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Capture of Grass Carp from Vegetated Lakes

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ABSTRACT

Seven techniques were evaluated for catching grass carp (*Ctenopharyngodon idella* Val.) in five Washington lakes containing aquatic vegetation. The capture methods included angling, pop-nets, lift nets, or traps in baited areas; angling in nonbaited areas; heating the water in small areas to attract fish; and herding fish into a concentrated area and removing them with gill nets or seines. Herding was the most effective of the techniques ($P < 0.001$), followed by angling in baited areas. Herding removed 0.8% to 8.2% of the original grass carp stock in one sweep in lakes containing thick vegetation, submerged logs and other underwater obstructions. This technique may be effective for reducing numbers of fish in small (<10 ha) overstocked waters, or for capturing fish to monitor growth.

Key words: white amur, fish capture methods, angling, herding.

INTRODUCTION

Grass carp have been used for aquatic plant control in the United States for over 25 years (Allen and Wattendorf 1987). However, information about the growth and mortality of grass carp stocked in natural lakes is hard to obtain because of the difficulties associated with capturing the fish, which has also hindered removal of grass carp from overstocked lakes.

Several studies investigated methods to capture grass carp. Conventional fish capture techniques such as fyke, gill and trammel nets, and electroshocking were used to catch small numbers of fish, but were not effective for removing large populations (Cumming *et al.* 1975, Shireman and Maceina 1983, Hestand *et. al.* 1987). Grass carp are sensitive to various piscicides (Marking 1972, Henderson 1974, Cumming *et al.* 1975) and were selectively removed from certain fish populations (Cumming *et al.* 1975, Colle *et al.* 1978). Angling was used to reduce grass carp numbers in lakes denuded of vegetation (Terrell and Fox 1974, Hestand *et al.* 1987) and in lakes containing less preferred plants (Buckley and Stott 1977). Haul seining was effective in capturing some grass carp in Florida lakes where vegetation was largely eliminated (Shireman and Maceina 1983, Hestand *et al.* 1987).

These methods were only moderately successful, and even the most efficient cannot be used in all situations. Use of piscicides can be restricted, publicly unacceptable, or impractical in certain waters. Success of angling in lakes containing preferred plants species remains unproven, and active netting techniques such as haul seining are not suited for lakes containing substantial stands of aquatic vegetation, submerged obstructions, or variable basin morphometry.

We tested several new methods to capture grass carp in lakes containing significant amounts of aquatic vegetation and underwater debris, as well as other methods which were reported as successful in the literature, from telephone surveys, and on a worldwide questionnaire (Bonar 1990). A major objective of the experiment was to identify methods which could capture significant numbers of grass carp in lakes containing palatable aquatic vegetation, so the fish could be

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removed before all valuable plant communities were eliminated. Further objectives of the study were to identify which of these methods would result in the highest catch-per-unit-effort (CPUE), and identify those techniques which would allow grass carp to be removed alive from natural lakes.

MATERIALS AND METHODS

Seven techniques for catching grass carp in vegetated lakes were evaluated in 1991. Four Washington lakes (Keevies, East Pipeline, Bull South, Shincke Road) stocked with 20- to 30-cm (total length) triploid grass carp in 1987, and one lake (Big Chambers) stocked with 20- to 30-cm triploid grass carp in 1990 were used in the experiment. The lakes ranged in size from 0.8 to 24.3 ha (Table 1), in maximum depth from 2.0 to 4.0 m, and were approximately round in shape, with the exception of Big Chambers which was long and narrow. Techniques were first tested in Keevies and Big Chambers Lakes, which received the highest stocking rates, to determine if the methods were successful. Techniques that successfully captured grass carp in one of these two lakes were then tested in the other lakes.

TABLE 1. SIZE OF LAKES (ha), ORIGINAL STOCKING RATES, MEAN DAILY AIR TEMPERATURE (C) DURING HERDING, AND PERCENT OF ORIGINAL STOCKED POPULATION REMOVED WITH ONE PASS USING HERDING.

