Production, food and harvest of trout in Nebish Lake, Wisconsin. No. 65 1973

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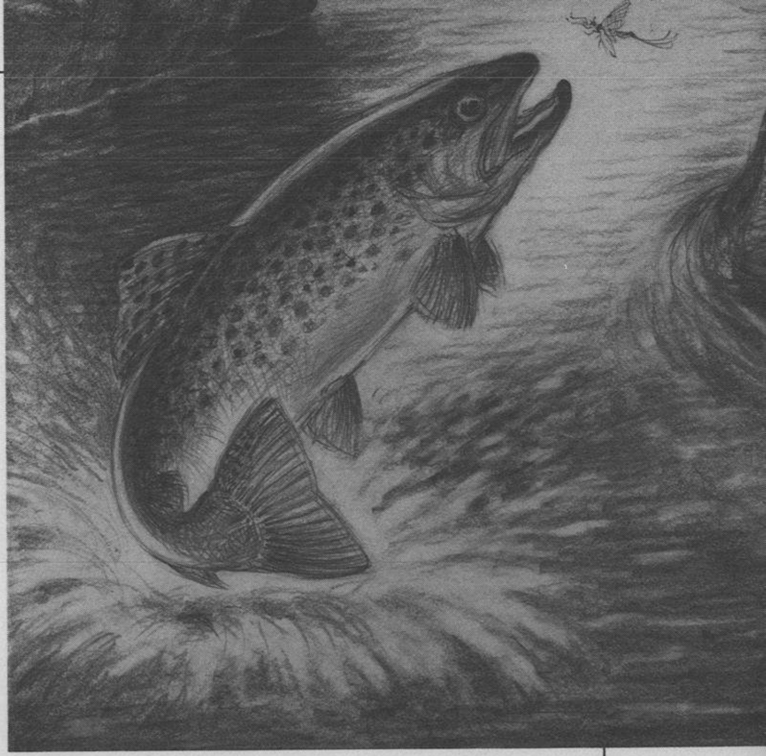

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DEPARTMENT OF NATURAL RESOURCES
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PRODUCTION, FOOD AND HARVEST OF TROUT IN NEBISH LAKE, WISCONSIN

ABSTRACT

In June 1967, stocks of 4,500 age 0 brown trout and 4,500 age 0 rainbow trout were stocked into Nebish Lake, a soft-water lake which had been chemically treated in 1966 to remove all resident fish. Relative production, growth, harvest and food of the two species of trout were compared for 4½ years after their release.

Rainbow trout had the higher production of the two stocks because they survived better and grew faster than the brown trout. Poundage of rainbow trout in the angler's catch during the first 2 years of fishing was higher than the total poundage of brown trout produced in the lake during 4½ years. For each pound of brown and rainbow trout stocked, 5.2 and 15.0 pounds, respectively, were harvested by anglers.

Copepods were not found in the trout stomachs. *Daphnia* 1 mm and larger was the staple food of brown and rainbow trout less than 16 inches, whereas fish was the prominant food of larger trout.

After 3 years of grazing by trout and by a burgeoning population of yellow perch, three of four species of *Daphnia* disappeared from Nebish Lake and small *Bosmina longirostris,* which had not appeared in the Clarke–Bumpus samples before, became the dominant open-water cladoceran. After 4 years of grazing by perch, two species of *Daphnia* reappeared but in relatively low numbers.

Based on these data, it appears that trout growth can be rapid in a soft-water lake containing large species of *Daphnia* if the lake's production capacity is not taxed by large stocks of planktivorous fishes.

PRODUCTION, FOOD AND HARVEST OF TROUT IN NEBISH LAKE, WISCONSIN

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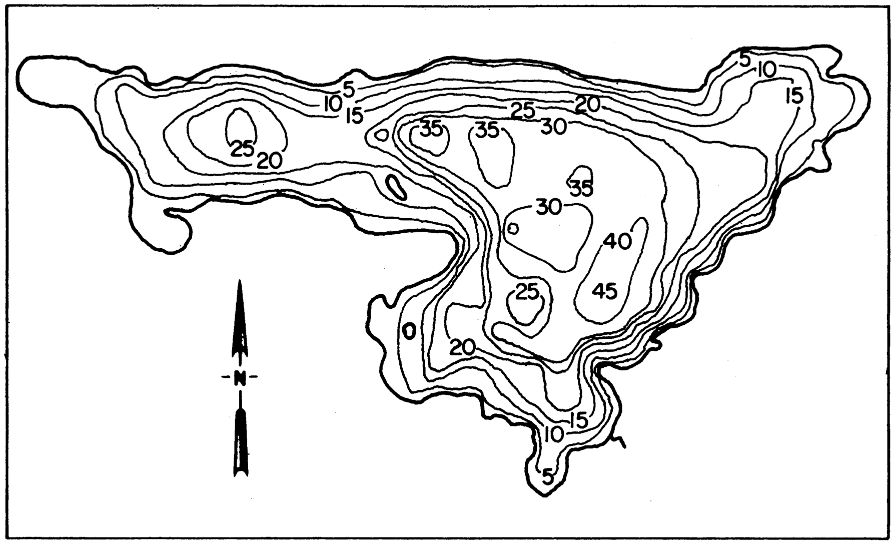
INTRODUCTION

Production of domesticated rainbow trout from summer fingerlings (age 0) to spring yearlings (age I) was greater than production of their brown trout counterparts in a stream infested with white suckers (Brynildson O. et al., 1966) and in a stream where white suckers and minnows were eradicated before stocking the fingerling trout (Avery, 1969). To compare production of brown and rainbow trout in a lake and to determine what contribution production would make to the angler's catch, 4,500 domesticated brown trout fingerlings and 4,500 rainbow trout fingerlings were stocked in Nebish Lake in June 1967. Nine months earlier, in October 1966, all resident fish in Nebish Lake (mainly minnows and white suckers) had been eradicated with rotenone.

FIGURE 1
Contour map of Nebish Lake.



During April and June 1967, Nebish Lake received breeding stocks of 31 yellow perch, *Perca flavescens* (Mitchill), and 38 smallmouth bass, *Micropterus dolomieui* Lacépède. The management plan for Nebish Lake was to establish and maintain fishable stocks of smallmouth bass and yellow perch. The addition of trout to the total fish stocks was not expected to affect the development of the bass and perch fishery because the stocks of trout were relatively low in relation to the potential bass and perch stocks. No fishing was permitted on Nebish Lake during the summer of 1967 and winter of 1967-68.

The objective of the study was, therefore, to determine growth, relative production, food and harvest of brown and rainbow trout stocked as summer fingerlings in 1967 (when the densities of perch and bass were low) through 1971 at which time perch and bass stocks had increased to expected high levels. Because of limited manpower, a complete study of trout food items was not attempted. Emphasis was placed on what was believed to be the most important food item—planktonic Crustacea. Food analyses and correlations were, therefore, limited to determining the relationship between planktonic Crustacea in trout stomachs and planktonic Crustacea in the lake and documenting changes in the density of this food resource.

Nebish Lake (Fig. 1), Vilas County, lies in the Northern Highland Fishery Research Area. Surface area of Nebish Lake is 94 acres and maximum depth is 45 feet. Origin of the water is seepage. Alkalinity is 10-20 ppm and pH, 6.6-7.1, depending on time of year. Kempinger (1968) describes the lake and its fish populations. Dissolved oxygen seldom exceeds 0.5 ppm and 2 ppm below 30 feet during late summer and winter, respectively. Dissolved oxygen and temperature measurements taken at 5 depths over an 8-month period are summarized in Table 13 in the Appendix.

METHODS

TROUT

Stocking

On 7 June 1967, stocks of 4,500 domesticated brown trout, *Salmo trutta* Linneaus, and 4,500 fall-hatched domesticated rainbow trout, *Salmo gairdneri* Richardson, were released in Nebish Lake. The trout were six months old and were graded in the hatchery to a length range of 3.0-3.9 inches in total length. Rate of stocking was 48 brown and 48 rainbow trout per acre. Both lots were reared in the Nevin hatchery in southern Wisconsin.

Determination of Standing Crop, Production and Growth

Production of trout was calculated as the product of the average standing crop in weight and the instantaneous rate of growth (g) of the trout during a given period of time. The term production, as used here, means growth in weight by all trout in the population during a specified period of time including growth by trout that died during the period.

Trout were captured in fyke nets along the shore of Nebish Lake, measured, weighed and marked by removing selected fins. Population estimates for spring and fall standing crops were determined by Peterson or Schnabel methods from returns of marked and unmarked trout examined at the checking station. Growth was determined from weights and length measurements taken from trout captured during netting operations and from trout caught by anglers and examined at the checking station.

Determination of Fishing Effort and Harvest

There was no closed season on fishing at Nebish Lake after 11 May 1968. Bag limit was 10 trout per day. A permit was required to fish on the lake, and after each fishing trip, the anglers returned their permits to technicians at the checking station where the trout in their catch were examined for missing fins and were measured and weighed.

The use of minnows or other fish for bait was prohibited on Nebish Lake, a precautionary measure to delay reintroduction of unwanted competitors.

Stomach Analyses

Trout stomachs, examined for food content, were obtained from trout presented at the checking station by anglers. Each stomach was examined for the presence of various food items. If the stomach contained large food items such as fish, these items were removed and individually counted. If the stomach contained small food items, the contents of the stomach were removed and, together with stomach contents from other trout in a given group or month, were placed in a common container and diluted with tap water to 1 liter. After thorough mixing, 3 sub-samples of 20 ml each were withdrawn and examined under a wide-field binocular microscope with an ocular micrometer to measure the size of the food items in the stomachs. Food items in the three 20-ml samples were taken as the number of food items in 60 ml of the 1-liter container. Relative density of a food item in a given group of stomachs was calculated.

