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ANALYSIS OF FISH CATCHES MADE WITH SUSPENDED AND BOTTOM SETS OF GILL NETS IN DEEP LAKES*

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A lake inventory crew** has experimented with gill nets suspended at various levels of depth. Such netting was done for three summers, and as other nets fished on bottom at the same times, the results afforded a comparison of the effectiveness of the two methods. The primary objective of the work with suspended nets was to determine the main locations of cold-water fishes as to depth.

This investigation was carried out during the months of July and August in conjunction with routine fishery inventories of four lakes. These lakes and the year each was studied are: Elk, in Antrim and Grand Traverse counties, 1956; Bellaire, Antrim County, 1957; Walloon, Charlevoix and Emmet counties, 1957; Torch, Antrim and Kalkaska counties, 1958. These lakes were well adapted for the work with suspended gill nets because virtually the same species of fishes inhabit all of them (including sizeable populations of cold-water species), the cool-water strata are adequately supplied with oxygen in summer, and the basins are morphometrically similar (See tables 1 and 2).

Fishery literature indicates that few research workers have used gill nets at mid-depths. Fry (1937) floated gill nets between surface and bottom to study

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**I. A. Rodeheffer and Jason Day.

Table 1.--Morphometric data on Elk, Bellaire, Walloon, and Torch lakes

Lake	Maximum depth (feet)	Surface area (acres)	Area over 30' deep (Percent of surface area)	Area less than 15' deep (Percent of surface area)
Elk	192	7,730	65	15
Bellaire	95	1,775	60	25
Walloon	100	4,320	35	40
Torch	285	18,770	75	10

Table 2.--Sport species of fish present in Elk, Bellaire, Walloon, and Torch lakes *

Species	Elk Lake	Lake Bellaire	Walloon Lake	Torch Lake
Brown trout	..	..	..	X
Lake trout	X	X	R	X
Rainbow trout	X	..	..	X
Burbot	X	X	X	X
Cisco	X	X	X	X
Smelt	..	X	X	..
Whitefish	..	..	..	X
Northern pike	X	X	X	X
Muskellunge	X	..	..	R
Yellow perch	X	X	X	X
Walleye	..	X	..	..
Largemouth bass	..	X	X	X
Rock bass	X	X	X	X
Smallmouth bass	X	X	X	X
Bluegill	X	X	X	..
Pumpkinseed	X	X	X	..
Black crappie	..	..	X	..
White sucker	X	X	X	X
Brown bullhead	..	..	X	..
Bullhead (species?)	X	..	..	..

* An "X" shows which species have been collected by biologists; an "R" indicates that a species has been reliably reported as present.

various distributional patterns of the cisco in Lake Nipissing. Cooper (1940) made suspension sets in Rangely Lake, Maine, that were similar to those that will be described in this report. The U. S. Fish and Wildlife Service has employed the oblique set (which was also used by Fry, op. cit.) quite extensively in the Great Lakes. Smith (1956) has described this method of gill netting and reported on results of its use. Tibbles (1956) described another assembly, which he has called the rolling gill net, for sampling all the strata of water at one location simultaneously.

Commercial fishermen on the Great Lakes customarily set their gill nets on bottom. Occasionally they "can up" (suspend them) above the bottom to avoid excessive catches of small perch.

Formerly a type of gill net known as the "bull net" was used extensively on Lake Erie for ciscoes and to a lesser extent for blue pike. This gear was 100 mesh deep (3 1/16-inch stretch mesh) and was suspended from the surface. These nets have been outlawed over much of Great Lakes water because it was thought that they seriously depleted cisco stocks. Suspended sets of ordinary gill nets have been used for ciscoes by Minnesota fishermen in Lake Superior.*

Carlander (1943) reported on the use of suspended nets by commercial fishermen on Lake of the Woods. He observed that they were less effective than bottom sets in catching ciscoes, but more effective on walleyes.

Equipment and methods

The gill nets used in this experiment were of the "experimental" type, composed of five different sizes of nylon mesh. They were 125 feet long by 6 feet deep and rigged with the usual lead and float lines. Mesh sizes (square measure) in each 25-foot section were 3/4 inch, 1 inch, 1 1/4 inches, 1 1/2 inches, and 2 inches.

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*The information in this paragraph provided by John Van Oosten.

In the conventional method of setting gill nets, the lead line rests on bottom. With suspended sets, the net was hung at a desired level between the surface and the bottom of the lake. The net was maintained at the desired level by additional floats that were attached to the float line of the net; the depth of the set was determined by the length of the lines that held the auxiliary floats.

