANICAL HARVESTING ON JUVENILE LARGEMOUTH BASS (*Micropterus salmoides*).

	COLLECTION DATE 8/13/82[1]		
	Site #1	Site #2	Combined
Total # fish removed	11	7	18
# fish removed/ha	220	56	103
Fish standing crop estimate (#/ha)	1,894	1,894	1,894
% standing crop removed	11.6	3.0	5.4

[1]Site #1 was previously harvested in June 1982. Site #2 was previously unharvested.

crop estimate of approximately 39,000 juvenile file per hectare and 37,000 bluegill juveniles per hectare (Table 3). Other species collected in 1982 included pumpkinseed sunfish, yellow perch, chain pickerel (*E. niger*) and Central mudminnow (*Umbra limi*). No largemouth bass were collected or removed by harvesting in May or June 1982 while they comprised 4% of similar collections in 1981. The percentage of the standing crop of juvenile fish that were removed by harvesting in June 1982 was approximately 2.5%.

In August of 1982, different numbers and species of juvenile fish were collected during standing crop estimates as well as during harvesting operations. The numbers of juvenile bluegills dropped to 77% of the standing crop estimates while yellow perch increased to almost 20%. Largemouth bass were first collected in 1982 during this period and comprised 2% of the total estimate. The percentages of other species collected included pumpkinseed sunfish (< 1%), brown bullhead (*Ictalurus nebulosus*) (< 1%) and unidentified minnows (*Notropis*) (< 1%). The large increase in numbers of yellow perch collected raised the total standing crop estimate to over 95,000 juvenile fish per hectare while bluegills were also higher than the June estimates (73,883). This total estimate could be high because of a temporary influx of yellow perch into the area. This is supported by the fact that the harvester did not remove similarly high numbers of yellow perch 13 days earlier. Significantly higher numbers of bluegills were collected and harvested in August than in June 1982. The August data relate a 4.7% standing crop removal rate by harvesting for bluegills and a 7.8% removal rate of total juvenile fish. These data are for a site that had been previously harvested in June 1982. Similar evaluation of largemouth bass data indicate approximately 5% of that population was removed by harvesting in August (Table 4).

The direct effect on fish of the removal of aquatic vegetation has been studied only recently[5] (11, 17). Investigations by Haller *et al.* (11) determined that as high as 32% of the standing crop estimates were affected by harvesting operations in a hydrilla infested Florida lake. However, when considering just the bluegill population examined in that study, 14% had been removed by harvesting and 1% of the largemouth bass population was affected.

A Saratoga Lake, approximately 4% of the total juvenile population was affected in the experimental harvesting conducted for this study. This rate is the average of the two harvestings in 1981 and 1982. The Florida and New York studies are not comparable in many ways (numbers of fish species, plant species, areas harvested, growing season, etc.), however, the numbers of bluegills and largemouth bass estimated in standing crops by Haller *et al.* (11) were very similar to those found here, as was the removal of mostly juvenile fish.

Previous studies on bass/bluegill interactions (7), the effects of vegetation densities on bass predation (15), and the information collected for this study seem to indicate that at the removal rates observed, the largemouth bass and bluegill populations would not be adversely effected by harvesting at Saratoga Lake. In fact, harvesting could possibly improve *Centrarchid* populations in certain situations.

Annual comparisons of total average biomass (g/m^2, dry) for the major plant species yielded wide ranges of values. Eurasian watermilfoil averaged 271.8 g/m^2 in 1981 and 103.8 g/m^2 in 1982. The data reflected standard deviations of ± 205.8 and ± 82.5 g/m^2, respectively, however. The large range of biomass values was noted for curly-leaf pondweed, wild celery and coontail as well. This was probably a result of seasonal variations in individual species. The total annual average biomass estimates were 105.1 g/m^2 for 1981 and 41.8 g/m^2 for 1982 in the study area. Standard deviations for these data were ± 167.4 and ± 79.6, respectively.