Data on the density of planktonic Crustacea in the lake and the occurrence of Planktonic Crustacea in trout stomachs were analyzed to determine if these food items were selected. Ivlev's (1961) "electivity index" was used to make this analysis based on the following equation:

$$E = \frac{r_i - P_i}{r_i + P_i}$$

where r_i is the quantity of a food item in the stomach expressed as a percentage of the total food in the stomach, and P_i is the relative density of the same food item in the environment expressed as a percentage. "E" values range from -1 to +1; a negative value indicates negative selection of the food item and a positive value, a positive selection.

PLANKTONIC CRUSTACEA

Density and Size Estimates

Periodic samples of the planktonic Crustacea were taken during the open-water months from 1967 to 1971 to estimate the density of planktonic Crustacea. Horizontal tows, mostly at 10-foot intervals from the surface down to 30 feet, were made with a Clarke–Bumpus plankton sampler with a Number 2 net. Duration of each plankton tow was 3 minutes at 3 miles per hour.

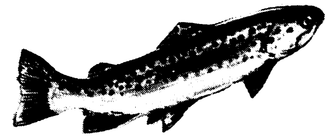
Crustacea were counted on a circular, 3-ml counting cell. Methods were similar to those employed by Priegel (1970) to count crustaceans in the stomachs of white bass. By counting the Crustacea contained in 3 counting cells, it was possible to examine a total of 9 ml of the original sample which had been diluted up to 1,000 ml. Crustacean length, excluding spines and antennae, was measured to the nearest 0.2 mm.

No data are available on density of *Daphnia* in 1969 since the Clarke-Bumpus samples were inadvertantly discarded before the identification of all species of *Daphnia* was verified. Only the identification of *Daphnia pulex* and *Daphnia galeata mendotae* was verified and these species were lumped together as total *Daphnia* present per liter at any given time (Kempinger and Morsell, 1969).

Counts of various Crustacea that were present in the Clarke–Bumpus samples taken in 1971 were not made. However, the samples have been carefully examined and relative density of the Crustacea, established.

Identification

Identification of the *Daphnia* was made according to *The Systematics of North American Daphnia* (Brooks, 1957) and was verified by Dr. S.T. Dodson of the University of Wisconsin. Crustacea collected with the Clarke–Bumpus using a Number 2 net included: *Alona affinis* (Leydig), *Bosmina longirostris* (O.F. Müller), *Chydorus sphaericus* (O.F. Müller), Cyclopidae, *Daphnia dubia* Herrick, *Daphnia galeata mendotae* Birge, *Daphnia pulex* Leydig, *Daphnia retrocurva* Forbes, *Diaphanosoma leuchtenbergianum* Fischer, *Diaptomus* sp., *Epischura lacustris* Forbes, *Eurycercus lamellatus* (O.F. Müller), *Holopedium gibberum* Zaddach, *Leptodora kindtii* (Focke), *Mesocyclops* sp., *Polyphemus pediculus* (Linne) and *Scapholebris mucronata* (O.F. Müller).



RESULTS

TROUT

Growth and Production

As was expected, the greatest production of trout occurred during the first 11 months that the trout were in Nebish Lake before fishing for trout became legal 11 May 1968 (Table 1). Because the rainbow trout survived and grew better than the brown trout, they produced 3 pounds of trout flesh for every pound produced by the brown trout from 7 June 1967 (when stocked) through April 1968 (Fig. 2). During this 11-month span, pounds of rainbow and brown trout produced were approximately 25 and 8 times the pounds stocked, respectively. The ratio of survival was 2.3 rainbow to 1 brown trout. Similar stocks of trout in Black Earth Creek, Dane County, Wisconsin from mid-June to early April had a survival ratio of 2.7 rainbow to 1 brown trout. Production of the rainbow and brown trout in that stream during those 10 months was 4 and 2 times the poundage stocked, respectively (Brynildson O. et al., 1966).

During the second year in the lake, the rainbow trout produced nearly three times as much trout flesh as the brown trout in spite of a rapid decline in their stock due to angling (Fig. 2). Production by both species of trout was "negative" in August 1968, when their instantaneous growth rate (g) was negative and their average coefficient of condition (R) was relatively low (Table 2 and Fig. 3). During May–September 1968, (g) of brown trout was highest in June, whereas (g) of rainbow trout was highest in May (Fig. 3).

Harvest

During the open-water season in 1968, rainbow trout were caught at a rate of 0.43 fish per hour, but ice fishing in 1968-69 rewarded anglers with only 0.26 rainbow trout per hour. This low catch rate reflects the relatively depleted stock of rainbow trout by freeze-up in 1968. Not so easily caught during the 1968 open-water season as rainbow trout, brown trout were caught by anglers at a rate of 0.32 per hour during open water and ice cover.

The greatest number of trout were harvested the first year (May 1968–April 1969) when 55 and 86 percent of the total catch of brown and rainbow trout, respectively, were recorded. The highest poundage of rainbow trout was harvested that first year as well (Fig. 2), however, poundage of brown trout harvested was higher the second year, May 1969–April 1970, when 204 pounds were harvested vs. 180 pounds, the first year. Except during the third year of fishing (1970), more pounds of rainbow trout were harvested than pounds of brown trout. The yield of rainbow trout to the anglers' catch (1,249 lbs) during 1968-1970 was greater than the entire production (1,239 lbs) of brown trout in the lake from June 1967 to October 1971 (Table 1 and Fig. 2).

In Nebish Lake, 5.2 and 15.0 pounds of brown and rainbow trout, respectively, were harvested by anglers for each pound stocked (Table 3). In nearby Weber Lake (also a rotenone-treated lake) the stocking–harvest ratio was 4.4 pounds harvested to each pound of rainbow trout stocked (Burdick and Cooper, 1956), 3.6 pounds harvested to each pound stocked in East Fish Lake, Michigan – a lake which contained only minnows and trout (Alexander and Shetter, 1969) and up to 18.2 pounds harvested to each pound stocked in Beardsley Reservoir, California – a lake which contained only trout (Cordone and Nicola, 1970).

TABLE 1
Standing Crops, Production, Yield and Total Length of Trout in Nebish Lake, 1968–1971

Species & Date	Standing Crops No.	Standing Crops Lbs	Lbs Produced	Yield No.	Yield Lbs	Total Length (in Inches)
Brown Trout						
June 67 (stocked)	4,500	76	0	0	–	3.0– 3.9
Apr 68	705	328	661	0	–	10.0–11.2
May–Jun 68	–	–	–	76	60	10.3–13.5
Jul–Aug 68	–	–	–	75	76	12.2–14.6
Sep–Oct 68	–	–	–	2	2	13.7–14.6
Nov–Dec 68	–	–	–	2	2	13.4–14.4
Jan–Feb 69	–	–	–	11	12	14.0–15.1
Mar–Apr 69	220	293	227	25	28	13.7–14.7
May–Jun 69	–	–	–	74	98	13.6–16.6
Jul–Aug 69	–	–	–	11	26	16.2–19.0
Sep–Dec 69	–	–	–	7	17	17.6–19.2
Jan–Apr 70	–	–	–	31	63	16.1–19.3
May–Jun 70	–	–	–	21	47	17.0–19.8
Oct–Nov 70	70	242	297	0	–	18.5–21.3
Dec 70–Jan 71	–	–	–	2	5	18.7–19.8
Mar–May 71	–	–	–	11	32	18.8–21.0
Oct 71	42	189	54	0	–	20.2–23.6
TOTAL	–	–	1,239	348	468	–
Rainbow Trout						
Jun 67 (stocked)	4,500	78	0	0	–	3.2– 3.9
Apr 68	1,642	1,034	1,988	0	–	9.8–12.1
May–Jun 68	–	–	–	299	351	11.1–15.9
Jul–Aug 68	–	–	–	398	549	13.1–16.6
Sep–Oct 68	–	–	–	11	16	14.8–16.3
Nov–Dec 68	–	–	–	1	2	–
Jan–Feb 69	–	–	–	16	26	14.2–17.4
Mar–Apr 69	104	190	652	23	38	15.2–17.8
May–Jun 69	–	–	–	72	132	15.2–17.8
Jul–Aug 69	–	–	–	25	75	16.4–20.2
Sep–Dec 69	–	–	–	10	32	15.3–21.3
Jan–Apr 70	–	–	–	6	18	17.7–20.0
May–Jun 70	–	–	–	4	10	18.3–19.4
Oct–Nov 70	1	4	76	0	–	–
Dec 70–Jan 71	–	–	–	0	–	–
Mar–May 71	–	–	–	0	–	–
Oct 71	–	–	–	0	–	–
TOTAL	–	–	2,726	865	1,249	–

FIGURE 2
Production of trout in Nebish Lake, 1967-1971, and yield to anglers, May 1968-May 1971.

