Journal of the Minnesota Academy of Science

Volume 25
Number 1 *Vol. 25/26*

Article 27

1957

Notes on Diurnal Movement, of Minnows in Shallow Waters of a Bog Lake in North Central Minnesota

Arthur R. Peterson

ARTHUR R. PETERSON
Minnesota Conservation Department, St Paul

Notes on Diurnal Movement, of Minnows in Shallow Waters of a Bog Lake in North Central Minnesota

INTRODUCTION

It is fairly well established that fish are not evenly distributed within the body of water that they inhabit. Some of the ways in which uneven distribution occurs are: (1) by biological habitat types; (2) by geographical features of a body of water; and (3) by aggregates or schools of fish. Bias caused by differences in biological habitat types and geographical features can be minimized by an application of existing statistical procedures. In the past the only effective technique for minimizing the effect of aggregates of fish in a sampling experiment was to use samples of a very large size, but in many situations it is not possible to work with large samples. Aggregate sampling problems as they exist today have three main features: (1) both the number of fish in a school and the number of fish in a body of water determine the amount of fish per sampling unit, (2) most of the present sampling techniques cannot distinguish between: (a) a high number of fish which is aggregated in a school; and (b) a high number of fish that is not an aggregated school or occurs in many schools; and (3) since it is only possible to record the data on an individual fish basis, information must be obtained regarding methods of analysis for minimizing the effect of aggregates in the data. It is the intent of this paper to show the nature of some of the variations of minnow density over two small portions of a lake bottom.

Surprise Lake is a small bog-water lake of 11 acres located in northern Minnesota. In addition to a good sized forage fish population consisting mostly of minnows, it has an artificially maintained population of rainbow trout.

METHODS USED

The equipment consisted of a watch with a second hand, a white cloth 11.5 by 15.5 inches or 1.24 square feet, and material for recording

the data. The cloth was used as a "flash board" to outline clearly the quadrat. The long side of the cloth or quadrat was always kept perpendicular to the shoreline. Minnows were counted at one minute intervals at different times during the day for a duration of 18 minutes for six counts and for 36 minutes for the remaining counts. The recording intervals were consecutive for the first series of counts (Station One) and had a 30-second recording pause for the second series (Station Two).

All of the counts were made when the water was calm and the count areas were in deep shade. Station Number One had one count quadrat while Station Number Two had two adjacent count quadrats.

ANALYSIS OF RESULTS

Test For Random Movements: Were the fish moving over the quadrat in numbers which occurred by chance alone? A series of identical objects was drawn from a box so that each object had an equal chance of being drawn.[1] The number of times the objects were drawn divided by number of objects in the box governs the mean of the distribution that will be obtained. In this type of comparison the number of objects in the box and the number of minute intervals must be equal and will be referred to as N. The arithmetic mean will be referred to by the symbol X.

TABLE 1.—*A Comparison Of Calculated (Randomized) Distributions With Thirty-Two Minutes of the Second Interval Count Divided Into Two Sixteen Minute Sections*

Number of Times A Number Occurred In a Tabulation	Obs. Quadrat Dist. 1	Calc. Dist. 1	Obs. Quadrat Dist. 2	Calc. Dist. 2	Obs. Quadrat Dist. 1 and 2	Calc. Dist.
0	2	0	6	2	8	0
1	2	3	3	7	5	4
2	2	3	4	2	6	6
3	3	5	1	3	4	3
4	4	2	0	2	4	2
5	2	3	0	0	2	1
6	0	0	1	0	1	0
7	1	0	1	0	2	0
N equals	16	16	16	16	32	16
X equals	3.00	3.00	1.75	1.75	2.37	2.37

[1]A table of random numbers can also be used.

The chi square values for distributions one and two in the preceding table are 8.9 and 16.6 with six degrees of freedom. An average chi square value of 12.7 is significantly different at the 95 percent level. In the remaining data variations of similar magnitudes were observed; thus, the conclusion is that the movements of individual minnows are not random movements.

Types of Movements With Respect to the Quadrat: Since the idea that fish travel in schools is common, and it has been previously established that the individual minnows were not behaving in a random manner, these data were also tested for runs with the sign test that was suggested by Dixon and Massey. This test is to find whether numbers in consecutive time sequence have a number of runs that is greater than or less than the number of runs which could be expected from randomized data. The confidence limits for a series of 36 consecutive intervals are 13 to 26 runs for randomized data. A coin tossing experiment gave a value of 23 runs or groups of heads and tails for 36 consecutive tosses of a coin while tests on 3 different interval counts gave values of 15, 12, and 10. The number of groups was low in all 3 tests; the mean value of the 3 tests was 12.3 runs which is lower than the low value of the confidence limits. From these tests the conclusion is that the fish were traveling in groups.