Two 125-foot nets tied end to end were used for suspension sets. Accessory equipment for each assembly included the following items: 11 sections of dry cedar fence posts, 6 to 8 inches in diameter and about 15 inches long, for floats; 11 sections of sash or maitre cord (the length of each approximately corresponding to the maximum depth at which the nets were set), with a snap at one end of each; two cement blocks for anchors; two 5-gallon oil cans used as buoys for the anchor-lift lines; two flags for attachment to the buoys to show the location of the net; a generous quantity of either sash cord, maitre cord, or rope for anchor lines.

Figure 1 diagrams a suspended gill net in set position. The length of rope A is equal to the depth of the water where the anchor rests; the rope (C) from the anchor to the bridle is about 1 1/2 times the length of rope A. A single length of rope may be used for this part of the assembly by tying it around the anchor at a point which will allow rope A to reach the surface in vertical position. Ropes B and C' are assembled similarly except that more rope is used for B than for A to facilitate stretching of the net.

Cords and the cedar blocks suspend the net at desired depths. The cords are of a length that corresponds to the depth of the deepest water to be netted. Each cord is stapled to a block and a snap fastened to the other end. The cords are snapped on the float line of the net at 25-foot intervals, 11 of the assemblies being attached to one 250-foot net. To change the depth of a

Figure 1.--Assembly of a suspended gill net in set position (depth of lake at location of set assumed to be 150 feet).

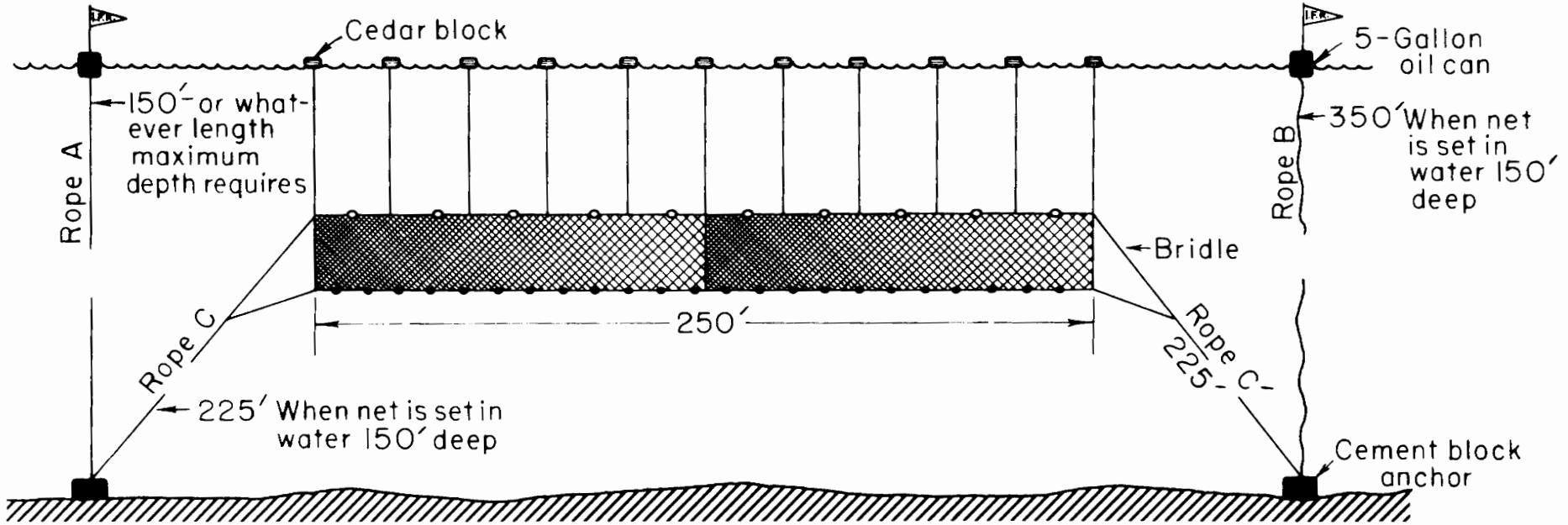
Cedar block
5-Gallon oil can
150′ or whatever length maximum depth requires
Rope A
Rope B
350′ When net is set in water 150′ deep
Bridle
Rope C
250′
Rope C
225′
225′ When net is set in water 150′ deep
Cement block anchor

Figure 1

setting, each cord is measured off to the desired length, and the excess then wound around the cedar block and tied.

