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METHODS OF DETERMINING FISH POPULATIONS

by

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The agriculturist and the silviculturist have long studied the natural production of areas on which they worked and experimented, and more lately in the practice of game management the census of the animals in given areas has become rather common practice. However, it is only within the last ten years that fisheries biologists of the United States have realized the necessity of learning something concerning the fish populations of natural waters. In the proper management of sport fishing it would be most helpful to know with some accuracy how many wild fish different types of natural waters normally support. This paper presents various methods which have been used in attempting to determine fish populations, some of the results obtained, and short discussions on the limitations of the various methods.

There are two ways of obtaining estimates of fish populations. One method is to directly count every individual in a given body of water. The other way is to take a random sample of the fish population from a measured representative portion of the lake or stream and compute the total population from the results of the sampling, i.e., in an indirect manner.

Methods of Stream Census

One direct method of determining the spawning population of a stream is by the use of a weir, or counting rack which blocks the stream. Fish are individually counted as they move one way or another. This method has been widely used on the Pacific coast where they have determined the spawning population of numerous salmon streams. This method is feasible only where the fish population has marked migratory tendencies.

Another direct method of stream census is to completely drain the stream bed by means of a by-pass channel. Census by drainage was performed on a small New York stream by Embody (1929) in 1928. All fish left stranded in the scattered pools were collected and counted. The stream averaged 7.3 feet in width and was 1,002 feet long, and 0.168 acres in area. From this area 7.7 pounds of fish were removed. Seventy per cent of this weight was made up of coarse fish (minnows and suckers), while 30 per cent of the weight was made up of rainbow and brown trout.

This manner of conducting a stream census is necessarily limited to small streams where the immediate topography permits easy by-pass drainage.

The use of dynamite as an indirect method of censusing streams has been attempted, but it is probably the least effective of the methods which have been tried. A section of the stream is blocked off at each end with nets, and a charge of the explosive laid and set off electrically. Theoretically, all fish in the enclosed area of the stream should be killed or stunned by the charge, enabling the investigator to capture and count them. What actually happens is this: the water in the section enclosed by nets is thrown high into the air, while the stream above continues to flow into the sample section as this occurs. When the water in the air falls back into the stream, the resulting mass of water almost always strains the nets to the breaking point, or the excessive debris caused by the explosion clogs the nets till the stream flows over and around the lower net. In either case efforts to obtain all fish killed or stunned are negated. Other disadvantages

are the cost of the explosives, and a certain amount of danger attendant with their use. It is also not well established at just what distances explosives kill or stun the fish in underwater operations.

Lehman (1935) writes that census by means of electricity has been practiced on certain German trout streams. Sections as long as 12,000 feet x 40 feet (ave. width) have been studied, although the details are not mentioned. This electrical method is perhaps the latest development in determining fish populations, and when information on the procedure becomes more generally available, might become a very usable technique in censusing streams.

An indirect method for censusing streams which has been used in both Michigan and New York streams is that of seining a measured sample section of stream and computing the population in fish per mile by direct proportions. The details of the field procedure used in this method were described by Greeley (1933), who has since used the method in a number of New York streams.

Censusing by means of sample section seining is conducted as follows: On the day preceding the actual seining the net stakes are set by sledge hammer. This precaution is taken in order that any fish readily disturbed may have a chance to resume their normal positions in the area to be seined. On the following morning woven wire netting is first strung across the stream to support the 1/4" mesh blocking nets. As soon as the blocking nets are in place seining begins, and continues until no fish can be captured in the enclosed area. The length of the section, average width of the section, and number of fish of the various species captured in the section are recorded. From these data the population per unit area or unit length of the stream may be computed.

A stream census of the Little Manistee River, Lake County, Michigan was conducted on August 18, 1936, in the manner described above. A total

of 601 fish was taken from a section of the stream measuring 160.4 feet long and having an average width of 30.4 feet. All but six of these fish were trout. The total fish population per mile of stream may then be estimated at 19,784, the total trout population per mile of stream at 19,588. The total fish per acre of stream is approximately 5,835; the total trout population per acre of stream is approximately 5,777. These results are summarized in Table 1.

The data on which these results are based were obtained by a cooperative project set up by the Institute for Fisheries Research and the Manistee Purchase Unit of the U. S. Forest Service.

