FISHERIES RESEARCH BOARD
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MANUSCRIPT REPORTS OF THE BIOLOGICAL STATIONS

No. 263

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Destruction of undesirable fish in Cassidy lake,
New Brunswick, by poison.

Author

M. W. Smith.

F I S H E R I E S R E S E A R C H B O A R D
O F C A N A D A

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Atlantic Biological Station, St. Andrews, N.B.

The principal sport fish in the Maritime lakes is the speckled trout. The lake trout (Cristivomer), land-locked salmon, and, to a lesser degree, the smallmouth black bass are also prized, but these species do not have the general distribution of the speckled trout in the region. In general all other species are considered undesirable by the anglers.

Maritime lakes present habitats as suitable, if not more so in many instances, for a number of undesirable species as for the speckled trout. When trout populations in lakes are reduced by angling, undesirable fish, if present, may occupy the ecological niche formerly held by the trout, and with increased competition, and in many cases predation by other species, trout populations are not restored, or even maintained at lower levels, by natural reproduction or by stocking. Only by control of the undesirable species can possible worthwhile improvement in the trout angling be realized by stocking, fertilizing the water or other procedure. Obviously the most effective control is the destruction of all the unwanted fish.

Rotenone, as contained in derris and cubé powder, is toxic to fish in low concentrations (at least as low as 0.5 p.p.m. of derris powder containing 5% rotenone) and is fairly specific in its action. Except for the microcrustaceans, most limnetic invertebrates are not affected at concentrations necessary to kill fish. However, it has been found that derris powder does not kill all fish in moderately deep Maritime lakes with thermally stratified waters, presumably because of inadequate dispersion of the poison throughout the entire volume of water. Accordingly derris powder has been considered limited in its usefulness as a fish poison to unstratified waters in which effective dispersion is assured. In recent years "emulsifiable rotenone" and "wettable rotenone paste" have been made available for which better dispersion has been claimed, but apparently the products are questionably effective in stratified waters over 20 to 25 feet in depth.

In 1947 a new fish poison -- "Fish-tox" -- was placed on the market. For it, the manufacturers make the following claims (Reynolds: The chemical eradication of undesirable fish. pp. 7-8):

"1. Approximately as low in cost as 5% wettable ground (derris) root.

2. Effective in very low dilutions.

3. As effective in low as high water temperatures.

4. Rapid, uniform, positive and self-dispersion to attain: (a) Penetration of the thermocline to the bottom of the deepest lake. (b) Thorough saturation of the water in the presence of heavy aquatic growth and organic or inorganic suspension.

5. Sustained toxicity -- effective for several days after application.

6. Non-poisonous to warm blooded animals.

7. Non-poisonous to aquatic insect life or crustacea.

8. Effectiveness increasing in proportion to the dosage used.

9. Even in very cold water, toxicity must dissipate within a thirty to sixty day period.

10. Easy to apply and not deleterious to the health or comfort of the applicator."

(The manufacturers have not divulged the ingredients in Fish-tox since the product has not yet been patented in the United States.)

In co-operation with the Fish Culture Development branch of the Department of Fisheries it was considered desirable to test "Fish-tox" in Maritime waters.

For some time the Sussex branch of the New Brunswick Fish and Game Protective Association has requested the Fish Culture Development branch to destroy the undesirable fish in Cassidy lake, Kings county, N.B., as the preliminary step in an attempt to restore a trout population. This lake reputedly provided good trout angling in the past, but, as claimed, the trout population declined, following the introduction of chain pickerel (Esox niger) by a local resident, to the point where in recent years, few, if any trout were taken by the anglers. Stocking this lake in 1939 and 1940 with 10,000 No. 1 trout fingerlings per year presumably made no improvement in the angling (Rodd: Annual Report on Fish Culture, 1939 and 1940, Ottawa, 1941).

On July 7, 1948, Cassidy lake was visited by the writer and Mr. Percy Hills, Supervisor of Fish Culture. The water was found thermally stratified in the deeper parts of the lake.

In view of the conditions that obtained in Cassidy lake it was decided to use this lake as a test area to study the effectiveness of "Fish-tox".

Proposed program of study

At a meeting at the Atlantic Biological Station on July 17, 1948, attended by Messrs. James Catt, Frank Tingley, Elmer H. Anthony and M. W. Smith, a program was drawn up, summarized as follows:

1. Study of effect of poison upon the invertebrate fauna.
   (a) Plankton - tows with nos. 5 and 18 plankton nets before and after poisoning.

   (b) Bottom fauna - sampling at ten stations, during the week prior to the poisoning and repeated during the week after treatment -- stations to be indicated by buoys and located from the littoral to the deepest-water zones.

2. Study of the dispersion and disappearance of the poison, as shown by the action of the poison upon fish held in cages at surface, half-depth and bottom (oxygen content of bottom water permitting).

   (a) Control tests before poisoning.

   (b) Tests during poisoning operations.

   (c) Tests after poisoning, at weekly intervals if possible, until the toxicity disappeared.

   (d) Use as many of following species as possible: pickerel, yellow perch, killifish, trout, bullhead, eel.

3. Hydrographic information.

   (a) Dissolved oxygen content of the water determined concurrently with retention of fish in cages and at levels at which cages held.

   (b) Temperature of water with oxygen sampling, and to indicate the extent of thermal stratification at the time of poisoning.

   (c) pH determinations, just prior to and after poisoning.

4. Two applications of Fish-tox planned, the first to give a concentration of 0.5 p.p.m., and a second, to assess the effectiveness of the first, of 1.0 p.p.m. -- the second treatment to be made about one month after the first if not too late in the season, otherwise to be carried out in 1949.

5. Estimate of fish population.

(a) Collection and enumeration, as to species, of all fish on 10 to 20 sections of the shore-line, each section 100 ft. in length. Sections to be purposely rather than randomly placed at approximately equal intervals around the lake.

(b) Collection and preservation of all fish found at least on one section to approximate as closely as possible a representative sample of the fish population for size and weight.

6. Erection of barrier dam in outlet.

This dam to be erected before the treatment with poison or while the waters in the lake are still toxic to fish.

The poison was not available until late in the season. Although the waters were no longer thermally stratified, the Fish Culture Development branch considered it advisable to proceed with the initial treatment and the poison was added to the lake on September 30 and October 1. Mr. Anthony, who was to make many of the observations upon the effect of the poison upon the invertebrate and fish life, carried out preliminary work in August and early September, but returned to university on September 15. As it developed certain phases of the program were incompletely carried out and others not attempted. A barrier dam was erected in the outlet before the poisoning operations.

Cassidy Lake

Location

Cassidy lake is situated in Kings county, New Brunswick, about fifteen miles from the town of Sussex (Cassidy lake is designated as DeForest lake by the Topographical Survey of Canada.) The lake lies at an elevation of 415 feet, in a region of rolling largely wooded hills. The outflow drains, by way of Lake brook, into the Hammond river, a tributary of the Kennebecasis river (Fig. 1).