Setting is commenced by paying out rope A with its anchor and buoy attached. Then while the boat backs slowly, rope C is paid out and tied to the net bridle after it has tightened on the anchor. One end of the net, with a cedar block float snapped to an end of the net float line, follows overboard; paying out proceeds, float lines being attached at 25-foot intervals. When the end of the net is reached, rope C' is fed out until it becomes moderately taut. Then the anchor is lowered to the lake bottom with rope B. With the buoy-end of this rope in tow, the motor is speeded up to tighten the net. After tightening, rope B is put overboard.

When the net is to be lifted, either anchor is pulled slightly off bottom and drawn a short distance toward the net to slacken the net and the lines. Now the net is picked up section by section and inspected for fish as the boat is pulled alongside. After a section has been examined, it is dropped back into the water. If the net is to be reset at the same site but at a different depth, the lines attached to cedar blocks are either shortened or lengthened as the situation demands, after which the net is retightened.

A few of the suspended sets rested on bottom and these have been disregarded in the evaluation of effectiveness because they were not exactly comparable either to other bottom sets or suspended sets. Also disregarded are bottom sets that fished partly in the zone designated as shallow water and partly in the deep-water zone.

Depths between the surface and 32 feet have been designated as shallow water, and those in excess of 32 feet as deep water. Such division seemed justified because the top of the thermocline was either at or close to 30 feet in all of the lakes. The boundary was established at 32 feet because several more bottom

sets could be included in the analysis than if 30 feet had been chosen as the line of demarcation.

Collection results

Elk Lake.--The experimental netting in Elk Lake was done during August 1956. Gill-netting effort included in the analysis consisted of 26 125-foot nets suspended at various levels over deep water, 51 bottom sets in deep water, and 31 bottom sets in shallow water. Four other bottom sets have been omitted from the tabulations because they fished in both the shallow-water and deep-water zones. Suspended nets fished at two locations, one where the water was 70 feet deep, and another where maximum depth ranged from 99 to 122 feet. At the first-named station, the gear operated successively at levels of 1 foot, 30, 40 (48 hours), and 45 feet. (That is, the float line of the net was at these levels.) The settings at the other station were at 70 (72 hours), 80, and 90 (48 hours) feet.

The total catch taken in the 26 suspended sets was four fish--one rainbow trout caught at 40-46 feet and three ciscoes at 90-96 feet. The bottom sets in deep water captured 43 fish, and shallow-water bottom sets took 223.

Lake Bellaire.--The work on Lake Bellaire was done during July 24-August 5, 1957. The gill netting considered in this study amounted to 18 suspended sets, 8 deep-water sets on bottom, and 20 shallow-water sets on bottom. Four additional bottom sets have been discarded. Suspended nets were hung at the surface, and at 10, 20, 30, 40, 50, 60, 70, and 80 feet.

The catch from the suspended nets consisted of 36 ciscoes and 1 longnose gar. The gar was captured in a surface set. The ciscoes were caught at the following levels: 2 at 30-36 feet; 11 at ~~60-66~~ feet; 16 at 50-56 feet; 6 at 60-66 feet; and 1 at 80-86 feet. The two bottom sets (90-96 feet) of this

series accounted for 12 ciscoes. As mentioned earlier, bottom sets made with nets used in the suspension series have not been included in the comparisons. The 8 deep-water sets on bottom took 47 fish, and the 20 shallow-water bottom sets caught 112.

An interesting sidelight on the results from suspended nets in Lake Bellaire is the difference in size between the ciscoes caught near bottom and those caught at higher levels. Those taken in bottom sets (90-96 feet) with nets of the suspended series were appreciably larger than those captured in lesser depths (30-66 feet). The mean lengths of these two groups were respectively 11.4 inches (11 ciscoes measured of a total of 12 collected) and 6.8 inches (31 measured of 35 collected); the respective size ranges were 7.4-14.2 and 6.3-8.9 inches. All of the latter were fish of age-groups I and II, whereas those from 90-96 feet included only one age-group I fish, the others being of age-groups V, VI, VII, and IX.

Walloon Lake.--The netting in Walloon Lake was done during August 9-29, 1957. Eighteen sets were of the suspended type, 14 were bottom sets in deep water, and there were 39 bottom sets in shallow water; two other bottom sets were discarded because they passed over the boundary between the shallow- and deep-water zones. Suspended nets fished at the levels of surface and 10, 20, 30, 40, 50, 60, 70, and 80 feet.

The suspended nets caught eight ciscoes, one at 20-26 feet, two at 50-56 feet, three at 60-66 feet, one at 70-76 feet, and one at 80-86 feet. The two attached nets set on bottom at this location (that fished between 84 and 93 feet) held a perch and a cisco. The 14 nets placed on bottom in deep water caught 20 fish. The catch from 39 shallow-water bottom sets was 144 fish.