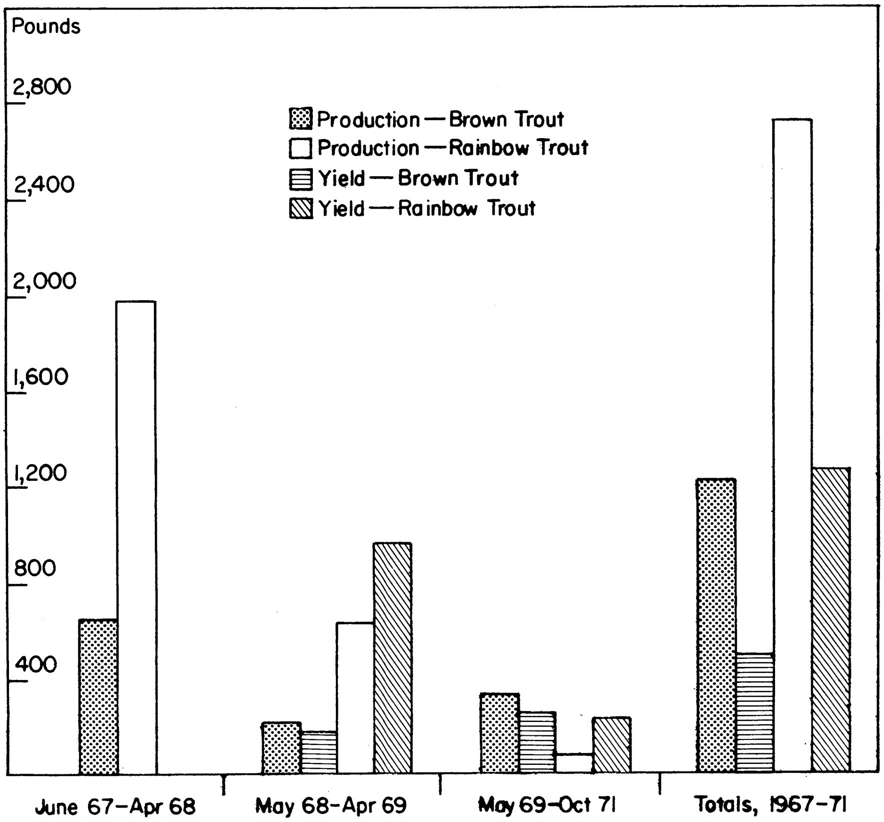
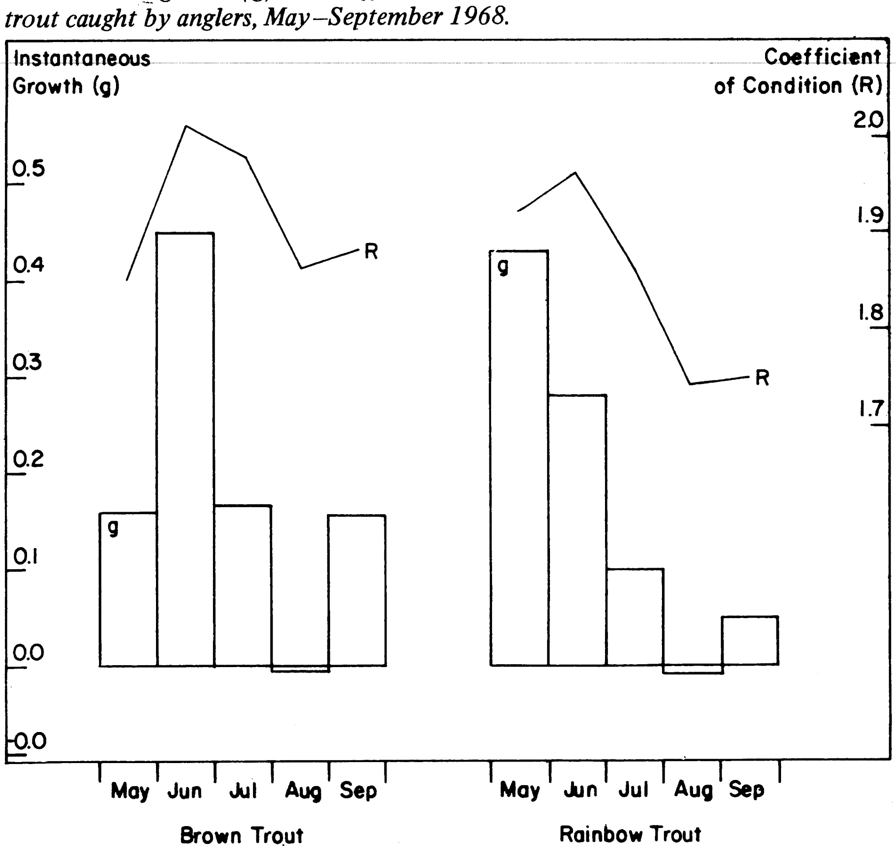


FIGURE 3
Instantaneous growth (g) and coefficient of condition (R) of brown and rainbow trout caught by anglers, May–September 1968.



Food

The percentage of trout stomachs containing a listed food item and the percentage of that food item in the stomach contents are presented in Tables 5–10 in the Appendix.*

Based on these data, a number of similarities between brown trout and rainbow trout stomach contents were apparent: (1) No stomachs contained cladocerans less than 1 mm long and none contained copepods during the 4 years that stomachs were collected. (2) Using Ivlev's (1961) "electivity index", a positive "E" value was found for *Daphnia* from May–August 1968, indicating that during the summer of 1968, this item was positively selected by trout (Table 11, App.). During January–April 1969, *Daphnia* was by far the most numerous food item in the trout stomachs (Table 7, App.). *Daphnia* was thus the staple food of trout during 1968 and 1969 when trout were yearlings and two-year-olds, respectively. Yearling brown trout and yearling and two-year-old rainbow trout also had similar diets in Turk Lake, Chippewa County, Wisconsin (Brynildson, 1958). (3) Fish were present in the trout stomachs for the first time during late summer of 1968 when the trout ranged in length from 12.2 to 16.6 inches (Table 6, App.). As the trout grew, less *Daphnia* and more fish (mainly perch) were consumed (Table 4). By the time the brown trout were three years old, only 2 out of 18 stomachs contained *Daphnia*, while 5 contained fish (Table 10, App.).

In addition to these similarities, comparison of brown trout and rainbow trout stomachs revealed a number of differences: (1) Based on the observation that stomachs from brown trout contained amphibians, but stomachs from rainbow trout did not, it appears that brown trout forage more along the littoral zone than the rainbow trout (Table 4). (2) Compared to the brown trout stomachs examined, a higher percentage of the rainbow trout stomachs contained *Daphnia* but fewer stomachs contained fish (Table 4). (3) The large planktonic crustacean, *Holopedium gibberum*, was found in 15 rainbow trout stomachs but in only 1 brown trout stomach (Tables 6–9, App.).

*All stomachs were taken from trout 9 inches and longer.

Two of the species of Crustacea collected in Nebish Lake were either absent or present in low numbers in the trout stomachs examined: *Diaptomus* was present at relatively high densities during May–June 1968 but the "E" value for this food item was negative (Table 11, App.). This copepod may have been unavailable to the trout in June because most of the *Diaptomus* collected in the lake in June were less than 1 mm in length. Similarly, density of Cyclopidae 1 mm and larger was relatively high in Nebish Lake in August 1968, but these crustaceans were absent in the trout stomachs collected during that month. Above the 30-foot level, they averaged less than 2 per liter—a density too low for efficient grazing by the trout.

Several miscellaneous food items consumed are of interest: Filter tips from cigarettes were found in one brown and four rainbow trout stomachs, and the remains of a bird was found in the stomach of a 20-inch brown trout caught in April 1971. When available, trout eggs were readily consumed by both species. In September–November 1968, trout eggs (deposited by yearling brown trout) were present in only one trout stomach (from a rainbow trout collected in November) but during November 1969–April 1970, when all brown trout were mature and spawning, 29.4 and 70.0 percent, respectively, of the brown and rainbow trout stomachs collected contained trout eggs (Table 9, App.). The stomach from one rainbow trout collected in April and two in May 1970, contained trout eggs. These were probably rainbow trout eggs deposited that same spring, further evidence that fall-hatched rainbow trout, when released into the environment as June fingerlings, revert to spawning during the spring.

TABLE 2
*Lengths, Weights, Instantaneous Growth (g) and Coefficient of Condition (R) of Trout in Nebish Lake, 1967–1971**

Species & Date	No. Captured	Total Length (in Inches) Range	Total Length (in Inches) Avg.	Avg. Weight (in Grams)	g	R
Brown Trout						
Jun 67 (stocked)	–	3.0– 3.9	3.4	8	–	–
Sep–Oct 67	5	6.7– 8.4	7.5	79	2.290	1.83
Apr 68	8	10.0–11.2	10.5	211	0.982	1.83
May 68	21	10.3–12.1	11.0	248	0.162	1.83
Jun 68	57	10.4–13.5	12.5	390	0.453	2.01
Jul 68	50	12.5–14.6	13.2	460	0.165	1.98
Aug 68	25	12.2–14.2	13.5	458	-0.004	1.86
Sep–Nov 68	11	13.4–14.6	14.1	517	0.121	1.85
Jan–Feb 69	11	14.0–15.1	14.6	508	-0.012	1.64
Mar–Apr 69	38	13.7–16.2	14.7	524	0.031	1.65
May–Jun 69	74	13.6–16.6	15.2	605	0.144	1.72
Jul–Aug 69	11	16.2–19.0	17.5	1,081	0.582	2.00
Sep 69–Jan 70	18	16.4–19.2	17.9	992	-0.088	1.74
Feb–Apr 70	29	16.1–19.3	17.3	911	-0.081	1.65
May–Jun 70	21	17.0–19.8	18.3	1,016	0.108	1.66
Oct–Dec 70	57**	18.5–20.9	19.9	1,568	0.432	2.00
Mar–May 71	11	18.8–21.0	20.1	1,321	-0.170	1.61
Oct 71	38***	20.2–23.6	21.7	2,038	0.434	1.99
Rainbow Trout						
Jun 67 (stocked)	–	3.2– 3.9	3.6	8	–	–
Sep–Oct 67	4	8.3–10.8	10.0	161	3.002	1.72
Nov 67	5	10.1–11.8	11.2	242	0.408	1.72
Apr 68	136	9.8–12.6	11.6	286	0.167	1.90
May 68	111	11.1–14.9	13.1	440	0.431	1.93
Jun 68	188	12.5–15.9	14.4	581	0.278	1.96
Jul 68	201	13.1–16.6	15.1	640	0.097	1.86
Aug 68	197	13.7–16.4	15.2	614	-0.041	1.74
Sep–Nov 68	14	14.8–16.4	15.6	671	0.089	1.78
Jan–Feb 69	16	14.2–17.4	16.4	748	0.109	1.69
Mar–Apr 69	39	15.2–17.8	16.4	745	-0.004	1.67
May–Jun 69	75	14.6–18.3	16.9	830	0.108	1.71
Jul–Aug 69	25	16.4–20.2	18.9	1,362	0.494	1.98
Sep 69–Mar 70	13	15.3–21.3	19.6	1,408	0.055	1.84
Apr–Oct 70	10	17.7–21.4	19.4	1,379	-0.032	1.88

*Includes trout captured by electrofishing, nets and anglers.
**Of the 57 trout, 55 were caught in fyke nets in late October and early November on the spawning grounds before loss of significant weight occurred due to deposition of eggs and milt and spawning activity.
***All 38 trout were caught in fyke nets, 22-27 October 1971.