The drainage area feeding the lake covers only about five square miles, with the result that inflowing streams are small and intermittent. Except for the eastern shores, farms surround the lake.

The lake lies in an area of sedimentary rocks (shale, limestone sandstone, gypsum) of the Mississippian period (Can. Dept. of Mines, Geological Survey, Map 259A, 1931).

Morphometry

A detailed survey for area and depth was made by the Sussex branch of the New Brunswick Fish and Game Protective Association (Fig. 2).

Table I. Morphometric features of Cassidy lake.

Area: 10,163,200 sq. ft.; 233.3 acres; 94.4 hectares

Volume: 127,154,000 cu. ft.; 3,601,000 cu. m.

Maximum length: 6,300 ft.; 1920 m.

Maximum width: 2,550 ft.; 777 m.

Maximum depth: 36 ft.; 11.0 m.

Mean depth: 12.5 ft.; 3.8 m.

Perimeter: 18,560 ft.; 5657 m.

Shore development: 1.66

Table II Area, depth and volume relationships

Depth ft.	Area sq. ft.	As % of surface area	Stratum ft.	Volume of water in stratum cu. ft.	As % of total volume
0	10,163,200	100.0	0-3	29,022,500	22.8
3	9,194,400	90.5	3-6	24,997,000	19.7
6	7,498,400	73.8	6-9	19,672,000	15.5
9	5,658,800	55.7	9-12	15,138,400	11.9
12	4,457,200	43.9	12-15	11,938,100	9.4
15	3,520,000	34.6	15-18	9,216,200	7.2
18	2,644,800	26.0	18-21	6,533,600	5.1
21	1,742,400	17.1	21-24	4,455,300	3.5
24	1,242,000	12.2	24-27	3,186,100	2.5
27	891,600	8.8	27-30	1,916,580	1.5
30	416,000	4.1	30-33	887,850	0.7
33	190,400	1.9	33-36	190,400	0.2
				127,154,030	

Hydrography

A vertical temperature series taken in 29 ft. of water on July 7, 1948, showed thermal stratification, with a thermocline in approximately the 15 to 18 foot stratum. Another series taken on September 30, 1948, in 33 feet of water showed almost a homothermous condition from surface to bottom, indicating that the fall mixing had previously taken place (Appendix I).

On July 7, 1948, the dissolved oxygen content at 21 ft. was about half saturation, with a further reduction in the saturation value to 41 per cent at 27 ft. (Appendix I). The low dissolved oxygen content in the deeper water pointed to stability in the thermal stratification of the water during

the summer season. It would seem probable that the amount of oxygen in the bottom waters in the deeper parts of the lake would be insufficient for most fish by late summer.

Except as affected by decomposition in the hypolimnion the water of the lake is slightly alkaline. The pH values observed on July 7, 1948, with an universal indicator, were 7.0 - 7.5 at the surface and 6.5 at 27 ft. The surface value on September 30, 1948, was 7.3 (Bromothymol Blue).

Plankton

Fifteen-minute plankton tows were made with number 5 and 18 nets at 0-1 metre depth on September 29, 1948. The tows were noteworthy in that they contained very little plankton. The amount of settled plankton was 1.0 and 1.4 ml. with the number 5 and 18 nets respectively.

The small amount of zooplankton consisted almost entirely of rotifers:

Keratella cochlearis

Polyarthra platyptera

Trichocera sp

Notholca longispina

Asplanchna sp

(The identifications have not been checked by a specialist). A few specimens of the cladocerans, Bosmina longispina and Ceriodaphnia reticulata, as well as metanauplius and copepodite stages of Cyclops, were found.

In the small quantity of phytoplankton one species of each of the following genera of algae was noted:

Myxophyceae - Chroococcus, Aphanocapsa, Microcystis, Anabaena

Chrysophyceae - Mallomonas, Synura, Uroglenopsis, Dinobryon,

Bacillarieae - Asterionella, Surirella

Chlorophyceae - Eudorina, Volvox, Sphaerocystis (?), Pediastrum, Dimorphococcus, Euastrum, Arthrodesmus, Spondylosium, Hyalotheca, Staurastrum (4 spp.)

Dinophyceae - Glenodinium (?) Ceratium

Rooted aquatic vegetation

The bottom of the shallow eastern basin of the lake appeared to be almost entirely covered with growths of Potamogeton sp. Beds of emergent vegetation were general in the littoral zone around the entire lake.

Treatment with Fish-tox

The concentration of Fish-tox planned for the initial treatment was 0.5 p.p.m. On September 30 and October 1, 1948, 3880 lbs. of the poison were distributed in Cassidy lake, which on the calculated volume of 127, 154,030 cu. ft. give a concentration of 0.49 p.p.m.

The poison was purchased by the Fish Culture Development branch from Standard Supply Distributors, Wenatchee, Wash., and the distribution in Cassidy lake was under the charge of Mr. Frank Tingley, Supervisor of Fish Culture. Members of the Sussex branch of the N.B. Fish and Game Protective Association, Drs. D. G. Wilder and M. W. Smith of the Atlantic Biological Station, and the local Fisheries Officer assisted.

The poison was delivered in pails, each containing 40 lbs., and in a form termed a "dry paste" by the manufacturers.

To assist in the distribution it was calculated, according to the volume of water involved, that about 14 per cent or 640 lbs. of the poison were required to treat the shallow eastern part of the lake (Fig. 2). The deeper western portion of the lake was zoned into four sections by markers placed at 300-yard intervals along the south and north shores. An estimate was also made of the amount of poison that should be distributed in each of these sections.

For distribution, the poison was transferred to gunny sacks, 40 lbs. to each sack. On September 30, the sacks containing the poison were towed at the surface behind boats, either driven slowly by outboard motors, or rowed. On October 1, with the boat driven at a faster speed, the poison was distributed more rapidly by moving the sack manually up and down in the water at the side of the boat and by some kneading. The shallow water at the shore-line was treated by dragging a sack of the poison around the entire lake on September 30. Pools in the almost-dry inflowing stream at the western end of the lake were also treated, as was the outlet as far as the barrier dam.

During the afternoon of September 30, over a period of about six hours, eight men in four boats, three of which were equipped with outboard motors, distributed 3000 lbs. of Fish-tox over the western portion of the lake. Trouble with motors slowed the operations. During approximately three hours on the morning of October 1, three men in a boat, driven by an outboard motor, distributed 800 lbs. of the poison principally over the

shallow eastern end of the lake. Distribution of the poison on October 1 was hastened by driving the boat at a faster rate, by more movement of the sacks up and down in the water and by some kneading of the material from the sacks. Two men distributed 80 lbs. of poison in about four hours in the shallow waters around the shore, in pools in a small inflowing stream, and in about one-quarter of a mile of the outlet stream.

During the poisoning there was a moderate to light westerly wind.