Seasonal growth patterns and regrowth after harvesting are presented for 1981 and 1982 in Figures 1 and 2. In 1981, peak biomass occurred in July in the control transect and declined steadily through September before leveling off in late October and November. Significant differences between the late June control transect samples and the harvested samples were apparent (t , $p < 0.05$). Average total plant and Eurasian watermilfoil biomass estimates in the harvested area increased steadily through late August and peaked at that time. Regrowth to pre-harvest levels had occurred in less than 30 days. Eurasian watermil-

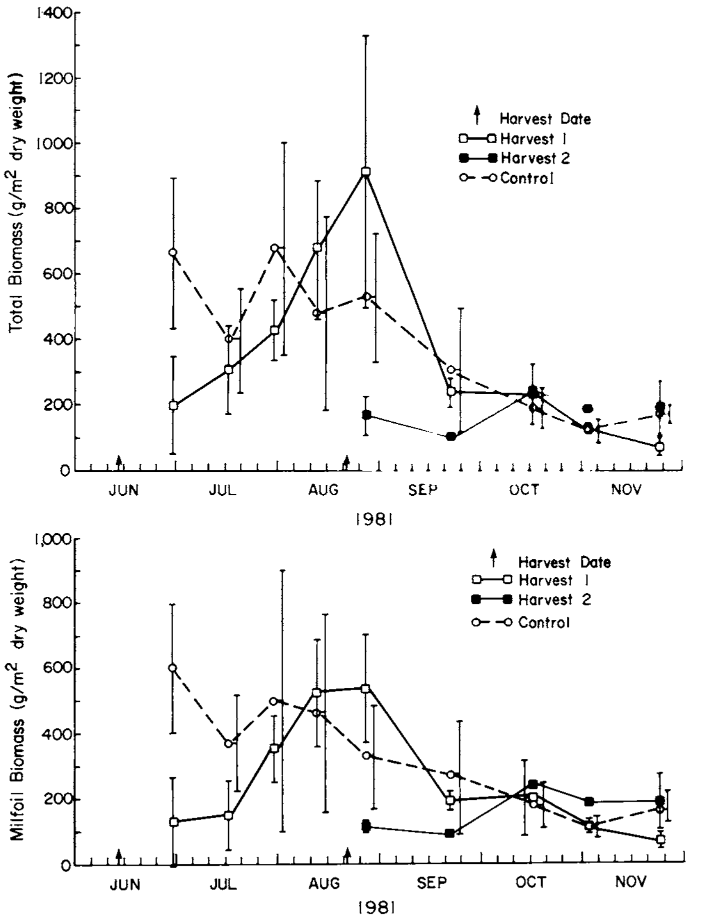

Figure 1. Total and Eurasian watermilfoil biomass (g/m^2, dry) estimates for harvested and control transects in 1981 (bracket = 1 std. dev.).

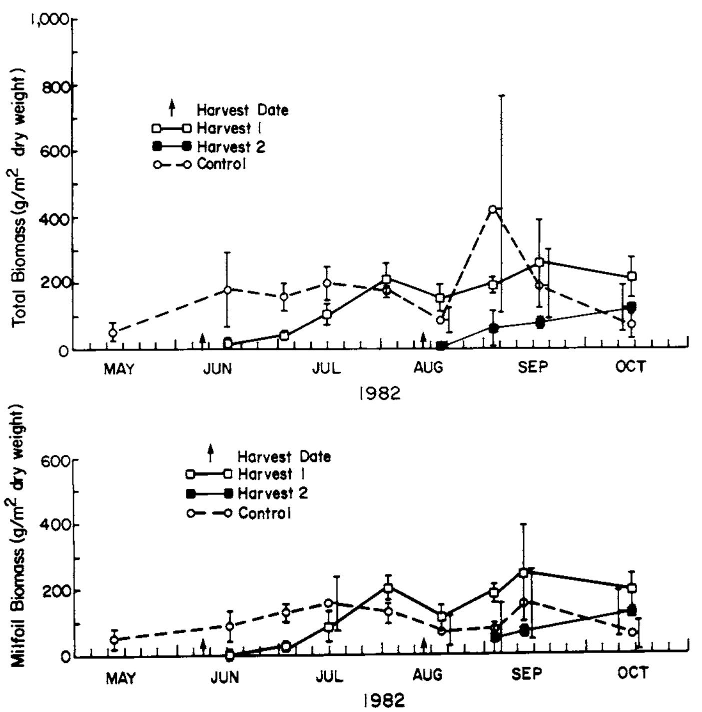

Figure 2. Total and Eurasian watermilfoil biomass (g/m^2, dry) estimates for harvested and control transects in 1982 (bracket = 1 std. dev.).

foil and total plant biomass in the area harvested in August declined to similar levels as the first harvest had produced. Biomass levels in the area harvested twice in 1981 remained significantly lower (t , $p < 0.05$) than the August harvest date until October 1981 when regrowth had brought this area up to levels not significantly different from the control transect or the area harvested once in June.