If the fish are traveling in groups further proof would be that most of the fish were entering one side of the test area in greater numbers. See the following table.

TABLE 2.—*Direction of Travel of Minnows Over The Quadrats Expressed As Ratios*

Station Number	Entrances Perpendicular To Shoreline	Entrances Parallel[1] To Shoreline	Entrances From Observers Right	Entrance From Observers Left
1	1	9.66 (expected 2.86)[2]	2.14	1
2	1	2.29 (expected 1.43)	. . .	.

The entrances right and left tabulation was made for one count only, however, general observations substantiated that the minnows

[1]At Station Number 1 it was not possible for the fish to enter from the shoreward side of the quadrat. At Station Number 2 it was possible to enter from all four sides.

[2]The expected value was calculated from the ratio of the lengths of the sides.

for a period ranging from 10 to 25 minutes had a pronounced tendency to enter the quadrat parallel to the shoreline and to enter from either the right or the left. The entrances perpendicular or parallel tabulation is an average of several counts, and so it is evident that the minnows were traveling in groups, in the same direction, and parallel to the shoreline.

Rate of Movement: Most of the fish entered and left the quadrat in a period of time which ranged from 6 to 25 seconds. The data as they were tabulated cannot be accurately used to calculate the rate of travel in feet per second.

While the variations in the numbers of fish occurring over the quadrat were not random variations, the preceding analysis suggests that they were systematic variations. The first quadrat count made on August 13, 1955 is the best illustration of this (See Figure 1). Three-quarters of the count appears to be composed of two "curves" that appear to be mirror images.

The graphs in Figure 1 show that the counts were a series of curves of steadily increasing and decreasing magnitude which vary between a maximum and minimum value.

TABLE 3.—*Rate of Minnow Movement and Time of Day*

	NUMBER OF FISH PER MINUTE			
	Station Number 1		Station Number 2	
Time of day	Range of Means	Average	Range of Means	Average
11 to 12 A.M.	5.8 to 7.6	6.7	6.4 to 10.8	8.6
2 to 3 P.M.	1.2 to 2.0	1.6	3.0 to 1.1	2.1
5 to 6 P.M.	1.2 to 1.6	1.4		

From the preceding table it can be noted that the minnows were more active during the middle of the day and less active towards evening.

Sudden Localized Disturbances of the Water: This includes such disturbances as putting the count cloth in the water, agitating the water with hands or stick, or throwing rocks in the water. The usual reaction to such disturbances was to leave the disturbed area, observe it from a safe distance, and return to the disturbed area after the disturbance had ceased.

TABLE 4.—*The Effect of the Count Cloth on the Quadrat Counts at Station Two And Expressed As the Average Number of Fish Per Count Unit (Minute)*

Count Number	Approximate Time Of Day	Carry-over Beginning and End Number Per Count	Pct.	Entrances Parallel Number Per Minute	Pct.	Entrances Perpendicular Number Per Minute	Pct.	Total Number Per Minute
1	11:00 A.M.	1.75	23.7	4.38	59.4	1.25	16.9	7.38
2	11:30 A.M.	3.11	28.9	4.89	45.4	2.87	25.7	10.78
3	2:00 P.M.	0.45	15.0	1.72	57.3	0.83	27.7	3.00
4A	2:30 P.M.	0.58	26.7	1.17	53.9	0.42	19.4	2.17
[1]4B	2:30 P.M.							1.08

TABLE 5.—*The Number of Fish Per Minute For the First Nine Intervals of Count: Natural Conditions Versus Conditions After the Count Cloth Was Placed In Water*

Time (Minutes)	NUMBER OF FISH Station Number 2 No Cloth vs. Cloth	Station Number 1 Cloth
1—3	7.7 15.7	13.3
4—6	9.7 15.3	8.7
7—9	7.0 7.0	7.3

The preceding tables illustrate the reaction of the fish to the white count cloth after the disturbance of placing the count cloth in the water had ceased. The minnows in the immediate vicinity of the count cloth converged on it with the maximum counts usually being twice as great as the maximum counts usually being twice as great as the maximum numbers usually tallied. After the count cloth had been in the water for an hour or two, the minnows did not avoid the count cloth, but, at the same time the period of time they remained over the quadrat for a much shorter length of time. In the statistical tests the data used was chosen so that the converging effect of minnows on the count cloth was minimized.

Influence of Wave Action on the Distribution of Small Fish: Another factor influencing the distribution of small fish seems to be the amount of wave action. The whole shoreline was checked on a

[1]4A counted at same time as 4B and the quadrats were adjacent. Total tabulation for only 4B. Counts 1 to 4A were the same quadrat; the count cloth was absent in 1 and 4A.