Vertical dispersion of the poison

On September 30 (about 12:00 N), before poisoning operations began, 15 pickerel, 51 killifish, 26 yellow perch and 5 golden shiners were placed in crates (2' x 2' x 3') of wire screening on wooden frames and sunk to a depth of 10 metres in the lake. The lengths of the fish used in the test are given in Appendix II. These fish were caught in Cassidy lake on September 29 by angling and by seining, and confined over night in crates held in shallow water near shore.

The surface water over the area in which the crates were sunk was treated with Fish-tox at about 4:00 p.m. September 30. The crates were raised at about the same hour on October 1. At that time, two of the large pickerel, two yellow perch and all of the golden shiners were dead, but the remainder of the fish showed no indications that they were affected by the poison. It was concluded that the fish found dead had died from handling and confinement in the crates rather than from poisoning and that the poison had not penetrated to a depth of ten metres in lethal concentration, if at all, during the 24-hour period.

Action of the poison upon the fish

Within thirty minutes, or even less time, fish were distressed by the poison in areas that were treated. When first affected, many of the fish made violent aimless movements which often resulted in breaking the surface of the water. It was observed, however, that some fish at least became quiescent for quite long periods before death ensued. Eels, suckers and other species were found in shallow water at the shore seemingly dead, but swam away when touched. In one instance a large sucker was noted in a distressed but quiescent condition in shallow water on October 2. Twenty-four hours later the same fish was still alive and would swim when prodded. This fish, as well as others affected by the poison, were apparently blinded, with the eyes quite opaque. Many eels came entirely out of the water upon the shore.

Certain species appeared more resistant to the poison than others, although judgement in this regard may have been quite faulty, since little was actually known of the distribution of the fish in the lake, and whether one species was subjected to a lethal concentration of poison much before another. However, due to the shallowness of the water it would seem probable that all of the species in the eastern part of the lake would encounter the poison within a short period of time. From the field observations the species have been listed as follows in order of increasing resistance to Fish-tox. The listing must be considered tentative. More precise information can be secured only from controlled experiments.

alewife
pickerel
yellow perch
white perch
killifish
sucker
pumpkinseed
common shiner
golden shiner
bullhead
eel

On October 3 all of the alewives, pickerel, yellow and white perch that were seen were dead, but numbers of the other species were observed alive. On that date notes were made upon the numbers of fish observed alive along the south shore west of the boat landing (Fig. 2). The ratio of live to dead fish along this shore was very small, however, the total number of fish on shore became progressively smaller in going from the first to the fourth section.

Table III. Fish observed alive along the south shore of Cassidy lake, Oct. 3.

Species	First 300-yard section west of boat landing	Second 300-yard section	Third 300-yard section	Fourth 300-yard section, taking in western end of lake
Killifish	0	3	1	2
Sucker	1	3	0	1
Pumpkinseed	5	2	0	4
Common shiner	0	0	2	5
Golden shiner	1	4	4	9
Bullhead	0	4	0	0
Eel	many	many	many	many

It was noted that of the golden shiners and eels observed alive those at the western end of the lake, adjacent to the water first treated, were the most active individuals. A few golden shiners were very active and difficult to capture in a dip-net. There was the suggestion that the poison in this area was falling below a toxic concentration, and that some fish, which for some reason had not as yet been subjected to a lethal dose, might survive the poisoning. In general, however, the fish that were noted alive were in a distressed condition.

Observations upon the fish population

Species present

A list of the species found in the lake following the poison is as follows:

1. Pomolobus pseudo-harengus (Wilson) - Alewife.
2. Catostomus commersonnii (Lacepede) - Common white sucker.
3. Notemigonus crysoleucas (Mitchill) - Golden shiner.
4. Notropis cornutus (Mitchill) - Common shiner.
5. Ameiurus nebulosus (LeSueur) - Brown bullhead.
6. Esox niger LeSueur - Chain pickerel.
7. Anguilla bostoniensis (LeSueur) - American eel.
8. Fundulus diaphanus (LeSueur) - Killifish.
9. Morone americana (Gmelin) - White perch.
10. Perca flavescens (Mitchill) - Yellow perch.
11. Lepomis gibbosus (Linnaeus) - Pumpkinseed.

Relative abundance of the species

Counts were made of the fish on four 100-foot sections of the shore-line. Sections I and II were along the south shore, the former east and the latter west of the boat-landing. The other two stations were on the north shore (Fig. 2).

The numbers of each species from the four sections are given in table IV. The counts cannot be considered very representative of the total population since the number of sections was small, and fish, particularly eels, were still dying and not recorded when the counts were made. Accordingly the order of numerical abundance shown in table IV can be considered only approximate. A rough classification may be given as follows:

Dominant - eel
golden shiner

Subdominant - alewife
pickerel
yellow perch

Common - killifish
pumpkinseed

Relatively scarce - common shiner
bullhead
sucker
white perch

Table IV. Numbers of fish counted on four 100-foot sections of the shore-line of Cassidy lake.

	Section I		Section II	Section III	Section IV	Av.wt.(gm.) No. for wt. in brackets
	Oct.2	Oct.3	Oct. 2	Oct. 3	Oct. 3	
alewife	18	25	41	266	76	2(18)
sucker	-	-	1	7	1	162(7)
golden shiner *	259	120	44	339	62	4(258)
common shiner *	-	-	-	27	-	5(24)
bullhead	4	8	3	4	2	73(11)
pickerel	12	3	32	196	134	149(75)
eel	8	354	260	118	80	35(258)
killifish	15	7	61	5	4	2(61)
white perch	-	-	-	6	-	212(6)
yellow perch	46	6	42	101	38	28(86)
pumpkinseed	3	16	2	26	7	14(16)

* A certain number of the fish of the year belonging to these two species may have been confused with each other in the field, especially in section III.

A sample of the fish was preserved and subsequently weighed. Also some were measured and weighed in the field. In Table IV the average weight for each species is presented. The eels and pickerel occupied the dominant position in the total weight of the population. By reference to weight the dominant position of the pickerel is more clearly shown. Species of small average size, such as the alewife and golden shiner which were numerically abundant, had less significance in the population when reference is also made to weight. The relatively scarce sucker and white perch were among the largest fish in the lake.

In considering the average weight of the fish it is to be kept in mind that the sample for weight was not satisfactorily representative, being moreso for the alewife which was present only as fish of the year, than for the eel and pickerel, with several year classes present.

The sample for weight was secured mainly from sections I and II, with lesser numbers from section III.

Total population of fish

It was originally planned to make an estimate of the total fish population. It became evident, however, that the number of fish involved was so large that five or six men would be required during the few days following the poisoning in order that an adequate number of shore areas could be covered to give a worthwhile estimate, providing, among other factors, that those fish which sunk to the bottom upon being killed would subsequnetly float at the fairly low water temperatures that prevailed when the lake was treated. Since the situation that obtained was not fully appreciated, the necessary assistance was not available to carry out the plan.

Growth and other characteristics of the fish

Length and weight measurements, and age determinations when made, are recorded in Appendix III.