Lake	Size	No. Fish	Temp.	Percent
Keevies	2.9	1,595	13	0.8
Big Chambers	24.3	12,622	10	0.4
Bull South	0.8	183	21	8.2
Shincke Road	13.2	395	—	—
E. Pipeline	0.9	103	15	6.8

We first attempted to attract grass carp with a thermal plume. This method was based on studies which showed fish can be attracted to warm effluent when ambient water temperature falls below their preferred temperature (Neill and Magnuson 1974, Reynolds 1977, Cincotta *et al.* 1982). Six 3-kw titanium bayonet heaters powered by a 20-kw generator were suspended on a 1.6-m^2 floating platform. A 28-m^2 pop-net was submerged and placed on the lake bottom underneath the platform to capture any fish attracted to the heater. The heater was operated in late spring so the ambient water temperature of the lake (15 to 19C) would be lower than that preferred by grass carp (25.3C, Bettoli *et al.* 1985). After the heaters were started, grass carp activity over the net was monitored visually from shore at 1-hr intervals both day and night. Continuous hydroaccoustical monitoring of the site was also conducted using a 107-kHZ transducer connected to a Simrad HE-203 chart recorder.

Next, bait was used to attract fish over the unheated submerged pop-net. This study was to evaluate previous trials by Schramm and Jirka (1986) who reported that grass carp were readily attracted to unobstructed baited areas. Thirteen different baits were presented to grass carp at field sites and in 4270-L laboratory tanks. These baits were: lettuce (*Lactuca sativa*), white bread, dry cat food, hominy (*Zea mays*), cabbage (*Brassica oleracea*), saltine crackers, sunflower sprouts (*Helianthus annuus*), cheese curls, alfalfa hay (*Medicago sativa*), spinach (*Spinacia oleracea*), alfalfa cubes and blocks, soybean sprouts (*Glycine max*), and dried bread cubes. Observation of baits selected first in these initial trials identified those to be used in the subsequent capture experiment. Preferred baits were concentrated in a 1.1-m^2 bamboo frame over the pop-net and also spread over a larger area to attract fish to the site. After fish were seen taking the bait, the frame was filled with bait at dawn and dusk to train grass carp to feed at those times. The net was popped from a blind on shore to capture fish after they became accustomed to feeding at the site.

Bait was also used to attract grass carp to two types of traps. In the weir trap (Figure 1), both a leader and a 1.1-m^2 bamboo frame inside the trap were baited and the trap was checked twice daily for captured grass carp. The L-trap consisted of an area enclosed by an "L" shaped poultry wire fence with one open side (Figure 2). A net curtain, operated from a blind on shore, could be pulled across the open side to catch fish attracted to bait scattered in the trap.

Angling was attempted using nine baits and two artificial lures which were: biscuit doughballs, bread, catfish power bait (cheese flavor), cheese marshmallows, cheese curls, cornbread dough, garlic marshmallows, hominy, iceberg lettuce, crappie jigs, and artificial minnow lures. Both tank and field observations were used to determine which baits were most effective, and comparisons also were made between sites previously chummed with bait and sites not chummed. Angling was conducted from a boat in a wide range of vegetated and nonvegetated habitats at various times of the day.

A literature and telephone survey were conducted to identify methods used to capture grass carp in their native range in Eastern Asia. We then used techniques that are commonly used throughout the region. The first was a 28-m^2 lift-net attached to a counterweighted lever mounted on a 5.2-m boat. The net was suspended just below the water surface, baited, and lifted to capture fish swimming over the net to feed.