Much less variability in the data was observed during the 1982 collections. Biomass levels were lower in May than October of the previous year, indicating a slight decrease in biomass over the winter. Total levels remained fairly low the entire season with peak growth in July, as in 1981. The mean biomass levels were near zero one week after June harvesting and were still very low three weeks later. In 1981, total plant biomass levels were approximately 100 g/m^2 two weeks after harvesting in June. Regrowth after harvesting occurred similarly to 1981. Biomass in the harvested transect was not significantly different (t , $p < 0.05$) than in the control area after approximately 30 days. By early August, Eurasian watermilfoil biomass in the harvested transect had surpassed the control transect levels. In fact, they remained higher than in the control area through October. These differences were not always significant on every sampling date, however the differences in the two areas could be indicative of a trend. In both years, regrowth of Eurasian watermilfoil in the harvested areas was to the water surface in 0.7 to 1.2 meter depths after approximately 30 days. However, in the 1.2 to 1.8 meter depths, this species reached the surface after 45 to 48 days. Regrowth in the area harvested twice also followed a similar pattern in 1982 as in 1981. Sample sizes were smaller, however, a general increase in biomass was observed from August (harvest date) to October 1982. Biomass levels were again dropped to near zero during the harvesting but had increased to control levels in approximately 30 days after harvest.

Annual total biomass statistics for the control and harvested areas are shown in Table 5 for 1981 and 1982. The decrease in overall total biomass from 1981 to 1982 is apparent from these data. The average annual total biomass was significantly lower (t , $p < 0.01$) in 1982 than in 1981 and were comparable to those reported for other eutrophic waters (12). Average unharvested area biomass levels in 1981 were 2.5 times higher than the levels observed in 1982 and were similar to data reported for other North American lakes with severe Eurasian watermilfoil investations (1, 8). The figures for the areas harvested once show similar differences, while the area harvested twice in 1981 was over three times the levels for similar areas in

Table 5. Total mean annual average biomass (g/m^2, dry) comparisons of harvested and unharvested transects in 1981 and 1982 (standard deviation).

Transect	1981	1982
Control	122.6 (192.4)	49.5 (90.0)
Harvested once	89.0 (146.6)	36.1 (72.0)
Harvested twice	102.6 (87.5)	31.9 (58.6)

1982. A small sample size in 1981 may be the reason for this discrepancy. Of interest in the current study is the ratio of the average annual biomass of the area harvested once, to the biomass of the control area. This ratio is the same for both years (0.73). These data seem to indicate that at least superficially, on an annual basis, the experimental harvesting effected a similar plant biomass reduction in 1981 and 1982.

Harvesting reduced the total plant biomass significantly for a relatively short period of time when performed in June. A slightly larger reduction was effected when harvesting was done in August. This is consistent with reported effects of later season harvesting by Wile and Hitchin[6]. The effect may involve a reduction of plant nutrients at a time when levels are highest (9). Harvesting did not, increase plant biomass levels after regrowth following control. Additionally, multiple harvesting shows some promise for increasing the possibility of longer term control. Nichols and Cottam (14) found that a single harvest reduced growth by 50%, two harvests reduced it 75% and three almost eliminated the vegetation for one year. Wile and Hitchin[6] also determined single harvests to be least effective, while three harvests were most effective. In the current study, harvesting areas twice was done on a small scale and did not produce the expected reductions. Eurasian watermilfoil, however, never grew back to the water surface, despite normal densities in an area harvested twice in 1981. This could be due to the depth above the sediment the plants were cut[5]. The more effective control observed in this study correlates with the hypothesis that the depths where "better" control was observed in 1.5 to 2.0 meters deep. The harvester should have effectively removed most of the leafy portions of the plants at those depths. Light intensity has been shown to be an important factor influencing the depth and extent of macrophytes (16, 3, 18). It is not felt to be the limiting factor in this case however, because of the relatively shallow nature of the study area.

ACKNOWLEDGEMENTS

The author would like to thank Sharon Hotaling for preparation of the manuscript and Denise Polsinelli for data collection, summarization, and graphics.

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