Alewife. Local residents claimed that in recent years at least alewives had spawned in Cassidy lake only in 1947 and 1948. The species was represented in the lake by fish of the year. The average notch length of 18 specimens was 3.8 cm. (s = 0.87 cm.).

Sucker. In a sample of seven suckers, six were 1+ years of age (average notch length, 15.5 cm.) and one about 11+ years. A scarcity of intermediate year classes was also noted in the field.

Golden shiner. The golden shiner was one of the most successful species in the lake, and the length frequencies in the preserved sample indicate a healthy condition of the population with large 0+ and, presumably, 1+ age groups.

Common shiner. Of all the species in the lake the common shiner was the only one that appeared to have a limited distribution. It was only collected with any certainty at the western end of the lake.

Bullhead. Like the sucker population, that of the bullhead was almost entirely represented by young and old fish, with a scarcity of intermediate age groups. Nine individuals in the sample had an average total length of 6.7 cm., presumably fish of the year, and two others with lengths of 29.6 and 30.7 cm.

Pickerel. The abundance of small fish in Cassidy lake provided an excellent food supply for the piscivorous pickerel. That this species did not dominate the fish population more is considered noteworthy. As far as could be learned the pickerel was subjected to little angling in Cassidy lake.

Age-length relationships are given in Table V.

Table V. Mean notch length of pickerel at several ages.

Number in sample	Age	Mean length cm.	Standard deviation
39	0+	10.6	2.22
21	1+	24.6	3.36
5	2+	33.0	6.17
4	3+	37.0	-
3	4+	43.6	-
1	5+	44.3	-
1	6+	51.9	-

Eel. A prominent feature of the fish population in Cassidy lake was the abundance of small eels. There was a large group with a modal total length at 11-12 cm. (Appendix III). Large eels approaching maturity were relatively scarce. From these observations as well as others made upon headwater lakes, there is the suggestion that eels move out of such lakes into more extensive waters (lakes, estuaries, etc.) lower in the drainage system some years before maturity.

Killifish. The killifish is an ubiquitous species in Maritime lakes and not infrequnetly holds a dominant position numerically, unlike the situation found in Cassidy lake.

White perch. In the small sample obtained there were four fish 2+ years of age, one 8+ and another about 11+ years. Similar to the situation when the fish populations were poisoned in Potter's lake, N.B., and in lakes Jesse, Tedford and Trefry's, N.S., no white perch of the year were found.

It would appear to be an anomaly that certain intermediate year classes were apparently absent in the cases of the white perch, bullhead, sucker and yellow perch. There are no obvious reasons that the habitat in Cassidy lake should be less suitable for these species than for others found in the lake. Short-term adverse conditions at spawning time could determine an unsuccessful year class, and such conditions

would not be readily apparent except by intensive study. The situation raises the question whether there are periodic cycles in the abundance of limnetic fish comparable to those which are well known for other animals. Most studies of limnetic fish are made upon species of interest to the anglers and accordingly subject to angling pressure, with the result that changes in abundance, even if periodic, tend to be attributed to angling rather than to any inherent cyclic changes that might be peculiar to a species.

Yellow perch. The age-length relationship found in the sample of yellow perch is set forth in Table VI.

Table VI. Mean notch length of yellow perch at several ages.

Number in sample	Age	Mean length, cm.	Standard deviation
6	0+	5.3	0.79
-	-	-	-
34	3+	12.1	1.22
40	4+	13.3	1.55
5	5+	16.9	2.41

A feature of the yellow perch population was the absence, or at least a scarcity, of fish belonging to the 1+ and 2+ age groups.

Pumpkinseed. Only a small number of this species was preserved. Their growth characteristics are shown in table VII. No fish of the year were observed.

Table VII. Mean notch length of pumpkinseed at several ages.

Number in sample	Age	Mean length, cm.	Standard deviation
9	1+	8.2	1.75
5	2+	9.7	1.11
1	3+	12.7	-
1	5+	17.2	-

Second treatment of Cassidy lake with "fish-tox"

According to plans the lake will be treated in 1949 with sufficient "Fish-tox" to give a concentration of 1.0 p.p.m., to test the effectiveness of the treatment with 0.5 p.p.m. made in 1948. The treatment will again be made under the auspices of the Fish Culture Development branch.

Certain recommendations may be made:

(1) that the 1949 treatment be carried out when a well-defined thermal stratification of the waters develops, probably in late June or early July;

(2) that a program, similar to the one laid down for 1948, with respect to a study of the dispersion of the poison and with respect to a study of the effect of the poison upon the invertebrate fauna be carried through as thoroughly as personnel and time permit;

(3) that hired labour be secured rather than volunteer assistance to distribute the poison;

(4) that the weedy littoral areas be treated with a spray-pump.

Acknowledgements

The field observations were made in company with Dr. D. G. Wilder. Mrs. L. Miller carried out most of the age determinations of the fish. Mrs. Miller and Miss M. Holmes made the measurements upon the fish which were preserved and brought into the laboratory.

Appendix I

Temperature and dissolved oxygen content of the water

Temperature

July 7, 1948 10:00 a.m., AST Cloudy to clearing Air: 19.1°C.		September 30, 1948. 10:10 a.m. AST Clear Air: 16.6°C.	
surface	19.1°C.	surface	14.5
9 ft.	19.2	2 metres	14.45
15 "	18.3	4 "	14.45
18 "	15.2	6 "	14.4
21 "	13.5	8 "	14.35
24 "	12.1	10 "	13.9
29 "	11.6		

Dissolved Oxygen Content

July 7. 1948

Depth ft.	Temp. °C.	Ml./l.	% sat.
3	19.1	5.28	81
15	18.3	5.42	82
21	13.5	3.73	51
27	11.8	3.09	41

Appendix II

Lengths (notch) of fish held in cages to test dispersion of Fish-tox to the bottom water, Sept. 30 - Oct. 1, 1948.

Yellow perch		Killifish		Pickerel	Golden shiner
notch length, cm.	frequency	total length, cm.	frequency	notch length, cm.	notch length, cm.
4.4	1	5.3	1	8.8	5.4
4.5	2	-		8.9	5.8
4.6	2	5.6	3	9.4	5.9
4.7	6	5.7	2	9.5	6.3
4.8	2	5.8	1	9.9	
4.9	2	5.9	3	11.6	n = 4
5.0	1	6.0	1	27.8	plus one
5.1	1	6.1	2	29.8	damaged.
5.2	2	6.2	5	32.6	
5.3	2	6.3	2	32.7	
5.4	1	6.4	2	35.6	
5.5	1	6.5	2	36.6	
-		6.6	4	40.9	
6.0	1	-		42.5	
-		6.8	2	44.9	
6.7	1	6.9	2		
6.9	1	7.0	5	n = 15	
	n =26	7.1	4		
		-			
		7.3	2		
		7.4	1		
		-			
		7.6	1		
		7.7	1		
		7.8	1		
		-			
		8.5	1		
		-			
		8.9	1		
		-			
		9.1	1		
		-			
		9.4	1		
			n = 51		

Appendix III

Length, weight, age and sex of fish in the sample from Cassidy lake.