Herding techniques have assisted substantially in the harvest of Chinese carp in China (Dela Cruz 1980, Lu 1986). We modified these techniques for use in our study lakes. First, fish were frightened starting at one end of the lake using

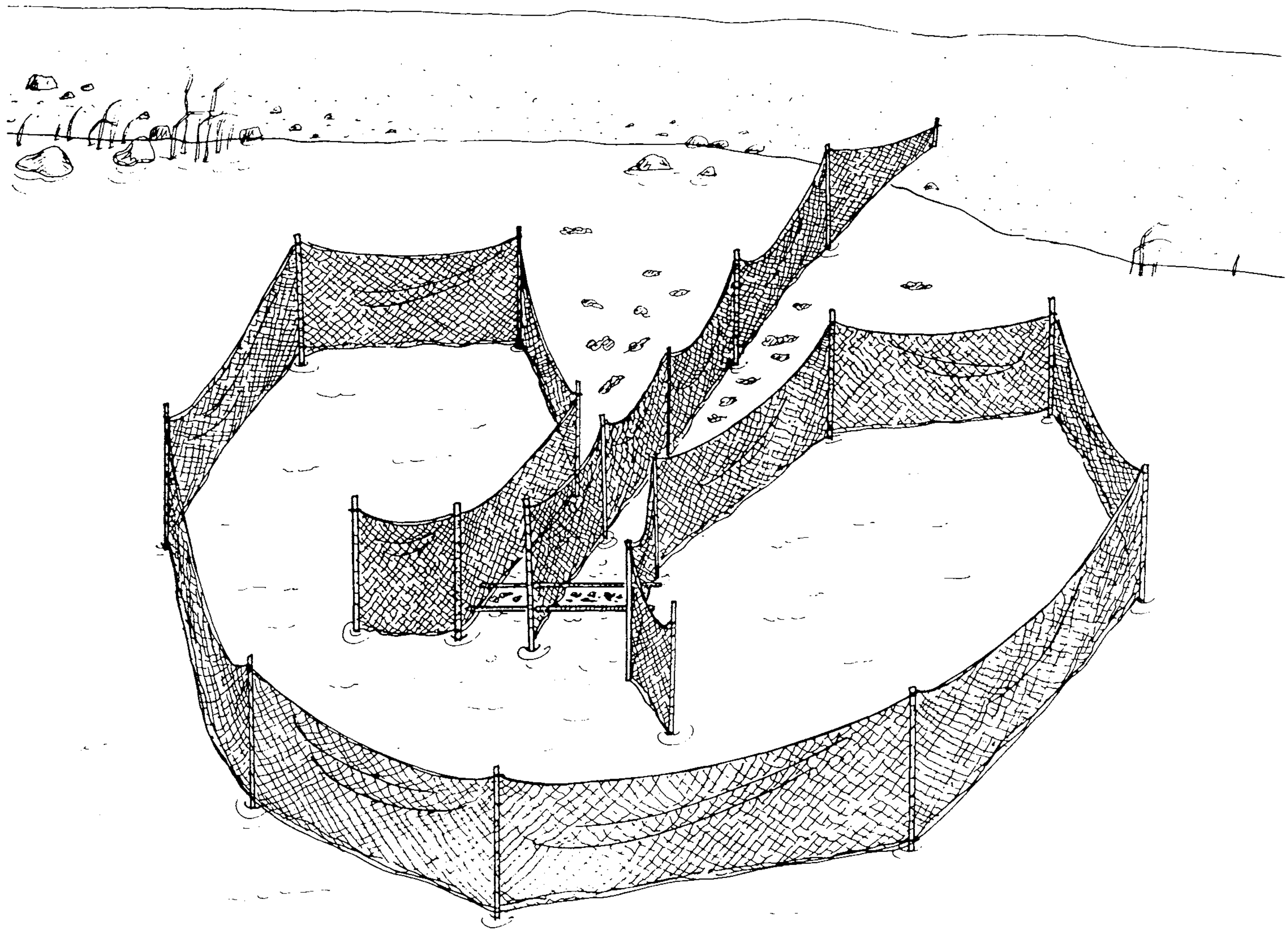

Figure 1. Diagram of the weir trap showing bamboo frame holding bait at the mouth of the trap.