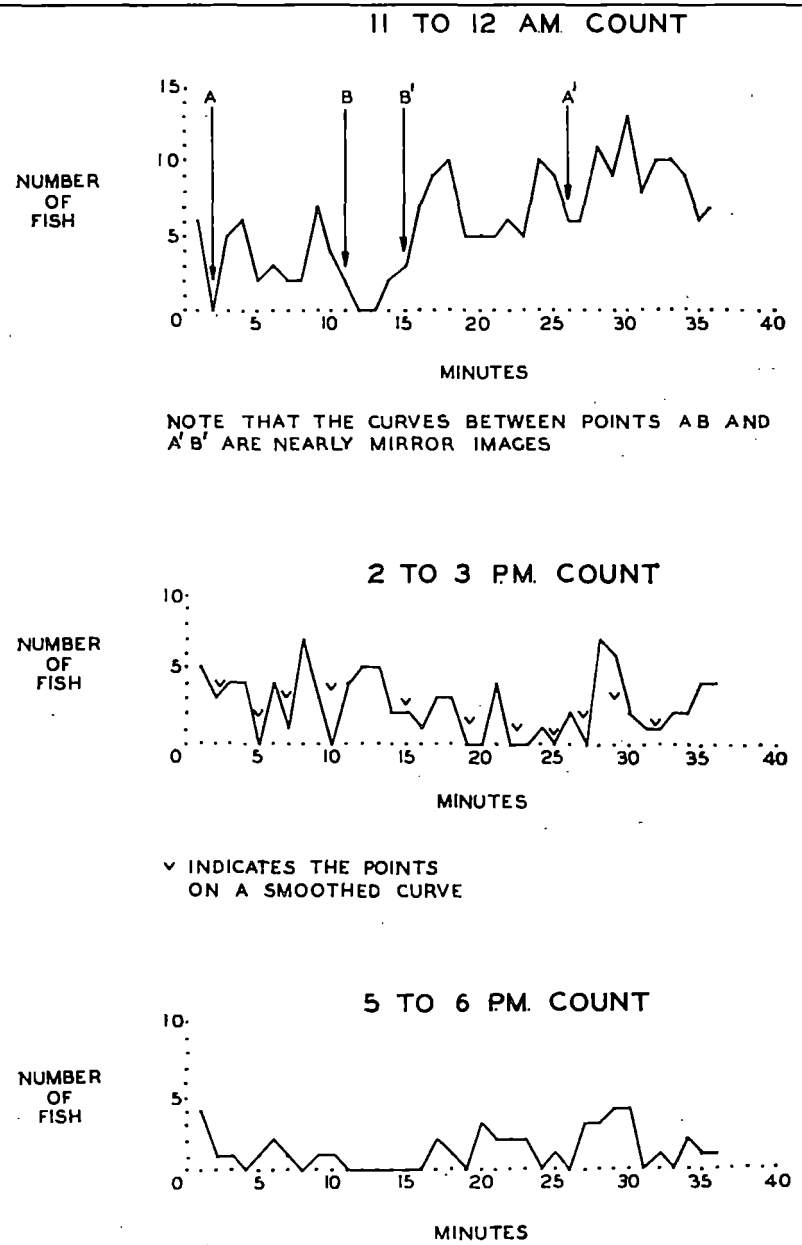

Fig. 1. Three thirty-six minute quadrant counts from station number one at different times of day showing the variations of the number of minnows present at one minute intervals.

windy day and it was noted that the minnows were present only in sheltered areas. The sheltered areas usually consisted of fallen logs or brush; and three inch waves caused enough disturbance to force the minnows into sheltered areas.

DISCUSSION AND CONCLUSIONS

The statistical literature is uninstructive as to how a series of data can be analyzed when the single units tend to occur in aggregative or schools and when both the single unit and size of the clump effect an amount per unit estimate. In many situations it is possible to measure the single unit only. The problem might be possibly solved through a modified application of the sign test or through a somewhat modified use of a table of random numbers. With some modifications in the tabulating and counting, the techniques used here could be used as indices of abundance.

The foregoing data illustrate that the minnows traveling over the quadrats were: (1) traveling parallel to the shoreline; (2) traveling in groups; (3) the minnows were most active during the middle of the day; and (4) their movements were not random with respect to the quadrat.

LITERATURE CITED

DIXON, WILFRED J. and FRANK J. MASSEY, Jr. 1951. *Introduction to Statistical Analysis*. New York, McGraw-Hill Book Co., Inc.