Alewife (all fish of the year)

Total length cm.	Weight gm.
5.1	1.3
5.3	0.9
5.5	1.3
5.5	1.4
5.6	1.4
5.6	1.5
5.6	1.6
5.6	1.9
6.0	1.9
6.0	2.3
6.3	2.2
6.5	2.2
6.7	2.6
6.7	2.6
6.9	2.5
7.3	3.4
7.5	3.3
8.3	4.7

n = 18

Sucker (originally weighed to nearest 0.1 oz.)

1+		11+	
notch length, cm.	weight gm.	notch length, cm.	weight, gm.
12.4	31.2	45.0	763
15.4	53.9		
15.6	56.7		
16.1	59.5		
16.4	59.5		
16.8	55.2		

Appendix III (cont'd.)

Golden shiner (presumably fish of the year)

Total length cm.	weight gm.	frequency
2.8 - 3.0	0.1	3
3.0	0.1	6
3.0	0.2	4
3.1	0.1	2
3.1	0.2	2
3.2	0.1	2
3.2	0.2	4
3.3	0.1	1
3.3	0.2	11
3.3	0.3	1
3.4	0.1	1
3.4	0.2	7
3.4	0.3	6
3.5	0.2	7
3.5	0.3	11
3.6	0.2	2
3.6	0.3	7
3.7	0.3	6
3.7	0.4	1
3.8	0.2	1
3.8	0.3	2
3.8	0.4	3
3.9	0.4	2
4.0	0.4	2
4.0	0.5	1
4.1	0.3	1
4.1	0.4	2
4.4	0.5	1

n = 99

Appendix III (Cont'd.)

Golden shiner (older fish)

Notch length cm.	weight gm.	notch length cm.	weight gm.	notch length cm.	weight gm.	notch length cm.	weight gm.
4.7	1.1	6.1	2.6	8.8	7.3	10.9	16.0
5.0	1.2	6.2	1.8	8.8	7.5	11.0	15.8
5.1	1.1	6.2	2.0	8.8	7.6	11.0	14.0
5.1	1.3	6.2	2.5	8.8	7.6	11.6	18.6
5.1	1.3	6.2	2.5	8.8	7.9	11.6	20.1
5.1	1.3	6.3	2.3	9.0	7.9	11.7	19.6
5.1	1.4	6.3	2.3	9.0	8.0	12.1	24.0
5.2	1.6	6.3	2.6	9.0	8.6	12.2	21.0
5.3	1.3	6.3	2.7	9.0	8.7	12.4	22.7
5.3	1.4	6.3	2.8	9.0	8.8	12.7	26.1
5.3	1.6	6.4	2.3	9.1	8.0		
5.4	1.4	6.4	2.5	9.1	8.3	n = 158	
5.4	1.5	6.4	2.6	9.2	8.1		
5.4	1.9	6.4	2.9	9.2	8.4		
5.5	1.9	6.5	2.4	9.2	8.9		
5.6	1.6	6.5	2.8	9.2	10.7		
5.6	1.8	6.5	2.8	9.3	8.6		
5.6	1.8	6.5	2.9	9.3	9.0		
5.6	1.9	6.6	2.8	9.3	9.1		
5.7	1.7	6.6	3.0	9.3	9.2		
5.7	1.7	6.7	2.3	9.4	8.9		
5.7	1.8	6.7	3.1	9.4	9.7		
5.7	1.8	6.9	3.2	9.4	10.9		
5.7	1.8	7.0	3.2	9.5	9.5		
5.7	1.9	7.2	4.3	9.5	10.0		
5.7	1.9	7.3	3.8	9.5	10.0		
5.7	1.9	7.3	4.0	9.5	10.3		
5.7	2.0	7.5	4.7	9.6	9.4		
5.7	2.0	7.8	5.3	9.6	10.2		
5.8	1.8	7.9	4.9	9.6	10.2		
5.8	1.8	7.9	5.9	9.6	10.7		
5.8	1.9	8.0	5.2	9.7	11.9		
5.8	2.0	8.0	5.5	9.9	9.5		
5.8	2.1	8.0	5.5	9.9	11.0		
5.8	2.3	8.1	5.2	10.0	11.8		
5.9	1.8	8.1	6.1	10.0	12.7		
5.9	2.0	8.2	5.7	10.1	11.7		
5.9	2.0	8.2	5.9	10.1	12.3		
5.9	2.1	8.2	6.0	10.2	12.5		
5.9	2.2	8.3	6.0	10.2	13.0		
6.0	1.7	8.4	6.7	10.4	12.4		
6.0	2.2	8.4	6.8	10.4	13.8		
6.0	2.2	8.4	7.2	10.5	12.9		
6.0	2.3	8.4	7.3	10.6	14.3		
6.0	2.4	8.5	7.1	10.7	14.3		
6.0	2.4	8.6	6.7	10.7	16.9		
6.1	2.2	8.6	8.0	10.8	15.1		
6.1	2.2	8.7	6.8	10.8	15.6		
6.1	2.3	8.8	7.1	10.9	15.7		

Appendix III (cont'd.)

Common shiner

Notch length cm.	weight gm.
5.4	1.4
5.4	1.5
5.6	1.6
5.9	2.8
6.0	2.0
6.1	2.0
6.2	2.3
6.5	2.5
6.6	2.5
6.7	3.3
7.0	3.8
7.1	3.2
7.3	3.7
7.3	4.2
7.3	4.4
7.5	4.6
7.7	4.3
7.8	4.6
8.4	6.5
8.5	7.0
9.1	8.8
9.8	11.1
10.0	12.3
10.2	14.1

n = 24

Appendix III (cont'd)

Bullhead

total length cm.	weight gm.
6.0	4.2
6.3	3.9
6.4	3.8
6.4	4.2
6.6	4.7
7.0	5.1
7.0	5.2
7.1	5.3
7.5	6.2
29.6	*340.
30.7	*416.

n = 11
* originally weighed in field to nearest 0.5 oz.

Pickerel

(Measured and weighed to 0.1 gm. in laboratory)
(all fish of the year)

notch length cm.	weight gm.	notch length cm.	weight gm.
8.1	3.2	9.7	5.0
8.5	3.8	9.8	5.3
8.6	3.8	10.1	7.2
8.6	4.2	10.2	5.9
8.7	3.9	10.2	6.6
8.8	4.2	10.3	6.3
8.8	4.4	10.3	6.9
9.1	4.1	10.8	6.9
9.1	4.7	10.9	7.0
9.1	5.2	11.6	9.7
9.2	4.1	12.1	11.0
9.2	4.4	13.9	15.1
9.2	4.7	13.9	15.8
9.3	4.0	14.5	19.1
9.3	4.5	14.8	22.7
9.3	5.7	14.9	21.3
9.4	4.6		
9.4	4.8		
9.5	4.6		
9.6	4.8		

n = 36

Appendix III (cont'd.)