various noisemakers including boat motors, plungers, scarelines (Brant 1984), boat paddles or human movement through the water (Figure 3). A 200- to 300-m long monofilament gill net, with 11.4 to 15.2-cm stretch mesh panels that reached from the lake's surface to the sediment, was used to cordon off the area after a reasonable amount of noise had been made. Barrier nets of 3.8-cm stretch nylon mesh were also used for the same purpose in some of the lakes. Noise was then made along the front of this net, again scaring the fish from the area. Another net was set out in front of the previously placed net. This process was repeated until fish were concentrated at the far end of the lake (Figure 3). Here, the monofilament gill net was elevated approximately 1 m by metal tripods floating on tire tubes to prevent the retreat of the fish by jumping back over the net (Figure 3). A combination of seining and herding the fish back into the gill net was used to capture fish. Only one pass was made through each lake using this technique. Fish were herded across the entire lake in all lakes except Big Chambers, where the method was used only in one large cove. Unlike the other techniques, this method was first attempted in Bull South Lake to determine its practicality because of the logistical problems of testing it initially in the larger Big Chambers or Keevies lakes. The method was not tested in Shincke Road Pond.

Nonparametric randomized block procedures, blocked by lake, were used to test the null hypothesis that the CPUE of the various capture methods were similar ($\alpha = 0.05$).

Effort (man-hours) for active techniques was defined as the time a crew fished multiplied by the number of people in the crew, while for passive techniques, the time required to check the trap multiplied by the number of people required to check it was used. Soak time, the amount of time a passive trap was fished, was also recorded.