PLANKTONIC CRUSTACEA

The first Clarke-Bumpus samples after the rotenone treatment 3 October 1966, were collected on 6 June 1967. Densities of planktonic Crustacea captured in the Number 2 net were low on that date. *Diaptomus* sp. and *Epischura lacustris* were dominant and they averaged only 0.2 per liter in the first 30 feet of lake water. *Daphnia pulex,* a daphnid absent from neighboring Pallette Lake (Brynildson and Kempinger, 1970), averaged only 0.1 per liter (although brood pouches of *D. pulex* were packed with eggs or young) and only traces of *Daphnia galeata mendotae* and *Holopedium gibberum* were found from the surface down to 10 feet. No Cladocera were present in the 20- and 30-foot-deep Clarke–Bumpus samples.

By 20 June 1967, the *Daphnia* population had increased (Table 12, App.) and averaged 2.4 per liter down to 30 feet in Nebish Lake. *D. pulex* averaged 2.3 per liter and the remainder of the *Daphnia* population was composed of *Daphnia dubia. Holopedium* had, by this date, attained the highest density it would have during the next three years – an average of 6.7 per liter from the surface to 5 feet, and an average of 3.8 per liter from the surface to 30 feet. Of these, 85 percent were 1 mm or larger. By July 1967, *Holopedium* had diminished in numbers and *D. dubia* and *Daphnia retrocurva* were the dominant cladocerans while *Diaptomus* and *Epischura* were the dominant copepods, averaging approximately 1 per liter down to 30 feet for the remainder of the summer. In Paul Lake, approximately 40 miles north of Nebish Lake,

TABLE 3
Comparison of Stocking-harvest Ratios from Nebish Lake with Ratios from Other Lakes

Species and Age of Trout	Stocking-harvest Ratio (in Lbs)	Lake Stocked	Source of Data
Rainbow Trout			
Fingerling			
June	1–15.0	Nebish Lake, Wis.	Present study, 1973
May–June	1–3.3	Weber Lake, Wis.	Burdick and Cooper, 1956
Sept.–Oct.	1–4.4	Weber Lake, Wis.	Burdick and Cooper, 1956
Sept.–Oct.	1–0.6	Crecy Lake, New Brunswick	Smith, 1968
Feb.–Oct.	1–3.0	Beardsley Reservoir, Cal.	Cordone and Nicola, 1970
Yearling			
Apr.	1–1.4	Riley Lake, Wis.	Brynildson, 1958
Apr.	1–1.3	Devils Lake, Wis.	Brynildson C. et al., 1970
Oct.	1–1.5	Crecy Lake, New Brunswick	Smith, 1968
Oct.	1–3.6	East Fish Lake, Mich.	Alexander and Shetter, 1969
Brown Trout			
Fingerling			
June	1–5.2	Nebish Lake, Wis.	Present study, 1973
Yearling			
Apr.	1–1.6	Devils Lake, Wis.	Brynildson C. et al., 1970

TABLE 4
Percentage of Trout Stomachs Containing Daphnia, Fish and Amphibians, Nebish Lake, 1968–1971

Species and Year Taken	Length Range of Trout (in Inches)	Percentage of Stomachs Containing Food Item		
		Daphnia	Fish	Amphibians
Brown Trout				
1968	10–15	58	2	0
1969	14–19	38	9	7
1970	16–20	6	15	10
1971	18–21	0	54	8
Rainbow Trout				
1968	10–16	62	2	0
1969	14–19	49	10	0
1970	18–21	0	25	0

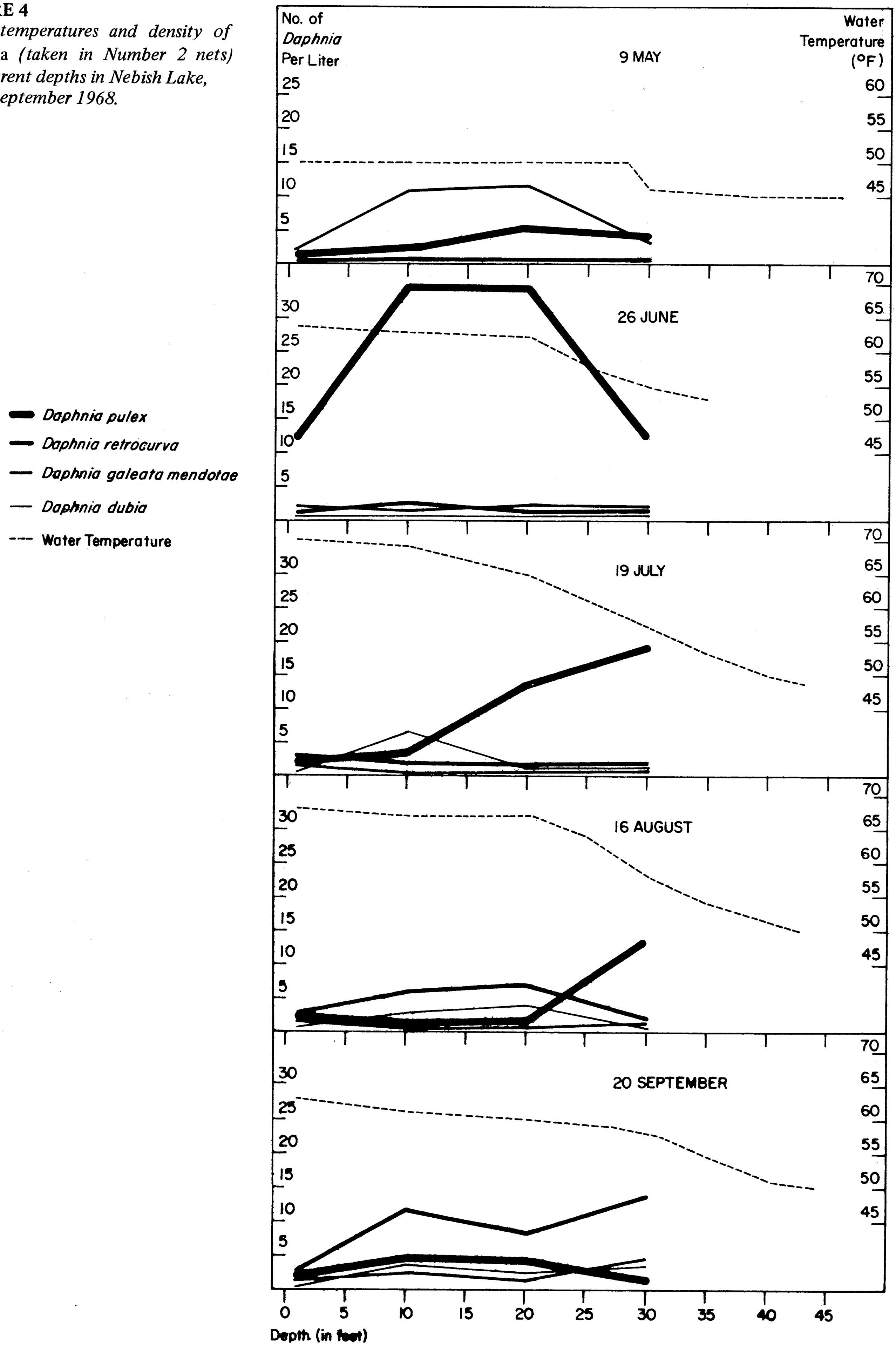
Holopedium was the dominant cladoceran in June but by July, had declined as *D. pulex* increased. In adjacent Lake Peter when *Daphnia* became dominant, *Holopedium* increased but *Diaptomus* remained at approximately the same concentration (Stross et al., 1960).

The relative densities of the planktonic Crustacea collected in the Number 2 net at different periods during the summer of 1968 are presented in Table 11 (App.). By the summer of 1968, the population of planktonic Crustacea was probably more typical of a stable population in Nebish Lake, that is, after recovering from the rotenone treatment in October 1966. Density and general size of *Daphnia* at various depths in Nebish Lake during 4 summers of sampling are presented in Table 12 (App.).

D. galeata mendotae was the dominant daphnid in May 1968; its density was low during June–August but showed a modest regain by September (Fig. 4). *D. dubia* was sparse during the sampling periods in 1968. It was absent in the May Clarke–Bumpus collections, showed a moderate rise in density beginning in July 1968, and maintained that density to at least 20 September 1968 (Fig. 4). *D. pulex* was the dominant daphnid in June and July 1968. *D. retrocurva*, the dominant daphnid during August and September 1967, regained this dominance during those same months in 1968 (Fig. 4). In general (at depths where the temperature was below 75 F), trout had access to high numbers of *Daphnia* in 1968 (Fig. 4).