Pickerel

(measured and weighed to 0.5 oz. in field)

notch length cm.	weight gm.	Age	Sex
14.5	28.4	0+	
14.9	31.2	0+	
15.4	31.2	0+	
19.5	59.5	1+	
20.6	68.0	1+	
20.9	68.0	1+	
21.2	73.7	1+	
21.4	79.4	1+	
21.7	82.2	1+	
22.8	85.1	1+	
23.0	111.	1+	
23.7	90.7	1+	
23.9	99.2	1+	
24.0	102.	2+	
24.1	93.6	1+	
24.1	108.	1+	
24.9	113.	1+	
24.9	119.	1+	
25.0	113.	1+	
25.3	116.	1+	
25.8	141.	1+	
25.9	150.	1+	
26.5	159.	1+	
27.5	170.	1+	
29.5	201.	2+	
31.4	238.	1+	
33.6	298.	1+	
35.2	312.	2+	♀♀♂♂
36.8	425.	3+	
38.2	422.	2+	
39.2	525.	2+	
41.1	567.	3+	
42.9	482.	4+	♂
42.9	712.	4+	
43.7	720.	3+	
44.3	839.	5+	♂ ♀
44.6	661.	3+	♂♀
45.0	822	4+	
51.9	1361	6+	♀

n = 39

Appendix III (cont'd.)

Eels

(All measured in laboratory, weight to nearest 0.1 gm. to 19.5 cm. length, then to nearest 0.5 gm.)

total length cm.	weight gm.	total length cm.	weight gm.	total length cm.	weight gm.	total length cm.	weight gm.
8.2	0.7	10.7	1.7	12.1	2.2	16.5	6.3
8.3	0.7	10.7	1.9	12.2	2.4	16.9	9.0
8.8	1.0	10.8	1.8	12.3	2.7	17.0	8.0
9.0	0.9	10.8	1.9	12.3	2.9	17.2	8.0
9.0	1.1	10.8	2.0	12.4	2.2	17.3	7.9
9.1	1.0	10.9	1.5	12.5	2.7	17.4	7.9
9.1	1.0	10.9	1.8	12.5	2.9	17.4	8.0
9.1	1.9	10.9	2.0	12.5	3.0	17.4	8.5
9.2	1.1	10.9	2.0	12.5	3.2	17.4	9.1
9.2	1.2	11.0	2.2	12.6	2.8	17.5	7.8
9.2	1.2	11.1	1.9	12.6	3.1	17.5	10.5
9.3	1.1	11.1	2.0	12.7	3.5	17.8	7.3
9.4	1.1	11.2	1.7	12.7	3.6	17.8	8.0
9.4	1.4	11.2	1.9	12.8	3.1	17.9	7.9
9.5	1.2	11.2	1.9	13.0	3.1	18.3	9.6
9.5	1.3	11.2	2.0	13.0	3.2	18.5	8.5
9.6	1.2	11.2	2.0	13.0	3.3	18.9	11.2
9.6	1.3	11.3	1.9	13.0	3.3	19.0	12.0
9.6	1.7	11.3	1.9	13.0	3.9	19.1	12.5
9.8	1.3	11.3	2.1	13.1	3.5	19.1	12.5
9.8	1.3	11.3	2.3	13.1	3.5	19.5	11.6
9.8	1.4	11.3	2.4	13.1	3.5	19.5	12.0
9.8	1.7	11.3	2.6	13.3	3.1	19.6	9.8
9.9	1.5	11.4	1.6	13.3	3.2	19.7	14.5
9.9	1.6	11.4	2.1	13.3	3.2	19.7	15.5
10.0	1.3	11.4	2.2	13.3	3.9	19.9	12.5
10.0	1.4	11.4	2.3	13.4	2.8	19.9	13.0
10.0	1.4	11.5	2.0	13.4	4.0	19.9	14.5
10.1	1.3	11.5	2.1	13.5	3.3	19.9	15.0
10.1	1.6	11.5	2.2	13.6	2.6	20.1	12.7
10.1	1.6	11.6	2.0	13.6	4.2	20.1	14.5
10.1	1.7	11.6	2.4	13.7	3.8	20.1	14.5
10.1	1.7	11.6	2.5	13.7	3.8	20.5	16.0
10.1	1.8	11.6	2.5	13.8	4.0	20.5	19.0
10.2	1.1	11.7	2.3	13.9	4.3	20.7	14.0
10.2	1.6	11.7	2.3	14.3	4.8	20.7	14.5
10.2	1.8	11.7	2.6	14.4	3.2	20.8	13.0
10.3	1.6	11.8	2.2	14.4	4.7	21.1	16.5
10.3	1.7	11.8	2.3	14.6	5.1	21.2	15.5
10.4	1.7	11.8	2.4	14.7	4.4	21.2	17.5
10.4	1.9	11.8	2.4	15.1	4.9	21.3	14.0
10.5	1.9	11.8	2.6	15.1	5.0	21.5	16.0
10.6	1.7	11.9	2.2	15.1	5.0	21.9	18.0
10.6	1.7	11.9	2.3	15.1	5.3	21.9	20.5
10.7	1.3	11.9	2.4	15.2	4.0	22.1	15.0
10.7	1.5	12.0	2.6	15.6	5.5	22.1	23.0
10.7	1.6	12.0	2.6	15.8	7.0	22.4	19.5

Appendix III (cont'd.)

Eels (cont'd.)

total length cm.	weight gm.	total length cm.	weight gm.
22.7	24.0	37.4	101.5
22.9	19.5	37.7	90.5
22.9	24.0	37.9	108.0
23.0	22.0	37.9	108.0
23.1	17.8(?)	38.0	95.5
23.8	23.5	38.1	90.0
24.3	27.0	38.3	124.
24.3	27.5	38.4	135.5
25.0	25.0	39.9	125.0
25.3	29.0	39.9	129.0
25.9	30.0	40.1	127.0
26.0	31.5	40.4	159.5
26.5	30.0	41.5	115.5
27.3	40.0	41.5	152.5
27.7	39.5	42.3	142.5
28.1	43.5	43.6	165.0
28.2	55.0	43.8	179.5
28.8	56.5	44.4	161.0
29.2	59.5	47.3	184.0
29.5	58.5	48.8	224.0
29.9	49.5	50.7	267.5
29.9	51.	54.6	353.5
29.9	55.5	58.1	432.5
30.1	54.0	87.7	1530.5
30.4	60.0		
30.6	50.5		
30.7	57.5	n = 259	
31.2	63.0		
31.5	57.5		
31.5	64.0		
31.6	52.0		
31.7	70.0		
32.1	64.0		
32.3	69.0		
33.6	83.0		
33.8	79.5		
34.4	77.0		
34.5	87.0		
34.9	94.5		
35.1	98.5		
35.1	104.0		
36.0	97.5		
36.1	101.5		
36.2	89.0		
36.2	94.0		
36.5	83.0		
36.8	101.5		

Appendix III (cont'd.)