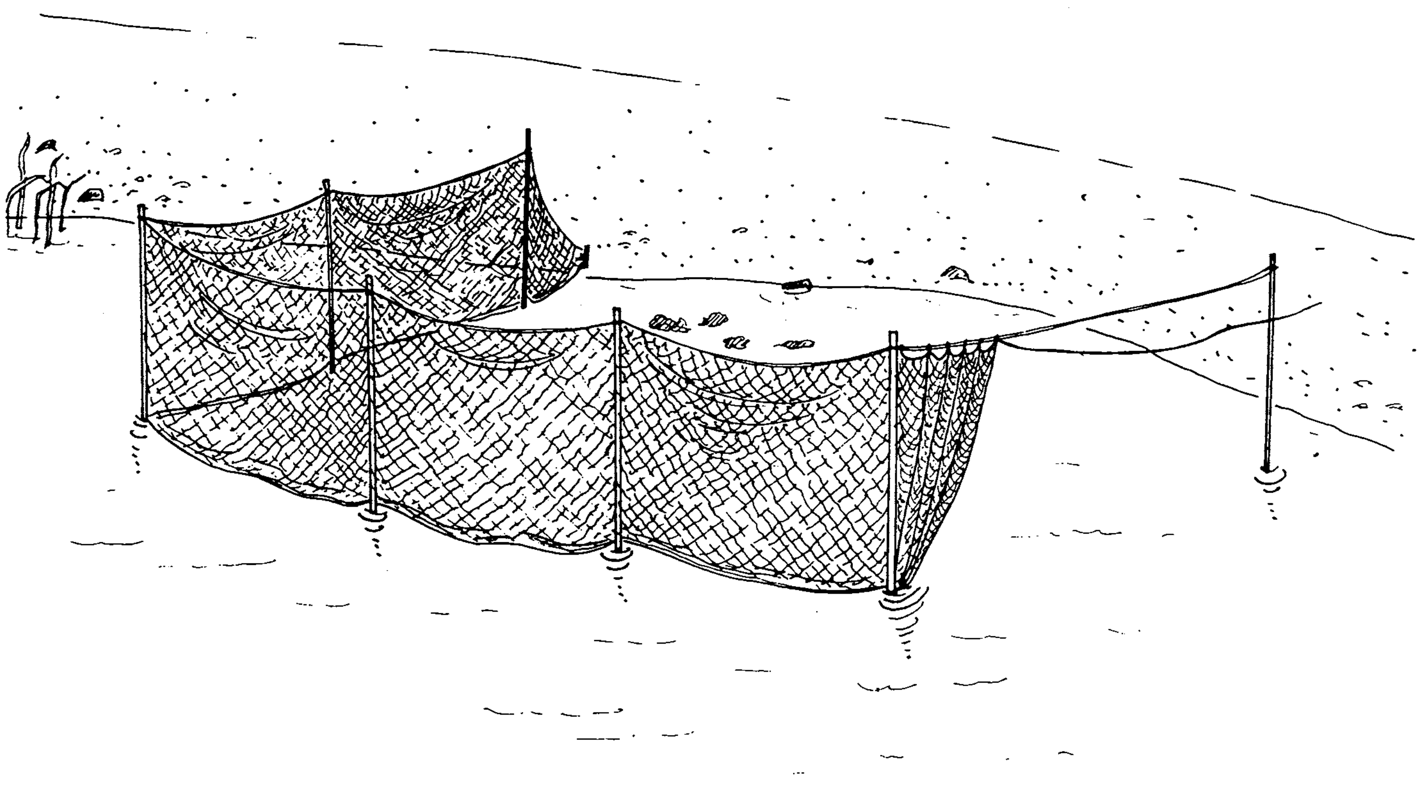

Figure 2. Diagram of the L-trap showing fenced portion of the trap and net curtain.

RESULTS AND DISCUSSION

Based upon CPUE, herding was the most effective method for catching grass carp, followed by angling ($P < 0.001$, Table 2). Time required to herd grass carp ranged from a single 6- to 10-hr day in smaller lakes (East Pipeline and Bull South) to 3 to 4 days in larger lakes (Keevies and Big Chambers).

Herding CPUE's (0.17 to 0.56 fish/man-hour) were comparable to CPUE's of the most effective methods in other studies. Ten grass carp were caught using a baited cage over a 34-day period in an agricultural canal (Schramm and Jirka 1986). Seventy-seven grass carp were removed in a 4-hr selective rotenone application in Florida with 72 personnel used in the operation, resulting in a CPUE of 0.26 fish/man-hour (Colle *et al.* 1978). Haul seining removed between 12 and 65 fish during each of six 6-hr hauls on a Florida lake (Hestand *et al.* 1987). Considering five to six fishermen were needed for each haul, CPUE ranged from 0.36 to 2.0 fish/man-hour. Different standing crops of grass carp, water temperatures, basin morphometry, and density of underwater obstructions in the various sites allow only the most general comparison of these CPUE's.

Several modifications may improve the success of herding. Only one pass was made on each lake during this study and multiple passes could result in an increase in the total number of fish caught. Herding was conducted in the fall when water temperatures were low compared to those preferred by grass carp (Bettoli *et al.* 1985). No water temperature data were taken during herding, and more points were needed to establish a significant correlation. However CPUE increased with mean daily air temperature (Tables 1 and 2). When temperatures were low, fish moved sluggishly, and would often not be scared out of an area toward the far end of the lake. When temperatures were warmer, fish moved quickly and were herded successfully across the lake. Herding fish at mid-summer when water temperatures are highest may improve CPUE.