Torch Lake.--The work on Torch Lake was done during July and August 1958. Gill netting consisted of 28 suspended sets, 32 bottom sets in deep water, and 17 bottom sets in shallow water. Thirty-seven bottom sets have been omitted from the analysis because they were located in both the shallow-water and deep-water zones. This transgression occurred so frequently because the drop-off in Torch Lake is very abrupt.

Suspended nets were used in two locations and fished at these levels at each station: surface, and 20, 50, 80, 120, 150, and 180 feet. The suspended nets caught only two fish, which were ciscoes, at one of the 80- to 86-foot levels. Six bottom sets with nets of the suspension series (maximum depths of 190, 215, and 230 feet) caught nothing. Other bottom sets in deep water produced 48 fish, and the 17 shallow-water bottom sets caught 60.

Discussion and conclusions

Suspended gill nets were moderately effective only in Lake Bellaire where the mean catch per set of 125-foot nets (fished in pairs) was 2.06 fish. They were least effective in Torch Lake where the rate of capture was less than one fish per 10 sets (Table 3).

The best rate of catch by shallow-water bottom sets occurred in Elk Lake--7.19 fish per 125-foot net. Deep-water bottom sets were most effective in Lake Bellaire (5.87 fish per net), and this lake also showed the best catch rate for bottom sets combined (5.97) and for the three types of collecting combined (4.56).

Except for Lake Bellaire, in which the rate of catch for deep-water bottom sets exceeded that for shallow-water bottom sets, empirical comparison of the data in Table 3 shows that shallow sets were most productive, deep sets less productive, and suspended sets least productive. Analysis of variance shows that the differences over all are greater than can be expected from chance; the

Table 3.--Rate of catch (mean number of fish per 24-hour set of a 125-foot net) by gill nets in Elk, Bellaire, Walloon, and Torch lakes

(Number of sets involved, in parentheses)

Lake	Suspended sets	Deep-water sets on bottom	Shallow-water sets on bottom	Bottom sets combined*	All sets combined*
Elk	0.15 (26)	0.84 (51)	7.19 (31)	3.07 (86)	2.41 (112)
Bellaire	2.06 (18)	5.87 (8)	5.60 (20)	5.97 (32)	4.56 (50)
Walloon	0.44 (18)	1.43 (14)	3.69 (39)	3.05 (55)	2.41 (73)
Torch	0.07 (28)	1.50 (32)	3.53 (17)	4.12 (86)	3.12 (114)

* Data of sets that were excluded from the "deep-water" and "shallow-water" categories because of boundary transgression are included under these headings.

multiple range test (Snedecor, 1956) reveals that although the results of suspended sets differ significantly from those of shallow sets, neither of these differs significantly from the intermediate results of deep sets.*

There is a definite need for an efficient net to sample fish populations of lakes at intermediate levels. Uses of such equipment would include: (1) To catch larger numbers of cold-water species (in experimental sampling projects) than can be collected with nets currently in use. (2) To delineate vertical distribution of cold-water species in the summer season, which would increase our knowledge of the habitat requirements of trout in lakes, and which might also contribute to a larger harvest from some lakes by revealing the predominant location of the fish. (3) To study depth preferences of warm-water fishes during the various seasons, about which little is known at present.

The gill net assembly described by Tibbles (1956) apparently is effective in collecting fish at intermediate levels. Tibbles named the gear he used the rolling gill net. It was composed of sections, with mesh of different sizes, hung side by side to make a net 18 feet wide and 50 feet long. The net was rolled on a galvanized steel spool 19 feet long which served as a float when the net was set. Joined sections of steel conduit, attached to the lower end of the net, served as weight to help remove the net from the spool and to keep it taut when set. Provision was made for joining two or more of these assemblies together if multiple sets at one location were desired. Offset anchors prevented drift by wave action. Setting and lifting operations were aided by two steel conduit supports, on which the axle of the spool rested, and a crank for turning the spool.

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*Statistical analyses made by D. W. Hayne.

Tibbles reported good success with this gear in his work with pelagic fishes, especially yellow perch. It appears to be well adapted for depth distribution investigations. Its disadvantage of limited lateral coverage could be overcome to some extent (as was demonstrated by Tibbles) by joining units of the gear together. Another apparent disadvantage is its bulkiness. This shortcoming, as well as other weaknesses it may have, probably are amenable to correction by further refinement of the design of the assembly.

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