The limitations of the sample seining method are several. In certain types of streams, and at certain times of the year, the retaining nets may clog with debris loosened by seining or carried naturally by the stream. This can be offset by having sufficient man-power to pick the retaining nets clean.

Also, it is not always possible to choose sections representative of all conditions in the stream which are seinable. A fairly accurate estimate of the population should be obtainable by seining from three to ten sample sections containing different bottom habitats and averaging the results so obtained.

In many streams it is not always possible to obtain every fish in the sample section, especially where banks are deeply undercut or old root channels provide means of escape. Streams which are filled with large boulders or glacial rock cannot be censused by the seining method with any degree of success. The fish hide under and between the rocks making it impossible to seine them out. Fortunately there are few streams of this type in Michigan. Depth of water is also a limiting factor in censusing streams, since it is not possible to seine effectively in swift current where the water is much more than waist deep.

Table 1

Stream Census Little Manistee River, August 18, 1936,

Showing Actual Fish Count of Sample Section,

Calculated Number Per Mile and Per Acre.

	Trout			Other Fish		
	Rainbow	Brook	Brown	Muddler	Sucker	Total
Actual Count	478	27	90	4	2	601
Calculated Number Per Mile	15,736	889	2,963	132	64	19,784
Calculated Number Per Acre	4,641	262	874	39	19	5,835

Length of section - 160.4 ft. (0.0304 miles)

Ave. Width of section - 30.6 ft.

Area of Section - 4908.24 sq. ft. (0.103 acres)

Another indirect method of determining populations of fish in streams is to mark a sufficiently large number of fish by removal of two or more fins or by attaching a tag. If the total number of marked and unmarked fish later removed from a given length of stream are known, an estimate of the total population of that portion of the stream may be easily calculated.

This procedure for stream census has been applied to the North Branch of the Au Sable River in Crawford County, Michigan, where trout were marked by the jaw-tag method (Shetter, 1936). Recoveries were obtained through seining operations. In November, 1935, 483 untagged brook trout and 69 tagged brook trout were recovered from various points in one and three-quarter miles of stream. Two thousand four hundred thirty-seven tagged brook trout were in the North Branch at the time of seining if it is assumed there was no mortality to tagged fish or loss of tags.

The population estimate is calculated as follows: Number of brook trout (size range 4"-10" total length) in 1.75 miles of stream = $2,437 \times \frac{483}{69} = 17,059$ total population. The number of brook trout per mile is then approximately 9,700; the number per acre approximately 700.

The limitations of the marking method for stream census lie chiefly in the manner in which information on recoveries are obtained. Unless the stream can be readily seined, it is necessary to rely upon tag returns from fishermen. In this case, an intensive creel census is necessary. No matter what recovery method is used, the number of unmarked fish caught must be known as well as the number of marked fish. Also publicity concerning the exporiment, both through newspaper accounts and by stream-side posters, is then a vital part of the program.

Marking fish by fin-clipping is less expensive than attaching tags, but the information secured from this method is usable only in mass experiments, since fish marked by fin-clipping cannot be distinguished from one another. The more detailed data resulting from fish marked with serially numbered tags justify their use in many experiments.

Regeneration of clipped fins may be considered as a minor limitation, since the work of Davidson (1934) and others has demonstrated that fin regeneration is negligible and easily recognizable. Loss of tags over a period of 7 months to a year has been recently demonstrated to also be negligible (Shetter, MS).

In view of the various limitations of the methods discussed for estimating stream populations, censuses made by means of seining sample sections of streams or by setting up tagging experiments with an accurate means of obtaining recoveries will probably give the best results with the fewest repercussions from the fishing public.

Methods of Lake Census

Methods used to estimate fish populations in lakes are slightly different from census methods in streams. Sample seinings cannot be used since the number and species often vary with the vertical habitats not touched by a seine.

Eschmeyer (MS) has poisoned and dynamited small lakes up to 11 acres in size on the Pigeon River State Forest and collected all dead fish, obtaining a direct count in this manner.

Explosives alone have proved successful in isolated cases. The most successful instance is reported in the Fisheries Service Bulletin No. 260 for January 4, 1937, which describes the complete elimination of carp from a 35 acre New Mexico lake by the use of 1100 quarts of nitroglycerin.