In small lakes, such as Bull South and East Pipeline, a higher proportion of the original stock of grass carp was removed than in larger lakes such as Keevies and Big Chambers (Table 1). Not including the initial costs for nets (approximately $1,000 to $3,000) and assuming labor costs of $8.00 per person per hour and a constant CPUE, herding costs would range from $1,471 to remove 50% of the original stock of fish from East Pipeline Lake to $90,157 to remove

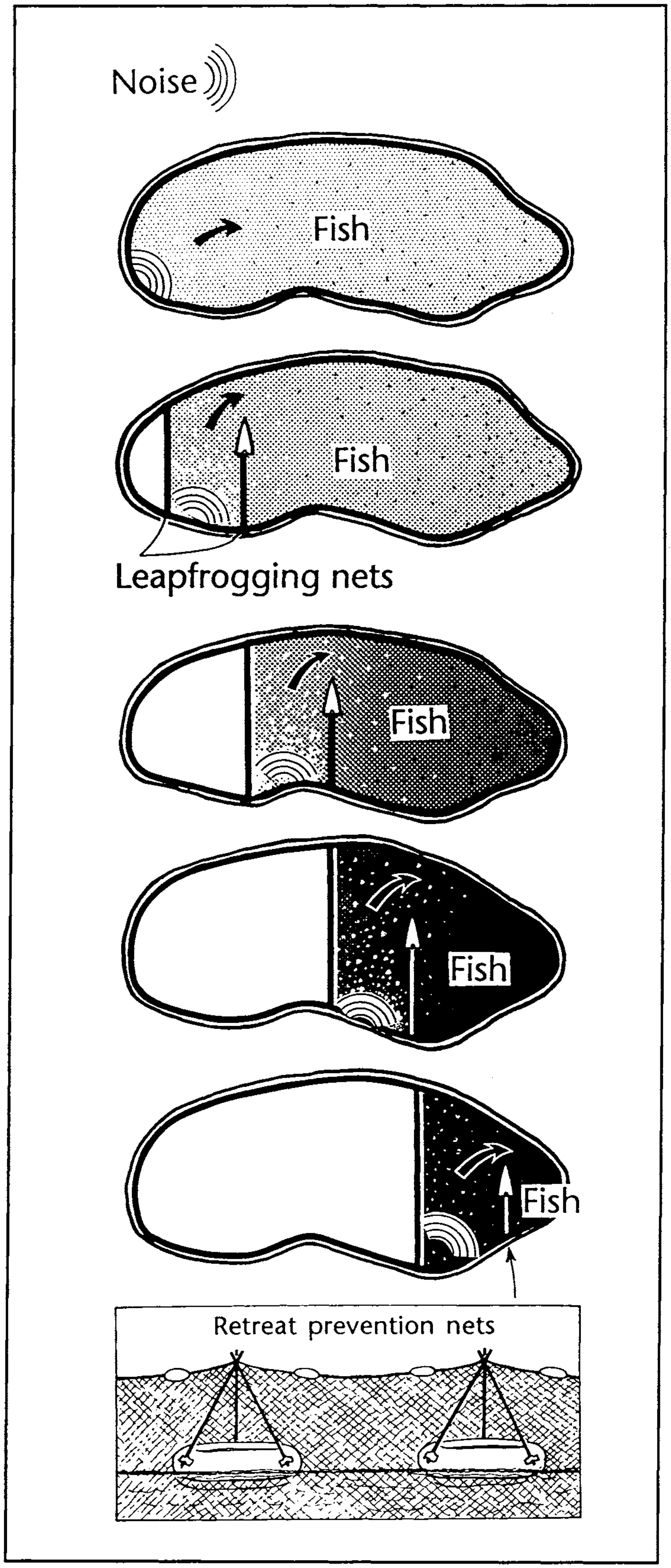

Figure 3. Diagram of herding technique and retreat prevention nets (insert)

TABLE 2. CATCH RATES OF GRASS CARP FROM KEEVIES LAKE (KV), BIG CHAMBERS LAKE (CH), BULL SOUTH LAKE (BS), EAST PIPELINE LAKE (EP), AND SHINCKE ROAD POND (SR), WASHINGTON, USING DIFFERENT CAPTURE METHODS.

