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Fish Harvest Resulting From Mechanical Control of Hydrilla[1]

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Abstract

Mechanical harvesting of the submersed weed hydrilla, *Hydrilla verticillata* (L.F.) Royle, in Orange Lake, Florida entangled fish in the cut vegetation resulting in their disposal with the weeds on shore. Three block-net samples in dense hydrilla indicated fish standing crops (mean ± SD) of 205,000 ± 35,000 fish/hectare and 460 ± 30 kg/hectare. The estimated loss of fish to mechanical harvesting represented 32% of fish numbers and 18% of fish biomass. Fish most susceptible to mechanical removal with hydrilla were juvenile sportfish and smaller species. The monetary replacement value of the fish lost was estimated at over $6,000/hectare.

The exotic submersed aquatic plant hydrilla, *Hydrilla verticillata* (L.F.) Royle, has spread in the past 20 years into nearly every area of Florida and into several other states. Hydrilla forms a dense, entangled surface mat and rapidly dominates the native aquatic flora (Haller and Sutton 1975). In 1977, an estimated 9.1 million dollars were spent in Florida for hydrilla control programs (Haller 1979). Hydrilla is usually controlled with herbicides, but mechanical means are being used more frequently.

The majority of research on mechanical harvesting of aquatic weeds has involved engineering design and cost efficiency estimates (Bryant 1970; Koegel et al. 1977; Johnson and Bagwell 1979). Recent studies have evaluated the effects of mechanical harvesting on the nutrient budgets and water quality of Lakes (Wile 1978).

Orange Lake is a shallow (mean depth = 3 m) 5,000 hectare lake 30 km south of Gainesville, Florida. Before hydrilla was introduced in 1971, the predominant littoral plants were species of *Nuphar*, *Ceratophyllum*, and *Cabomba*. Low water levels from 1974 through 1978 favored the expansion of hydrilla, which covered 90% of the lake by the summer of 1977.

Methods

The mechanical harvesting operation utilized a harvester for cutting and picking up vegetation, a transporter for moving the vegetation to shore, and a shore conveyer which elevated the vegetation from the transporter to a dump truck.

In September 1977, three swaths 2.3 m wide, 1.5 m deep, 94, 102, and 230 m long, were harvested from an undisturbed hydrilla bed 500 m from shore in waters between 1.5 and 2 m deep. The harvester operated at 3–4 km/hour. After each swath was harvested, the vegetation was loaded onto the transporter and conveyed on shore into a dump truck. The vegetation from each load was weighed with a tared truck on truck scales, dumped, and hand-sorted for separation of fish. Fish were placed on ice and later separated into species and size classes, which were counted and weighed.

A population estimate of the fish in unharvested hydrilla was determined from three 0.08-hectare block-net samples. Nets were set in 1.5–2 m deep, undisturbed stands of hydrilla (similar to the harvested sites), and the lead lines were pushed into the sediment. Approximately 300 live fish, common to the lake, were captured by electrofishing, marked by fin clip, and released into each block net to determine recovery rates. Rotenone (2 mg/liter) was uniformly applied inside the nets through the vegetation with outboard motors. All fish coming to the surface were picked up over a 3-day period.

Results and Discussion

The block-net samples contained 20 species, of which sunfish made up 52% of the fish numbers and 57% of fish biomass (Table 1). The population estimate (210,000 fish weighing 460 kg/hectare) is similar to other fish population

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TABLE 1.—*Standing fish crops from block-net samples in hydrilla beds and quantities of fish lost during mechanical hydrilla harvesting in Orange Lake, Florida. Species are listed in the order of their numerical abundance in block-net samples.*