Except for a trace of *D. retrocurva* in the Clarke–Bumpus sample taken at 10 feet 11 August 1970, *D. pulex* was the only daphnid found in the samples taken during 1970. At all depths except for 30 feet, *D. pulex* was present in progressively declining numbers in the Clarke–Bumpus samples taken in 1970 (Table 12, App.). At the 30-foot depth in late July and August, the large *D. pulex* were in an environment of low dissolved oxygen of only 1 ppm as in August 1968 (Fig. 10, App.) and therefore were relatively secure from overgrazing by perch. The near disappearance of *D. dubia, D. galeata mendotae* and *D. retrocurva* by 1970 was due to probable overgrazing by perch. In contrast, Galbraith (1967) reported that after the buildup of a planktivorous fish population in Sporley Lake in Michigan, *D. pulex* disappeared and was replaced by *D. retrocurva* and *D. galeata mendotae.* The buildup and decline of the entire

FIGURE 4
Water temperatures and density of Daphnia *(taken in Number 2 nets) at different depths in Nebish Lake, May–September 1968.*

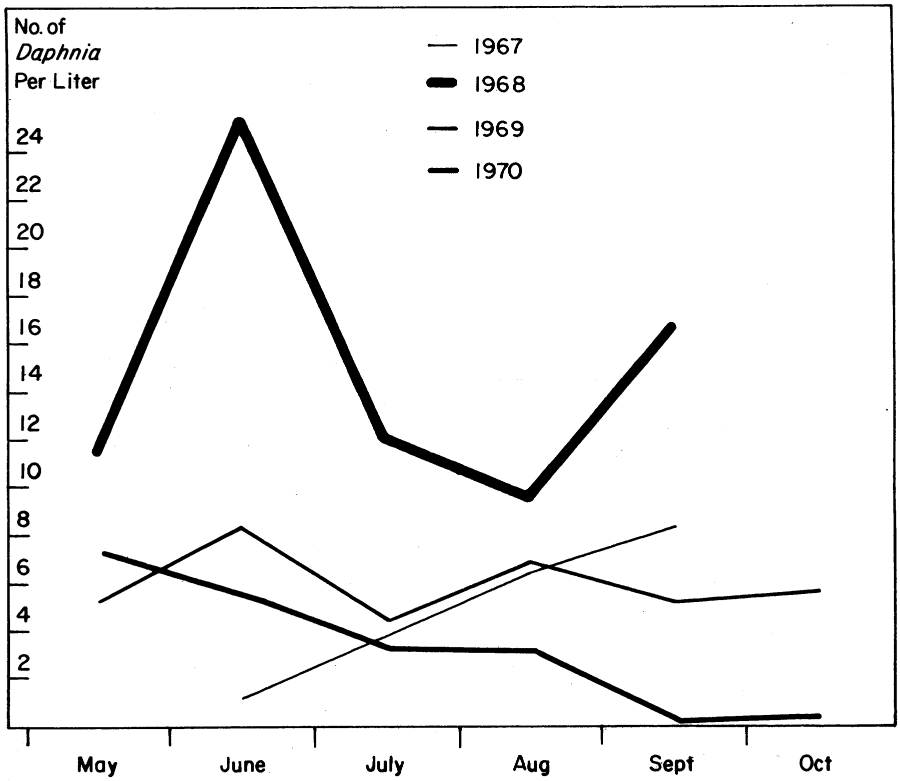


Daphnia population in Nebish Lake during 1967-70 is presented in Figure 5.

During July 1970, *Holopedium* was concentrated at 20 feet where an average of 13.2 per liter were present, but only 50 percent were 1 mm and larger. By October 1970 when the lake was in its fall overturn, *Holopedium* averaged only 0.3 per liter from the surface of Nebish Lake to a depth of 30 feet, with only 17 percent being 1 mm and larger.

By late June 1971, *D. pulex* was sparse above the 30-foot level, and had nearly disappeared from that level by late September. During this month (September), a renewed dissolved oxygen supply reached the depth of 30 feet as the lake cooled, again exposing the large *D. pulex* to predation by perch. By late July, *D. galeata mendotae* had regained dominanace over *D. pulex* and was the dominant daphnid in the last plankton samples taken in mid-October 1971. *D. dubia* also reappeared at low levels (highest in July 1971, at the 20-foot depth). *D. retrocurva* was not found in any plankton samples taken in 1971.

FIGURE 5
Average density of Daphnia *(taken in Number 2 nets) in Nebish Lake during open water months, 1967-1970.*



DISCUSSION

TROUT

Growth and Production

Unlike splake in neighboring Pallette Lake, brown and rainbow trout in Nebish Lake grew most rapidly when they were fingerlings and yearlings and were feeding mainly on invertebrates. Splake grew slowly until their fourth year in Pallette Lake when fish became important in their diet (Brynildson and Kempinger, 1970).

When domesticated brown and rainbow trout were released in Nebish Lake, Black Earth Creek and Devil's Lake as June fingerlings or as April yearlings, production of the rainbow trout was greater, mainly because they survived better than their brown trout counterparts. When stocked in lakes, growth of rainbow trout was also more rapid than growth of the brown trout (Brynildson O. et al., 1966 and Brynildson C. et al., 1970).

The negative instantaneous growth rate (g) and decrease in the condition factor (R) of both brown and rainbow trout during August 1968 may reflect relatively warm water temperatures – 65 F down as far as 25 feet, 20 August 1968. Although large *Daphnia* were available, trout may not have been feeding on them at all depths. At 10 feet, where *Daphnia* density on 23 August 1968 was highest, the water temperature there was 69 F – above the optimum for aggressive feeding at least by brown trout (Brown,1946). In two out of three lakes in northwestern Wisconsin, rainbow trout had negative instantaneous growth in August during two successive years when living space decreased due to lack of dissolved oxygen in the hypolimnion of the lakes. This resulted in overgrazing of the *Daphnia* by trout when prey and predator were forced to reside in the narrow thermocline and the warm epilimnion (Brynildson, 1958).

During ice cover in 1969-70 and March–May 1971, the brown trout had negative instantaneous growth, and during March–May 1969, the rainbow trout had negative instantaneous growth. These negative growth rates may be the result of weight loss following the November and April spawning periods of brown and rainbow trout, respectively.

Prior to the study of trout in Nebish Lake, growth rate of stocked domesticated brown and rainbow trout in fertile Black Earth Creek in southern Wisconsin was as rapid as any recorded in Wisconsin waters. In that stream, brown and rainbow trout stocked when 3 to 5 inches in total length in June averaged 9.1 and 9.5 inches, respectively, the following April (Brynildson O. et al., 1966) in comparison to their counterparts in Nebish Lake which averaged 10.5 and 11.6 inches, respectively, the following April.

Similarly average growth of all ages of the brown and rainbow trout in Nebish Lake was better than the average growth of brown and rainbow trout in most other Wisconsin streams (Brynildson and Christenson, 1961; Brynildson O et al., 1966; Mason et al., 1966) and inland lakes (Brynildson, 1958; Brynildson and Christenson, 1961; Mason et al., 1966).

In three 10- to 20-acre northwestern Wisconsin lakes, domesticated, winter-hatched rainbow trout 28 months of age in May (a year after stocking) ranged from 10 to 13 inches in average total length (Brynildson, 1958). In Nebish Lake, the fall-hatched rainbow trout, 28 months of age, averaged 16.4 inches in length in May. This rate of growth was similar to that of winter-hatched rainbow trout released as May and June fingerlings in neighboring, soft water, Weber Lake (Burdick and Cooper, 1956).

Growth of the rainbow trout during their second year of life in Nebish Lake was exceeded by growth of domesticated, winter-hatched rainbow trout stocked in Lake Michigan. These trout, released as 9-inch fish in May at age 16 months, grew another 8 inches the following year (Daly, 1968). Those in Nebish Lake grew on an average of 6.2 inches their second year. Moreover, had these Lake Michigan trout been stocked as 3- to 4-inch fingerlings as were the ones stocked in Nebish Lake, they probably would have grown even more rapidly because the rainbow trout in Nebish Lake grew 10.7 inches from the stocking date in June 1967, to June 1968.

Brown trout, averaging 6.1 inches, stocked at 16 months of age in a 10-acre, soft water lake in northwestern Wisconsin averaged 10.2 inches the following April when 28 months old (Brynildson, 1958). Brown trout in Nebish Lake averaged 14.7 inches at 28 months of age. However, the rapid growth of brown trout in Nebish Lake also fell short of the growth rate shown by brown trout stocked in Lake Michigan. Nine-inch brown trout released in Lake Michigan at age 17 months in May ranged from 16 to 18 inches in total length after 12 months in the lake (Kernen, 1969). On the other hand, brown trout released in Nebish Lake at age 6 months ranged from 14 to 16 inches in total length after 23 months in the lake. Like the rainbow trout, had the brown trout been released in Lake Michigan as 3- to 4-inch June fingerlings, they probably would have grown even more rapidly.

The rapid growth of trout in a soft water lake, such as Nebish, demonstrates that such lakes can support fast-growing stocks of trout if their production capacities are not taxed by large populations of stunted panfish. Many soft water lakes in Wisconsin have ideal environmental characteristics for production of trout: depths of 40 to 70 feet, good exposure to prevailing winds during the spring to insure turnover and a good limnetic food chain from desmids to *Daphnia*. The ability of a lake to produce copepods and small forms of Cladocera in abundance may be ideal for young panfish but not for adult panfish or yearling and older trout.

Harvest

The management of trout in Nebish Lake as a "put-grow-and-take" fishery was highly successful. By this method, the rainbow trout grew to harvestable size before anglers took them from the lake. The slower-growing brown trout also were able to produce more total pounds and to grow to larger size by being spared from angling mortality during their first year in Nebish Lake.

Stocking both brown and rainbow trout in Nebish Lake had the advantage of offering the angler good fishing for large rainbow trout for two years and large brown trout for four years after only 1 stocking. Although rainbow trout provided the angler with greater numbers and pounds of trout during the first two years after fishing was permitted, the brown trout prolonged the fishery for "trophy" trout for an additional two years (but only an estimated 42 brown trout remained in the lake by October 1971). The same phenomenon occurred at Devil's Lake. There, rainbow trout were depleted by fishing to the point that none were caught after July, whereas brown trout provided extended fishing opportunity through autumn and winter (Brynildson C. et al., 1970).

In both Devil's and Nebish lakes, a high percentage of the rainbow trout were caught at night by anglers still-fishing with corn, cheese, mayfly nymphs and worms under the glare of gas lanterns. Not as attracted to the bright lights as the rainbow trout, brown trout provided an excellent trolling fishery during the day on both lakes. Fishermen trolling with minnows on Devil's Lake were very successful. Had this bait been allowed on Nebish Lake, anglers would have taken more brown trout and fewer brown trout would have been lost to natural mortality during that first fishing season of 1968.

Whether to manage a lake for brown or rainbow trout should depend upon production potential of a lake for brown or rainbow trout and the level of fishing pressure. Brown trout, probably because they are usually less pelagic, do not respond as readily to *Daphnia* abundance as do their rainbow trout counterparts. Brown trout do, however, withstand higher fishing pressure longer than rainbow trout, especially when the latter trout is taken by "lantern fishing". If the rewards of bulging creels at night seem less important than an extended opportunity to fish for trout during the day, then a lake should be managed mainly for brown trout.