Lake	Method	Effort (man-hr)	Fish caught	CPUE (fish/ man-hr)
KV	Herding	78.3	13	0.17
	Angling, baited area	65.3	7	0.09
	Thermal plume	31.4	0	0.00
	Weir	12.0 (193.3)[1]	0	0.00
	Baited pop-net	24.3	0	0.00
CH	Herding	79.8	45	0.56
	Angling, baited area	25.2	7	0.14
	Angling, no baited area	72.1	0	0.00
	Lift-net	27.2	0	0.00
	L-trap	15.8	0	0.00
BS	Herding	65.3	15	0.23
	Angling, baited area	68.5	0	0.00
EP	Herding	24.7	7	0.28
	Angling, baited area	4.0	0	0.00
SR	Angling, baited area	16.8	0	0.00
	L-trap	11.4	0	0.00

[1]Soak time (hr).

the same proportion from Chambers Lake. Herding techniques need to be improved to be cost effective for large-scale removal in larger lakes. In mainland China, herding has substantially increased fish recovery from larger lakes (Dela Cruz 1980). Fishermen harvested 500,000 kg of various Chinese carp species in one operation from a 1,466-ha lake stocked originally with 3,000 fingerlings (>15 cm) per hectare. However, 1 to 2 dozen motor boats, 32 pieces of 2,000-m-long gill nets and at least 70 people were used in the proceedings, which lasted from 25 to 30 days (Dela Cruz 1980). Such resources would probably not be available for many grass carp removal projects in the United States. Simply making more than one pass on a lake will likely capture fish that escaped the first time. Placing nets closer together in larger lakes would result in smaller areas from which to herd the grass carp, but this would substantially increase the amount of time to complete the process. Developing better methods to drive grass carp may be a more effective means of raising CPUE. Schramm and Jirka (1986) reported that grass carp were driven by electroshocking more effectively than by surface disturbances. Qi-Wen (1990) reported manpower requirements were reduced 45% and man-days reduced 60% to 85% by using an electric driving system as opposed to traditional net-driving systems. Use of electroshock systems to drive fish may lower the number of fish returning through the source of disturbance, and decrease the amount of manpower needed to create effective disturbances.

The retreat prevention devices elevated the net and blocked escape of several fish which tried to jump back over the net. However, a slight wind would capsize them, and they were difficult to place in the net. Some other simpler device to elevate the net when fish are crowded could lower the effort required for herding.

Angling was considerably less successful than herding. The most effective angling technique was to attract fish to an area baited with iceberg lettuce (Lactuca sativa L.), and fish using lettuce tied to a #8 hook. Of all of the baits tried in the experiments, iceberg lettuce was the most effective. No fish were caught with bread, but it was successfully used to attract fish into an area. Other baits were not successful in either respect.

Greater than 9-kg test line was most effective for catching the fish, which ranged in size from 0.7 to 6.8 kg. Lighter line frequently broke, and of a total of 14 fish hooked in the experiments, 8 were lost because of line failure.

Greatest angling success was obtained in the evening or on calm days. It was difficult using the method on windy days because the bait used to attract the fish would be blown out of the area, and the feeding activity of the grass carp could not be easily observed.

In most previous studies where angling was reportedly successful, there was a lack of preferred plants in the lake. CPUE's ranged from 0.04 to 1.56 fish/man-hour in ponds devoid of vegetation (Terrell and Fox 1974, Hestand *et al.* 1987). In a northern British lake containing stands of less-preferred *Myriophyllum spicatum* L. and *Ranunculus cicinatus*, CPUE was 0.13 to 0.35 fish/man-hour (Buckley and Stott 1977). Fish that did not have anything to eat may have been readily attracted into baited areas and captured, which is consistent with the findings of our study where grass carp were attracted to bait in Keevies and Big Chambers Lakes which contained only less-preferred plants such as *Nuphar* sp., *Nymphaea* sp., *Brasenia schreberi* Gmel., and *Typha* sp. (Bonar 1990).