Species	Number/hectare ± SD (% of total)		Weight (kg)/hectare ± SD (% of total)		Percent fish lost to hydrilla harvest	
	Block-net samples	Harvested samples	Block-net samples	Harvested samples	Number	Weight
Bluegill *Lepomis macrochirus*	43,000 ± 15,000 (21)	9,200 ± 400 (14)	110 ± 23 (24)	21 ± 4 (25)	21	19
Warmouth *Lepomis gulosus*	36,000 ± 9,800 (18)	7,100 ± 1,200 (11)	96 ± 7.5 (21)	18 ± 5 (21)	20	19
Bluefin killifish *Lucania goodei*	36,000 ± 14,000 (18)	32,000 ± 3,000 (49)	7.5 ± 2.9 (2)	4.6 ± 0.4 (5)	89	61
Redear sunfish *Lepomis microlophus*	27,000 ± 10,000 (13)	6,000 ± 600 (14)	53 ± 15 (12)	12 ± 8 (15)	22	23
Golden shiner *Notemigonus crysoleucas*	25,000 ± 8,000 (12)	1,800 ± 500 (3)	56 ± 16 (12)	3.4 ± 1.5 (4)	7	6
Black crappie *Pomoxis nigromaculatus*	15,000 ± 7,700 (7)	3,600 ± 1,000 (6)	24 ± 12 (5)	5.7 ± 1.5 (7)	24	23
Swamp darter *Etheostoma fusiforme*	9,700 ± 5,600 (5)	2,100 ± 400 (3)	3.2 ± 1.9 (1)	0.6 ± 0.1 (<1)	22	19
Bluespotted sunfish *Enneacanthus gloriosus*	4,000 ± 4,500 (2)	800 ± 500 (1)	5.5 ± 5.7 (1)	0.9 ± 0.4 (1)	20	17
Mosquitofish *Gambusia affinis*	3,500 ± 1,100 (2)	1,800 ± 700 (3)	0.9 ± 0.3 (<1)	0.2 ± 0.1 (<1)	51	22
Taillight shiner *Notropis maculatus*	1,400 ± 1,300 (1)	20 ± 30 (<1)	0.9 ± 0.9 (<1)	<0.01	1	10
Brook silverside *Labidesthes sicculus*	1,200 ± 800 (1)	80 ± 60 (<1)	0.9 ± 0.5 (<1)	<0.1	7	
Golden topminnow *Fundulus chrysotus*	1,200 ± 900 (1)	500 ± 100 (1)	1.1 ± 0.6 (<1)	0.2 ± 0.1	42	18
Largemouth bass *Micropterus salmoides*	1,000 ± 200 (1)	300 ± 100 (1)	12 ± 0.4 (3)	2.5 ± 0.4 (3)	30	21
Lake chubsucker *Erimyzon sucetta*	300 ± 200 (<1)	100 ± 100 (<1)	30 ± 12 (7)	1.2 ± 1.0 (1)	33	4
Brown bullhead *Ictalurus nebulosus*	200 ± 300 (<1)	30 ± 20 (<1)	5.5 ± 9.1 (1)	0.4 (<1)	15	8
Chain pickerel *Esox niger*	200 ± 100 (<1)	50 ± 50 (<1)	30 ± 11 (6)	2.8 (3)	25	9
Gizzard shad *Dorosoma cepedianum*	100 ± 200 (<1)	0	0.4 ± 0.6 (<1)	0	0	0
Florida gar *Lepisosteus platyrhincus*	40 ± 20 (<1)	30 ± 20 (<1)	23 ± 17 (5)	11 ± 5 (12)	75	48
Dollar sunfish *Lepomis marginatus*	30 ± 60 (<1)	40 ± 75 (<1)	0.1 ± 0.1 (<1)	0.1 (<1)	133	100
American eel *Anguilla rostrata*	4 ± 7 (<1)	0	2.2 ± 5.7 (<1)	0	0	0
All species	205,000 ± 55,000	66,000 ± 2,000	460 ± 30	85 ± 19	32	18
Total sportfish	122,000 ± 19,000 (60)	26,000 ± 3,000 (39)	335 ± 14 (73)	61 ± 12 (72)	21	18
Creel-size sportfish[a]	360 ± 76	130 ± 90	6,318 (14)	13 ± 5 (15)	36	21

[a] Creel (harvestable) sportfish as determined by Swingle (1950). Only harvestable *Lepomis* species were captured by the harvester in this study.

studies of dense submersed vegetation (Barnett and Schneider 1974). In general, this habitat contains a high population of both juvenile sportfish and small forage fishes (darters, gambusia, topminnow et cetera). The calculated average weight of the fish in the block-net samples was 2.2 g/fish.

The three loads of hydrilla, from which the fish were separated, weighed 540, 826, and 1,415 kg. The estimated hydrilla biomass (25,000 ± 240 kg/hectare) in Orange Lake is similar to previous estimates of dense hydrilla infestations (Haller and Sutton 1975).

Generally, the proportion of fish species removed with the harvested vegetation reflected their relative abundance in the block-net population estimate. Warmouth, for example, accounted for 18% of the estimated fish population, and 11% of the harvested species. The biomass of warmouth in the population estimate and in the harvested fishes constituted 21% of each sample.