Both brown and rainbow trout would do well, together or separately, when managed so that they grow in the lake or stream before they are harvested by anglers. Such put-grow-and-take management seems especially suited to lakes and streams where low demand for fishing opportunity would permit closing of specified waters the first year after stocking.

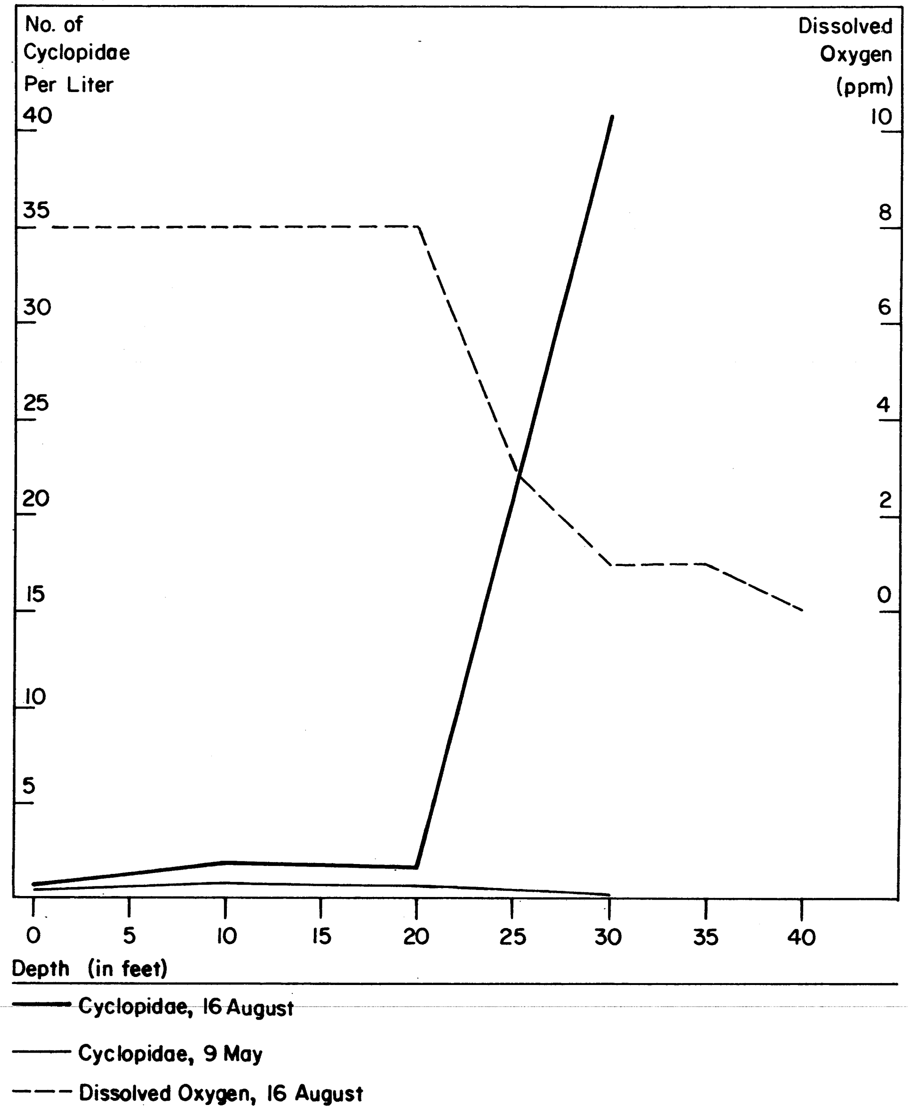
Food

The absence of cladocerans less than 1 mm in length from the brown and rainbow trout creeled on Nebish Lake is additional evidence that planktivorous fishes feed on the larger planktonic Crustacea. Other studies demonstrated that rainbow trout 7 to 17 inches in total length (Brynildson, 1958, 1960, 1961 and 1969; Galbraith, 1967), alewife (Brooks and Dodson, 1965), yellow perch 3 to 10 inches in total length (Galbraith, 1967) and splake over 6 inches in total length (Brynildson and Kempinger, 1970) preyed mainly on crustaceans 1 mm and larger.

The importance of large cladocerans to planktivorous fishes is indicated by the presence of *Leptodora kindtii* in their diets. *Leptodora* was present in rainbow trout stomachs (Brynildson, 1958) and perch stomachs (Kempinger and Morsell, 1969) when it was too sparse to be collected with the Number 2 plankton net in Turk and Nebish Lakes, respectively. Density of *Leptodora* in Pallette Lake (a neighbor to Nebish Lake) during 1964-66, never exceeded 0.1 per liter, yet it comprised at least 93 percent of the total crustaceans in the splake stomachs (Brynildson and Kempinger, 1970). The absence of *Leptodora* in stomachs of brown and rainbow trout taken by anglers from Nebish Lake indicates it was scarce and, hence, not readily available to the trout. *Leptodora* was not present in the 1967, 1969 or 1970 Clarke–Bumpus samples, and was present only in trace amounts in 1968 and 1971.

The absence of copepods in stomachs of brown and rainbow trout taken by anglers from Nebish Lake may be in part related to: (1) the distribution of copepods in depths with low dissolved oxygen, and (2) the preference of trout for other food items such as *Daphnia*. In most of the Clarke–Bumpus samples, the density of copepods 1 mm and larger was less than 1 per liter. Whenever these larger Cyclopidae were present at a density of 5 or more per liter, they were generally found at depths in Nebish Lake that lacked sufficient dissolved oxygen for trout (Fig. 6). In May and June 1968, however, when the water was saturated with oxygen, *Diaptomus* 1 mm and larger were present in the lake at a density of 4.7 per liter down to 30 feet, but were absent from the limited number (15 brown and 23 rainbow) of trout stomachs examined.

FIGURE 6
Dissolved oxygen 16 August 1968 and densities of Cyclopidae at different depths in Nebish Lake, 9 May and 16 August 1968.



Because no stomachs from the trout were examined during the summer of 1967, it is unknown whether these smaller trout fed on copepods. *Daphnia* 1 mm and larger averaged 11.4 per liter at 10- and 20-foot depths during that same period. Although both *Diaptomus* and *Daphnia* were present, the trout may have preferred *Daphnia* or may have been able to catch *Daphnia* more easily.

Copepods were present in the stomach contents of one- and two-year-old rainbow trout from small (10-20 acres) western Wisconsin lakes most of the year (Brynildson, 1958), but generally density of copepods averaged at least 4 per liter and the trout were taking those 1 mm and larger. In Lake Petrea (15 miles north of Nebish Lake), a large *Diaptomus* sp. shared dominance with *Daphnia* in the diet of rainbow trout (Johnson and Hasler, 1954). In other lakes, *Daphnia* was found to be the major planktonic crustacean consumed by rainbow trout (Johnson and Hasler, 1954; Galbraith, 1967; Applegate and Mullan, 1969), fingerling and adult yellow perch (Galbraith, 1967) and yellow perch fry over 14 mm in total length (Kempinger and Morsell, 1969).

PLANKTONIC CRUSTACEA

Brown and Ball (1943), Hooper (1948), Hoffman (1956) and Almquist

(1959), among others, demonstrated that a majority of aquatic invertebrates were killed by rotenone at concentrations needed to eradicate fish. The capacity of the *Daphnia* to make a comeback in Nebish Lake by late June 1967, may have been due partly to the presence of ephippia or resting eggs that *Daphnia* carried or had released before the rotenone treatment. These eggs, being highly resistant, were not damaged by rotenone and hatched the following spring into parthenogenetic females which produced young by June 1967. *Daphnia* containing ephippia in their brood pouches were eaten by trout in Nebish Lake during early October 1968, indicating that ephippia were formed by the time rotenone was applied 3 October 1966.

In addition to the survival of the ephippia, recovery of the *Daphnia* population probably was related to the relatively poor year class of perch (230/acre) in June 1967. Numbers of adult perch stocked were too low to have produced a year class of young perch strong enough to overgraze the *Daphnia* in 1967. Moreover, the 9,000 fingerling trout stocked 7 June 1967 (only 96 per acre) were probably of little consequence in slowing the upsurge of the *Daphnia* population.

As this upsurge continued during the summer of 1968, fluctuations in density were noted for different months at different depths. A possible explanation for these fluctuations is that *D. pulex* may prefer the deeper waters during the day in the warmest months of the year. In Nebish Lake, Clarke–Bumpus samples (taken between 10:00 a.m. and noon) showed that *D. pulex* densities increased markedly below 10 feet in July and below 20 feet in August 1968. When the water temperatures were moderate (May, June and September 1968) *D. pulex* was found at all depths sampled. This preference for cooler waters at certain times of the day and year was also found by other researchers. Brooks (1957) found that in lakes, *D. pulex* usually occupies the deeper waters during the day, tending to come up nearer the surface at night. Hall (1964) found *D. pulex* only in the deeper, colder regions of the lakes during the summer.

Beginning in late 1968 and continuing through 1971, numbers of *Daphnia* and other species of planktonic Crustacea in Nebish Lake declined. A number of comparisons seem to indicate that this decline was brought about by overgrazing by yellow perch: (1) On 16 August 1968, dissolved oxygen was too low for trout at 30 feet where *D. pulex* were large (85 percent were 1 mm or larger) and numerous (13.8 per liter). But at 10 and 20 feet where dissolved oxygen was high, *D. pulex* numbered 0.9 and 0.3 per liter), respectively, suggesting that where available to trout and perch, *D. pulex* was heavily grazed. (2) In April 1970, the 1969 year class of yellow perch was estimated at 2,130 yearlings per acre. Predation by this large year class further reduced the Crustacea population in 1969 and 1970. By October 1970, only 10 and 50 percent of the *Holopedium* and *D. pulex*, respectively, were 1 mm and larger, compared to 20 June 1967 when 77 and 84 percent, respectively, were 1 mm and larger. In September 1968, *Daphnia* averaged 16.5 per liter but were reduced to 0.2 per liter two years later. (3) By 1970 when predation was severe, *Bosmina longirostris* replaced *D. pulex* as the dominant open-water cladoceran. This same phenomenon was also reported by other observers who found that after heavy grazing by alewives (Brooks and Dodson, 1965) and bluntnose minnows and bluegills (Poff and Brynildson, 1965), the large dominant daphnids were replaced by small *B. longirostris* as the dominant open-water cladoceran.