Killifish

total length cm.	weight gm.	frequency
2.5	0.1	1
2.9	0.1	1
3.0	0.1	4
3.0	0.2	2
3.1	0.1	2
3.2	0.1	3
3.2	0.2	1
3.2	0.3	1
3.3 - 3.5	0.2	3
3.5	0.2	2
3.5	0.3	4
3.6 - 3.8	0.2	1
3.8 - 4.8	0.3	1
4.8 - 5.1	0.8	1
5.1 - 5.5	0.9	1
5.5 - 5.8	1.1	1
5.8	1.2	1
5.8 - 6.0	1.7	1
6.0	1.6	1
6.0	1.7	2
6.1	1.7	1
6.1	1.8	1
6.1	1.9	1
6.1	2.4	1
6.2	1.9	1
6.2	2.2	1
6.3	2.2	1
6.4	1.8	1
6.4	2.3	1
6.4	2.4	1
6.5	2.2	1
6.5	2.3	1
6.5	2.4	2
6.5	2.5	2
6.5	2.6	1
6.6	2.5	1
6.6	2.6	1.
6.7	2.3	1
6.7	2.6	1
6.7	3.0	1
6.8	2.3	1
6.8	2.6	1
6.8	2.7	1
6.8	2.8	2
6.9	2.4	1
6.9	2.8	1
6.9	2.9	1
7.0	2.6	1
7.0	3.0	1
7.0 - 7.2	3.2	2
7.2	3.6	1
7.2 - 7.4	3.7	1
7.4	3.3	1
7.5 - 7.8	3.8	1
7.8 - 8.7	4.4	1
8.7 - 9.5	6.4	1
9.5	8.2	1

n = 75

Appendix III (cont'd.)

White perch

(measured and weighed to nearest 0.5 oz. in field)

notch length cm.	weight gm.	Age	Sex
18.5	77.1	2+	♂
18.6	80.7	2+	♂
18.7	77.1	2+	♂
19.2	86.2	2+	♀
22.5	156.	8+	♂♀
34.1	797.	11+ or 12+	♂♀

Appendix III (cont'd.)

Yellow perch

(04 fish weighed to nearest 0.1 gm., others to nearest 0.5 gm.)

notch length cm.	weight gm.	Age	Sex	notch length cm.	weight gm.	Age	Sex
4.6	1.5	0+		12.4	23.0	4+	♂
4.6	2.0	0+		12.4	23.0	4+	♀♂
5.0	1.5	0+		12.4	24.5	3+	♀♂
5.3	1.4	0+		12.5	22.5	4+	♂
5.6	3.0	0+		12.5	25.0	3+	♂
6.7	4.0	0+		12.5	27.0	4+	♂
10.7	18.5	4+	♂	12.6	28.5	3+	♂
10.8	16.5	3+	♂	12.6	29.0	4+	♂
10.9	19.0	3+	♂	12.8	28.0	4+	♀♂
11.0	16.5	3+	♂	12.9	28.0	3+	♂
11.1	17.5	3+	♂	13.0	25.0	3+	♂
11.3	16.5	3+	♂	13.0	25.5	3+	♀♂
11.3	17.0	3+	♂	13.1	25.5	3+	♀♂
11.3	19.5	4+	♂	13.2	32.5	4+	♂
11.4	22.0	4+	♂	13.3	30.5	4+	♂
11.4	22.5	3+	♂	13.4	31.5	4+	♂
11.4	23.0	4+	♂	13.4	35.0	4+	♂
11.5	18.0	3+	♂	13.5	29.5	4+	♀♂
11.5	19.5	3+	♂	13.5	30.0	4+	♀♂
11.5	19.5	3+	♂	13.5	30.0	4+	♀♂
11.5	19.5	3+	♂	13.5	33.5	5+	♀♂
11.5	20.0	3+	♂	13.6	30.0	4+	♂
11.5	21.5	5+	♂	13.7	32.0	3+	♂
11.6	20.5	3+	♀♂	13.7	33.5	4+	♂
11.6	22.5	3+	♀♂	13.7	37.0	3+	♀♂
11.7	18.5	3+	♀♂	13.9	33.0	4+	♀♂
11.7	19.0	3+	♀♂	14.0	34.0	4+	♀♂
11.7	20.0	3+	♀♂	14.1	38.0	4+	♀♂
11.8	20.5	4+	♂	14.1	40.5	4+	♀♂
11.9	19.5	4+	♂	14.4	36.5	4+	♀♂
12.0	21.0	4+	♀♂	14.6	40.0	4+	♂
12.0	22.5	3+	♀♂	14.7	41.0	4+	♀♂
12.1	21.5	4+	♂	14.9	46.0	4+	♀♂
12.1	22.0	3+	♂	15.2	46.0	3+	♀♂
12.1	23.0	3+	♂	15.6	48.0	4+	♀♂
12.1	26.5	4+	♂	15.6	49.0	4+	♀♂
12.2	20.5	3+	♂	15.9	50.5	5+	♀♂
12.2	25.5	4+	♂	16.1	57.5	4+	♀♂
12.3	21.5	3+	♀♂	17.3	69.0	5+	♀♂
12.3	21.5	4+	♀♂	17.4	74.0	5+	♀♂
12.3	24.5	4+	♂	18.8	98.5	4+	♀♂
12.3	25.0	3+	♂	20.1	104.0	5+	♀♂
12.3	25.0	4+	♂				