Bull South Lake, East Pipeline Lake and Shincke Road Pond contained preferred plants such as *Elodea canadensis* (Planch.) Casp., *Potamogeton pectinatus* L. and other thin-leaved pondweeds (Bonar 1990). Grass carp were not attracted to baits at these sites, probably because of the abundance of preferred foods. Wilson and Cottrell (1979) reported an angling CPUE of only 0.0046 fish/man-hour in a pond that contained sufficient amounts of algae and rooted vegetation to provide an adequate food supply for the grass carp. However, they did not describe the species of plants present. Their baits were earthworms, artificial minnow lures, spinners, and aquatic and terrestrial vegetation. While some of their baits may not have been effective, their results and ours suggest that grass carp may be effectively angled or attracted to baited areas only in lakes containing less-preferred plants or devoid of aquatic vegetation.

The baited pop-net, the weir, the L-trap, and the lift net did not catch any fish. Small groups of three to five fish were attracted to baits over the pop-net and into the L-trap. However, the grass carp were able to escape by jumping over the sides of the pop-net after it was popped, or between the net curtain and the fencing of the L-trap as the curtain was being pulled across the opening. A roller-net was installed on the pop-net to cover the top when the net was popped, but fish were able to find gaps along the side of the roller-net to escape. Fish fed around the edges of the lift net, but could not be induced to swim over it. Fish fed on bait placed in the leader of the weir, but did not go into the trap.

The heating unit did not create a thermal plume sufficient to attract fish. With all heaters working, water temperatures were only raised a fraction of a degree next to the heating units. Further calculations revealed that a prohibitive power requirement would be necessary to create an effective thermal plume.

This study did not investigate the efficiency of electroshocking to capture grass carp. However, electroshocking was used on the lakes in the spring of 1990 and 1991 to survey all fish species. No grass carp were caught in Keevies, East Pipeline or Shincke Road Pond, but a CPUE of 1.52 fish/man-hour was obtained in Big Chambers. Hestand *et al.* (1987) reported catch rates of 5.0 to 7.0 fish/man-hour using electroshocking, but expressed doubt about its feasibility for removing large numbers of fish. Their reasons were the substantial manpower requirements of this method coupled with a reduced catch rate of continued electroshocking due to gear avoidance and a diminishing population. The majority of respondents from a worldwide survey that included questions on grass carp capture methodology rated electroshocking as "poor" for capturing grass carp (Bonar 1990). Electroshocking is effective as a survey tool, has potential as a herding device, and may be effective for reducing grass carp populations in some lakes. However, use of this technique for large-scale removal of grass carp is apparently limited.

We conclude that herding and angling are effective for removing small numbers of grass carp. Herding, with further modifications, might be successful for removing large numbers of fish, especially from small (<10 ha) lakes and ponds. Herding would be effective in shallow lakes containing any combination of plant species. It would be most effective in narrow lakes, or those containing coves that could be cordoned off easily. Herding would probably not work well in deep lakes where nets would not reach to the bottom, or large, round lakes where areas could not be cordoned off.

Although angling did not result in the capture of many fish, there are advantages to using the technique when conditions are favorable. It requires less gear than any of the other techniques, and could easily be used by lakefront homeowners or the general public to aid in the removal of fish. The most effective terminal gear we found to catch fish is simple, and could be used quite easily at low cost. A disadvantage to this technique would be that anglers may move captured grass carp to unstocked lakes.

It is unlikely that modifying the pop-net, L-trap, weir, or lift net to capture the fish attracted to them would result in CPUE higher than that associated with herding or angling. Since only small numbers of fish were over or in the netted areas at any one time, they could probably be removed as effectively by angling as by the more gear-intensive techniques. Additionally, once the pop-net was popped or the net curtain pulled on the L-trap, fish would not return to the site for several days. These baited traps also would not work well in lakes containing preferred plant species.

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