The fish population of Lake Jesse, a 45 acre Nova Scotian lake, was estimated by Smith (1935) after the waters of the lake had been treated with copper sulphate ($CuSO_4 \cdot 5H_2O$) by towing bags of crystals of the copper compound behind row boats. Enough copper sulphate was used to bring the concentration to 3.06 p.p.m. From detailed counts of the dead fish on one-eleventh of the shore line, the fish population of Lake Jesse was estimated at 33,025 individuals, made up mostly of yellow perch

(Perca flavescens), killifish (Fundulus diaphanus), and white perch (Morone americana). The estimated standing crop of fish was 19.8 pounds of fish per acre.

The use of these rather severe direct methods are limited by both cost and public opinion to small lakes having little or no value for fishing. In the use of poison or explosives it is also questionable whether all the fish killed in deep water come to the surface and are included in the count. If either dynamite or poison are to be used in the future, more experimental work on the proper methods of application will be necessary.

Fisheries workers should take advantage of mortalities resulting from pollution, natural oxygen depletion or extreme high water temperatures. Population estimates from such occurrences can be made by counting the number of dead fish in several measured sample plots of shoreline or lake bottom. The amount of shoreline or lake bottom covered with dead fish should also be measured to give an accurate total result. Hazzard and Esclmeyer (MS) report such a count made in a southern Michigan lake by the Institute for Fisheries Research in which the entire fish population died under the ice from suffocation. The fish population of this lake was conservatively estimated at approximately 1,125 fish per acre of an average size of 6 inches (total length).

A valid objection to censuses based on such accidental killings is that fish which die and fall to the bottom in deep water may be omitted from the calculations. Since such killings are infrequent and are usually accidental, they do not constitute a true census method. Nevertheless valuable results may be secured by taking advantages of such mortalities.

As in streams, the indirect method of tagging or marking lake fish will provide a means of estimating the fish population of the lake. The general method is the same as for streams. An adequate number of fish are marked and a careful record of the number of individuals marked and all

attendant data are recorded. Recovery of marked fish may be made in any manner, so long as the number of marked and unmarked fish recovered during the same period is tallied.

The Institute for Fisheries Research, at the invitation of Dr. Miles D. Pirnie, Director of the Kellogg Bird Sanctuary, has set up a tagging experiment on Wintergreen Lake, Michigan. Conditions for an accurate count of tagged and untagged fish caught are ideal, since all fishermen are required to report their catches, and fishing is by permission only. From returns obtained during 1936, calculations on the large-mouth bass (Aplites salmoides) and bluegill (Helioperca machrochira) populations of Wintergreen Lake have been made. It was estimated that there were a total of 15,366 legal (6" total length) bluegills in Wintergreen Lake, or approximately 770 per acre. By similar calculations the legal (10" total length) large-mouth bass population was estimated at 3,519 for the lake, or approximately 175 per acre. These population estimates were calculated in the same manner as used on the North Branch of the Au Sable.

The limitations of the marking method for estimating lake fish populations are also the same as for streams. There must be some means of checking on the number of unmarked fish caught as well as the marked fish. On large lakes an intensive creel census program in conjunction with the tagging experiments is necessary. If fish are to be recaptured by methods other than fishing, the size of the fish tagged and possible habitats of the fish must influence the choice of gear to be used.

Experiments similar to that conducted in Wintergreen Lake, but on a much larger scale, have been operated by the Illinois Natural History Survey on southern Illinois lakes. Their results, however, are as yet unpublished.

The best all-around methods of censusing lakes of those so far mentioned seem to be to take advantage of occasional mortalities or to estimate populations by means of marking experiments.

Summary

1. The use of draining, weirs, dynamiting, electricity, seining sections of a stream, and of marking as methods of estimating populations of stream fish were discussed.

2. Seining sections of a stream, or marking are the methods of stream census which are most likely to give satisfactory results in view of the limitations of the other procedures. Results obtained in Michigan streams by both methods were presented. The electrical method may have excellent possibilities.

3. The use of poison, explosives, and of marking as methods of estimating lake fish populations were discussed. Results obtained by means of marking were presented. It was pointed out that studies on lakes which had suffered natural mortalities might yield valuable data on fish populations of such lakes. Results of such a study were presented.

4. Except on small lakes (10 acres or less) of little value to public fishing where dynamite or poison may be used successfully, marking experiments probably would be the most accurate method of censusing the fish population of a lake.

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