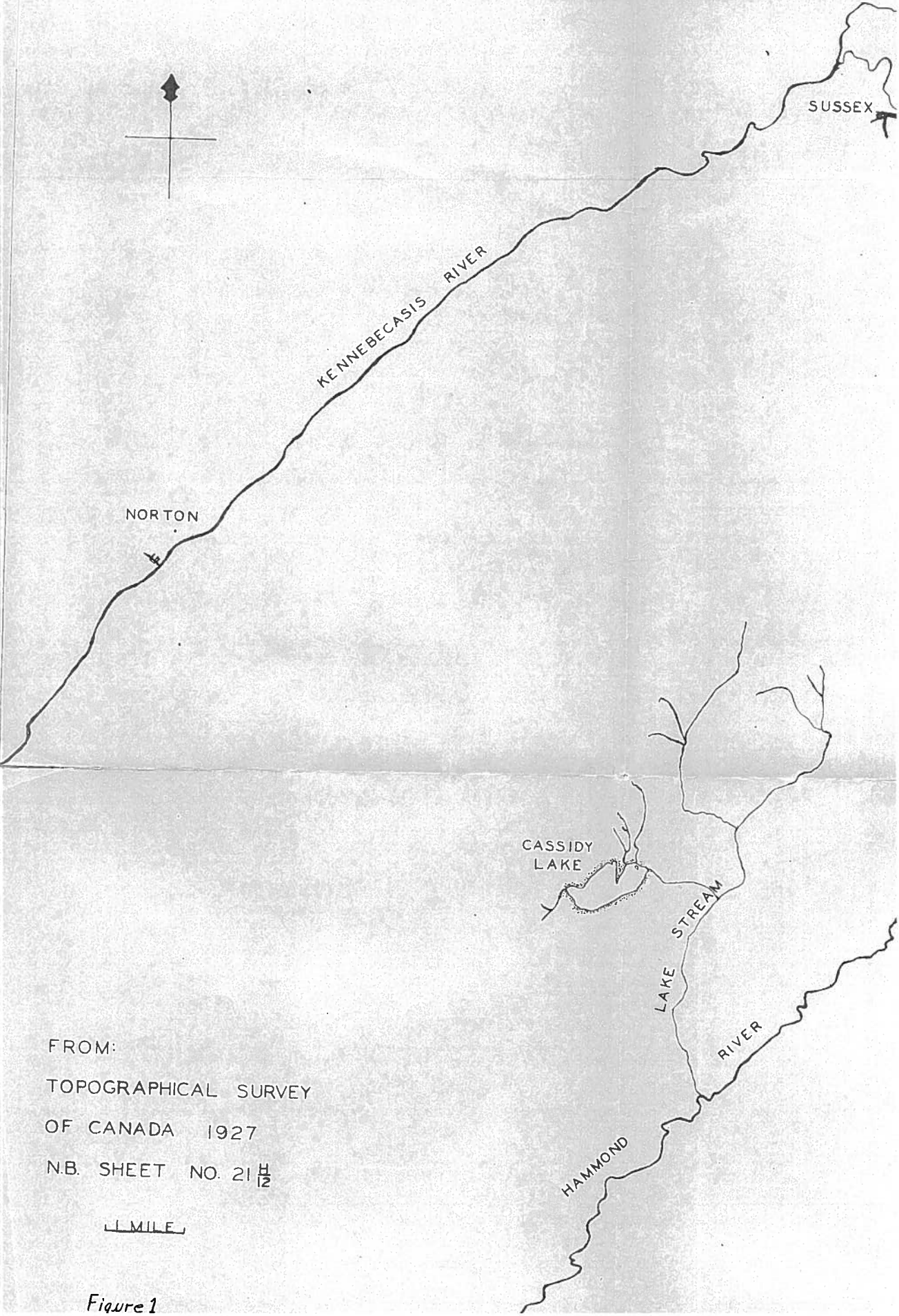
n = 85

Appendix III (cont'd.)

Pumpkinseed

notch length cm.	weight gm.	Age	Sex
6.5	4.5	1+	
6.6	4.5	1+	
6.6	4.5	1+	
6.9	6.6	1+	
7.4	7.6	1+	
8.4	9.3	1+	
8.4	9.6	2+	
9.1	12.0	2+	
9.3	13.5	2+	
10.2	18.3	1+	
10.4	18.9	2+	
10.4	19.5	1+	
10.5	20.8	1+	
11.2	27.7	2+	
12.7	33.9	3+	
17.2	241.	5+	♂

n = 16



FROM:

TOPOGRAPHICAL SURVEY

OF CANADA 1927

N.B. SHEET NO. 21 H/12

1 MILE

Figure 1

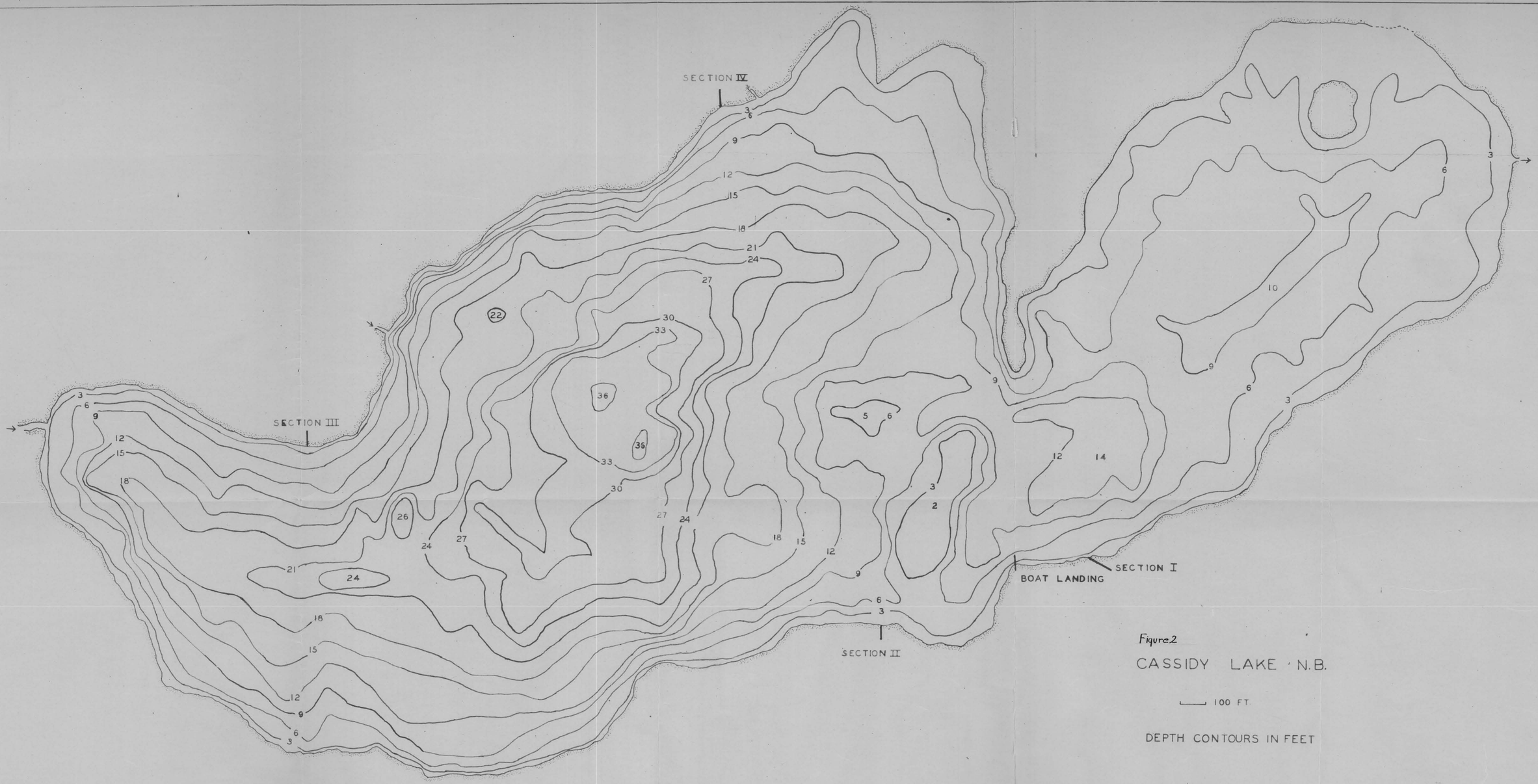


Figure 2

CASSIDY LAKE · N.B.

100 FT

DEPTH CONTOURS IN FEET