Sunfish were dominant by weight and number in the block-net population estimate. They were also dominant in the harvested fish biomass (51 kg of a total 85 kg harvested/hectare), but were not dominant by number. Nearly half (49%) of the fish removed with the vegetation were bluefin killifish. The occurrence (130/hectare) of creel-size (>45 g) sunfish accounted for much of this group's weight dominance in the harvested hydrilla samples. Sunfish were the only creel-size fish captured by the harvester during this study; however, large chain pickerel, largemouth bass, black crappie, and other large fishes were commonly collected with the vegetation in the harvesting operation.

The 66,000 harvested fish represented 32% of the standing crop by number and 18% by weight. The harvester selectively removed smaller fish. With one exception (redear sunfish), the percent fish loss to hydrilla harvesting was greater by number than by weight, evidence that larger numbers of small fish were being harvested. The average weight of harvested fish was 1.3 g, versus 2.2 g in block-net samples. The majority of fish harvested were young of the year, particularly with respect to sportfishes (D. DuRant, unpublished data).

An index of fish loss to hydrilla harvesting is the ratio (in percent) of fish in the cut hydrilla to that in the block-net samples. Four species were harvested in excess of half their estimated populations: bluefin killifish 89% by number and 61% by weight, mosquitofish 51% by number, Florida gar 75% by number, and dollar sunfish 133% by number and 100% by weight. These species are generally found in association with littoral vegetation rather than in open water. It is surmised that they sought cover in the vegetation when the harvester approached and consequently became entangled in the vegetation.

Three species—golden shiner, brook silverside, and taillight shiners—although abundant in the block-net samples, were not readily collected by the harvester. It is possible that these species, when disturbed by the harvester, swim out of the immediate area and thus avoid removal with the vegetation. Seven species, particularly the sunfishes, were almost equally removed with the cut vegetation. Bluegill, warmouth, redear sunfish, black crappie, swamp darter, bluespotted sunfish, and largemouth bass all were harvested at rates between 20 and 30% of their population by number and 17 to 23% by weight.

Nearly all the data in this study are compared to the estimated standing crop of fish in dense hydrilla as determined by block nets. Maximum effort was given to accurately determine the fish population by using small nets (0.08 hectare), mark-recapture correction factors, 20 to 30 hours of pickup per net, and stirring of the vegetation by outboard motor.

All fish species commonly collected by electrofishing were placed in several nets of which this study is a portion. The recovery data from 18 block nets is currently being prepared for publication of a study similar to that of Grinstead et al. (1978). Recovery of finclipped fish (percent) in this study varied from 7.3% (brook silverside) to 81.3% for redear sunfish (D. Durant, unpublished data).

The block-net population estimate likely underestimates the population of small bluefin killifish, mosquito fish, and fishes of similar size. Marked fish of these species were larger than some individuals occurring in the nets (marking of small individuals of each species was not feasible) and their recovery rate would be slightly higher. To a lesser extent, estimates of fish removed by the mechanical harvester also are conservative because the 25-mm^2 mesh conveyer belts on the harvester, transporter, and conveyer allow some fish to fall onto the barge in inaccessible areas and on the ground under the conveyer.

Mechanical control of nuisance aquatic vegetation generally is considered more environmentally sound than chemical control. As well as reducing the use of herbicides, physical removal of plants removes nutrients and is generally thought to improve water quality. However, mechanical weed control has not been subjected to the same environmental scrutiny or regulation as chemical control. Regulations pertaining to mechanical control apply only to those activities defined as dredge-and-fill operations.

In contrast, agencies charged with the enforcement of pollution control and abatement laws frequently levy replacement charges for fish killed by applications of weed-control chemicals. If the mechanical weed control operation in Orange Lake, which involved 65 hectares overall, had been conducted by chemical means and the same number of fish had been killed as were harvested, the assessed value of these fish would have been over $410,000 based on current fish replacement values (Pollution Committee 1975).

This study shows that mechanical control of aquatic weeds can have direct and measurable impacts upon fisheries resources. The Orange Lake control program was small (65 of 5,000 hectares harvested), so its lakewide impact probably was minor. However, very significant changes in fish populations could occur in smaller lakes in which mechanical harvesting removes vegetation from the entire lake two or three times in a growing season.

There is potential for greater environmental damage by mechanical aquatic weed control programs than previously believed. As aquatic weed problems increase it is becoming more apparent that various control methods have both advantages and disadvantages. Their separate benefits and risks must be considered before a weed control program is begun.

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