Based on the changes brought about in the planktonic Crustacea population by overgrazing and with the standing crop of yellow perch as high as it is at present in Nebish Lake, it appears that fingerling trout stocked in the future may find only barren pastures to graze in the littoral as well as the pelagic zone.

The large cladocerans and copepods may become sparse and the open-water dominants may consist of small species of Crustacea or the younger and smaller adults of *Daphnia.* The probability of this occuring in Nebish Lake is made all the more real by similar drastic changes which have been reported for other waters. In Riley Lake (northwestern Wisconsin), planktivorous fishes, including rainbow trout, reduced the size of *D. pulex* by predation (Brynildson, 1958). Similarly, in Sporley Lake (northern Michigan), predation by rainbow trout, minnows and smelt not only reduced the size of *D. galeata mendotae* and *D. retrocurva,* but also led to the disappearance of *D. pulex* (Galbraith, 1967).

MANAGEMENT IMPLICATIONS

For rapid production of fish flesh to the creel in *Daphnia*-rich lakes (i.e., those lakes containing at least ten 1-mm and larger *Daphnia* per liter), rainbow trout should be stocked. Where rapid production of fish flesh to the creel is not the objective and where prolonged harvest of trout at lower fishing intensity is the goal, brown trout should be stocked for future "quality" trout fishing. Whether the trout stocked are brown trout, rainbow trout or both species, ideally they should be released in waters where the fish can be protected from angling for a year after release (as was done on Nebish Lake). In this way the trout, through growth in the wild, would produce many more pounds to the creel than were originally stocked.

In Wisconsin, there are many clear,

soft-water lakes similar to Nebish that have depths of 40 to 70 feet have good exposure to prevailing winds to insure spring turnover, and have an ideal short food chain from desmids to *Daphnia* and *Holopedium* to trout. Rather than managing these lakes for panfish and bass which can rapidly overpopulate and overgraze their feeding zones, the lakes could be managed for brown trout or rainbow trout alone or in combination with a noncompetitive fish such as largemouth bass or smallmouth bass. Largemouth bass and trout have in the past been a successful combination in Wisconsin (Brynildson, 1958) where fishing pressure held the fish biomass to levels which did not tax the lakes' production capacity.

Because brown and rainbow trout do not feed heavily on fish until they reach approximately 16 inches in total length, we cannot expect to grow trout to that size in a lake without high densities of Cladocera such as *Daphnia, Leptodora* or *Holopedium* because these Crustacea are, as adults, large enough for trout to feed on. To speed up the reestablishment of this important fish food after a lake has been chemically treated, these crustaceans should be stocked into the lakes after treatment. Larger crustaceans such as *Mysis* could also be experimentally introduced as food for trout in deep-water, oxygen-rich lakes.

SUMMARY

Conclusions of this 4½-year study were that fall-hatched, domesticated rainbow trout, stocked in a lake as 3.0- to 3.9-inch fingerlings in June, had higher survival and growth rates and higher yields to anglers than did their brown trout counterparts.

During the 2 years after fishing for trout was permitted on Nebish Lake, anglers creeled more pounds of rainbow trout than total poundage of brown trout produced in the lake during 4½ years. For each pound of brown and rainbow trout stocked, 5.2 and 15.0 pounds, respectively, were harvested by anglers. Nearly all of the rainbow trout were depleted by angling or natural mortality after two years of fishing, whereas a small number of "trophy" brown trout were still being caught by anglers four years after fishing for trout was permitted.

Daphnia occurred more frequently than fish in the trout stomachs during 1968-69 when the trout were between 1 and 3 years of age and ranged from 10 to 19 inches in total length. By 1970-71, fish occurred more frequently in the stomachs of the 16- to 21-inch trout than did *Daphnia.*

Overgrazing of the planktonic Crustacea by perch was evident by mid-summer in 1969, 1970 and 1971, soon after each year class of perch were hatched. Of four large species of *Daphnia (dubia, galeata mendotae, pulex* and *retrocurva)* present in the Clarke–Bumpus samples during 1967-68, only *D. pulex* was found in the 1970 samples after August. In 1971, *D. pulex* became sparse and was dominated by *D. galeata mendotae,* while *D. dubia* reappeared in low numbers and *D. retrocurva* was absent.

APPENDIX

TABLE 5
Contents of Stomachs from Trout Caught by Anglers from Nebish Lake, May and June 1968

Food Items	Brown Trout 15 Stomachs–7,068 Food Items*		Rainbow Trout 23 Stomachs–47,077 Food Items*	
	Percentage of Stomachs Containing Food Items	Percentage of Total Food Items in Stomachs	Percentage of Stomachs Containing Food Items	Percentage of Total Food Items in Stomachs
Crustaceans				
Daphnia	53.3	13.9	13.0	0.8
Eurycercus lamellatus	46.7	3.8	0.0	–
Hyalella azteca	13.3	x	13.0	0.1
Insects				
Chironomid				
larvae	33.3	0.7	60.9	2.9
pupae	93.3	66.0	91.3	38.0
adults	40.0	15.1	100.0	57.9
Chaoborus larvae**	6.7	x	13.0	x
Haliplidae adults	13.3	x	13.0	x
Corixidae	13.3	x	13.0	0.1
Notonecta undulata	6.7	x	4.3	x
Odonata nymphs**	13.3	0.2	17.4	0.2
Mayfly nymphs**	6.7	x	8.7	x
Caddis larvae	6.7	x	0.0	–
Other				
Water mites	13.3	x	8.7	x
Spiders	6.7	x	0.0	–
Plant material	6.7	x	0.0	–
Snails**	6.7	0.2	8.7	x

*Stomachs were taken from brown trout 10.3–13.5 inches in length and from rainbow trout 11.1–15.9 inches in length.
**The snails were mainly *Amnicola* sp., *Chaoborus* included *flavicans* and *punctipennis,* the Odonata included damselflies and dragonflies and the mayfly nymphs were *Hexagenia* sp.
xIndicates trace of food item in stomachs.

TABLE 6
Contents of Stomachs from Trout Caught by Anglers from Nebish Lake, July and August 1968

Food Items	Brown Trout 33 Stomachs–2,460 Food Items*		Rainbow Trout 77 Stomachs–24,960 Food Items*	
	Percentage of Stomachs Containing Food Item	Percentage of Total Food Items in Stomachs	Percentage of Stomachs Containing Food Item	Percentage of Total Food Items in Stomachs
Crustaceans				
Daphnia	60.1	37.5	83.1	77.2
Holopedium gibberum	3.0	0.5	0.0	–
Eurycercus lamellatus	51.5	18.0	19.5	4.2
Hyalella azteca	3.0	x	0.0	–
Crayfish	0.0	–	5.2	x
Insects				
Chironomid				
larvae	51.5	8.3	63.6	3.3
pupae	72.7	21.9	75.3	1.8
adults	18.2	4.1	13.0	0.1
*Chaoborus***	15.2	1.2	26.0	1.3
Simuliidae adults	9.1	x	0.0	x
Haliplidae adults	6.2	0.7	6.5	x
Sialis nymphs	9.1	x	22.0	0.8
Notonecta undulata	3.0	x	0.0	x
Odonata nymphs**	6.1	x	3.9	x

TABLE 6, Continued

Food Items	Brown Trout 33 Stomachs–2,460 Food Items* Percentage of Stomachs Containing Food Item	Brown Trout Percentage of Total Food Items in Stomachs	Rainbow Trout 77 Stomachs – 24,960 Food Items* Percentage of Stomachs Containing Food Item	Rainbow Trout Percentage of Total Food Items in Stomachs
Mayfly				
nymphs**	6.1	x	22.0	0.7
adults	0.0	–	9.1	x
Caddis				
larvae	3.0	x	5.2	x
adults	0.0	–	2.6	x
Terrestrial insects	0.0	–	2.6	x
Fish	3.0	x	1.3	x
Other				
Statoblasts	0.0	–	1.3	x
Snails**	24.2	2.1	18.2	2.2
Pill clams	6.1	3.0	10.4	0.2
Water mites	15.2	1.0	36.4	7.4
Spiders	0.0	–	1.3	x
Plant material	6.1	1.7	23.4	0.5

*Stomachs were taken from brown trout 12.2–14.6 inches in length and from rainbow trout 13.1–16.6 inches in length.
**The snails were *Amnicola* sp. and *Helisoma* sp., *Chaoborus* included larvae and pupae of *flavicans* and *punctipennis*, the Odonota included damselflies and dragonflies and the mayfly nymphs were mainly *Hexagenia* sp.
xIndicates trace of food item in stomachs.

TABLE 7
Contents of Stomachs from Trout Caught by Anglers from Nebish Lake, September 1968–April 1969

Food Items	Brown Trout 37 Stomachs–9,743 Food Items* Percentage of Stomachs Containing Food Items	Brown Trout Percentage of Total Food Items in Stomachs	Rainbow Trout 45 Stomachs–26,771 Food Items* Percentage of Stomachs Containing Food Items	Rainbow Trout Percentage of Total Food Items in Stomachs
Crustaceans				
Daphnia	56.8	89.0	77.8	81.1
Holopedium gibberum	0.0	–	24.4	6.2
Eurycercus lamellatus	2.7	x	2.2	x
Hyalella azteca	29.7	6.8	15.6	0.7
Crayfish	5.4	x	6.7	x
Insects				
Chironomid				
larvae	18.9	0.2	17.8	0.3
pupae	0.0	–	8.9	0.1
Chaoborus larvae**	0.0	–	11.1	0.1
Aquatic beetles	5.4	0.4	0.0	–
Notonecta undulata	2.7	0.3	4.4	0.2
Sialis nymphs	0.0	–	6.7	0.1
Dragonfly nymphs	16.2	0.2	11.1	0.2
Damselfly nymphs	0.0	–	4.4	0.1
Mayfly nymphs**	32.4	0.4	40.0	0.8
Caddis larvae	40.5	1.3	11.1	0.3
Terrestrial insects	2.7	x	0.0	–
Fish				
Fish	8.1	x	11.1	0.2
Trout eggs	0.0	–	2.2	x
Amphibians***	16.2	0.1	0.0	–
Other				
Snails**	27.0	1.3	6.7	0.3
Pill clams	0.0	–	4.4	6.8
Water mites	2.7	x	6.7	0.4
Plant material	13.5	x	46.7	2.1

*Stomachs were taken from brown trout 13.7–14.7 inches in length and from rainbow trout 14.8–17.8 inches in length.
**The snails were *Amnicola* sp., *Chaoborus* included *flavicans* and *punctipennis* and the mayfly nymphs were *Hexagenia* sp.
***Skeletal remains of unidentified amphibians.
xIndicates trace of food item in stomachs.

TABLE 8

Contents of Stomachs from Trout Caught by Anglers from Nebish Lake, May–August 1969

Food Items	Brown Trout 48 Stomachs–55,050 Food Items*: Percentage of Stomachs Containing Food Item	Brown Trout 48 Stomachs–55,050 Food Items*: Percentage of Total Food Items in Stomachs	Rainbow Trout 47 Stomachs–101,884 Food Items*: Percentage of Stomachs Containing Food Item	Rainbow Trout 47 Stomachs–101,884 Food Items*: Percentage of Total Food Items in Stomachs
Crustaceans				
Daphnia	22.9	0.6	21.3	21.6
Holopedium gibberum	0.0	0.0	6.4	0.1
Hyalella azteca	8.3	x	4.2	0.1
Crayfish	2.1	x	2.1	0.1
Insects				
Chironomid				
larvae	83.3	3.7	87.2	19.7
pupae	87.5	61.8	91.5	28.1
adults	79.2	19.4	74.5	17.8
Chaoborus				
larvae**	2.1	x	8.5	0.8
pupae**	47.9	7.2	55.3	5.8
Aquatic beetles	27.1	0.3	23.4	0.2
Notonecta undulata	8.3	0.3	6.4	0.1
Corixidae	35.4	0.8	42.6	1.0
Gerris	0.0	–	2.1	0.1
Sialis nymphs**	8.3	0.9	23.4	1.6
Damselfly nymphs	4.2	0.6	8.5	0.1
Dragonfly nymphs	0.0	–	17.0	0.3
Mayfly nymphs*	6.2	x	21.3	0.1
Caddis larvae	2.1	x	19.1	0.1
Terrestrial insects	2.1	x	8.5	0.2
Fish	6.2	0.1	6.4	0.2
Other				
Snails**	27.1	0.3	6.4	0.2
Pill clams	6.2	4.0	2.1	x
Water mites	8.3	x	27.6	1.0
Spiders	0.0	–	2.1	x
Plant material	6.2	x	53.2	0.7

*Stomachs were taken from brown trout 13.6–19.0 inches in length and from rainbow trout 15.2–20.2 inches in length.
**Snails were *Amnicola* sp. and *Helisoma* sp., *Chaoborus* included *flavicans* and *punctipennis* and mayfly nymphs were mostly *Hexagenia* sp.
xIndicates trace of food item in stomachs.

TABLE 9

Contents of Stomachs from Trout Caught by Anglers from Nebish Lake, November 1969–April 1970

Food Items	Brown Trout 34 Stomachs–6,226 Food Items*: Percentage of Stomachs Containing Food Item	Brown Trout 34 Stomachs–6,226 Food Items*: Percentage of Total Food Items in Stomachs	Rainbow Trout 10 Stomachs–1,249 Food Items*: Percentage of Stomachs Containing Food Item	Rainbow Trout 10 Stomachs–1,249 Food Items*: Percentage of Total Food Items in Stomachs
Crustaceans				
Daphnia	2.9	x	0.0	–
Holopedium gibberum	0.0	–	10.0	0.7
Hyalella azteca	26.5	12.0	20.0	0.7
Crayfish	5.9	x	0.0	–
Insects				
Chironomid				
larvae	11.8	0.6	0.0	–
pupae	0.0	–	10.0	0.1
Chaoborus				
larvae**	5.9	x	0.0	–
pupae**	2.9	x	10.0	0.1
Aquatic beetles	23.5	1.6	30.0	0.2
Corixidae	8.8	0.8	10.0	0.4
Notonecta undulata	50.0	17.2	60.0	49.6
Sialis nymphs	2.9	0.3	10.0	0.4
Damselfly nymphs	23.5	0.6	10.0	1.3
Dragonfly nymphs	20.6	1.4	20.0	0.2
Mayfly nymphs**	58.8	1.7	50.0	5.1

TABLE 9, Continued

Food Items	Brown Trout 34 Stomachs–6,226 Food Items* Percentage of Stomachs Containing Food Item	Brown Trout Percentage of Total Food Items in Stomachs	Rainbow Trout 10 Stomachs–1,249 Food Items* Percentage of Stomachs Containing Food Item	Rainbow Trout Percentage of Total Food Items in Stomachs
Caddis larvae	47.0	13.4	20.0	0.2
Terrestrial insects	0.0	–	10.0	0.2
Fish				
Fish	5.9	0.1	20.0	0.3
Trout eggs	29.4	34.3	70.0	39.6
Amphibians* **	17.6	0.1	0.0	–
Other				
Snails**	23.5	5.1	10.0	0.7
Water mites	0.0	–	10.0	0.1
Plant material	35.3	10.8	10.0	0.1

*Stomachs were taken from brown trout 17.6–19.3 inches in length and from rainbow trout 15.3–20.0 inches in length.
**The snails were *Amnicola* sp., the *Chaoborus* included *flavicans* and *punctipennis* and the mayfly nymphs were *Hexagenia* sp.
***Skeletal remains of unidentified amphibians.
xIndicates trace of food item in stomachs.

TABLE 10
Contents of Stomachs from Trout Caught by Anglers from Nebish Lake, May 1970–May 1971

Food Items	Brown Trout May–June 1970 18 Stomachs–12,602 Food Items* Percentage of Stomachs Containing Food Item	Brown Trout May–June 1970 Percentage of Total Food Items in Stomachs	Rainbow Trout May–June 1970 3 Stomachs–5,033 Food Items* Percentage of Stomachs Containing Food Item	Rainbow Trout May–June 1970 Percentage of Total Food Items in Stomachs	Brown Trout Dec. 1970–May 1971 13 Stomachs–374 Food Items* Percentage of Stomachs Containing Food Item	Brown Trout Dec. 1970–May 1971 Percentage of Total Food Items in Stomachs
Crustaceans						
Daphnia	11.1	x	0.0	–	0.0	–
Hyalella azteca	16.7	x	0.0	–	0.0	–
Crayfish	5.6	x	0.0	–	7.7	0.3
Insects						
Chironomid						
larvae	39.9	2.0	33.3	x	0.0	–
pupae	72.2	41.8	100.0	39.4	7.7	8.0
adults	5.6	30.8	100.0	48.0	0.0	–
Chaoborus						
larvae**	16.7	3.3	0.0	–	0.0	–
pupae**	38.9	2.6	33.3	11.6	0.0	–
Aquatic beetles	27.8	0.3	33.3	x	15.4	0.5
Corixidae	33.3	0.3	33.3	x	7.7	0.3
Notonecta undulata	16.7	0.1	0.0	–	15.4	9.6
Sialis nymphs	16.7	3.2	0.0	–	15.4	0.8
Damselfly nymphs	5.6	x	0.0	–	7.7	0.3
Mayfly nymphs**	0.0	–	0.0	–	15.4	0.5
Caddis larvae	0.0	–	0.0	–	38.5	2.4
Terrestrial insects	11.1	x	0.0	–	0.0	–
Fish						
Fish	27.8	0.9	0.0	–	53.8	6.1
Trout eggs	0.0	–	66.6	1.0	15.4	69.8
Amphibians* **	0.0	–	0.0	–	7.7	0.5
Other						
Snails**	61.1	3.0	0.0	–	7.7	0.3
Pill clams	5.6	10.2	0.0	–	0.0	–
Leeches	0.0	–	0.0	–	7.7	0.3
Birds	0.0	–	0.0	–	7.7	0.3
Plant material	44.4	1.5	33.3	x	0.0	–

*In May–June 1970, stomachs were taken from brown trout 17.0–19.8 inches in length and from rainbow trout 18.3–19.4 inches in length. In December 1970–May, 1971, stomachs were taken from brown trout 18.7–21.0 inches in length.
**The snails were *Amnicola* sp., the *Chaoborus* included *flavicans* and *punctipennis* and the mayfly nymphs were *Hexagenia* sp.
***Skeletal remains of unidentified amphibians.
x Indicates trace of food item in stomachs.

TABLE 11
Electivity Values (E) for Brown and Rainbow Trout in Nebish Lake, May–August 1968*

Months & Crustacea	Crustacean Resource in Nebish Lake: Avg. No. Per Liter (All Depths)	Crustacean Resource in Nebish Lake: Percentage 1 mm and Larger	Percentage of Total Crustacea in Stomachs: Brown	Percentage of Total Crustacea in Stomachs: Rainbow	E: Brown	E: Rainbow
May–June						
Cyclopidae	0.5	50.0	0.0	0.0	–1.00	–1.00
Daphnia	18.6	71.2	100.0	100.0	+0.14	+0.14
Diaptomus	4.7	62.0	0.0	0.0	–1.00	–1.00
Epischura	0.0	–	0.0	0.0	–	–
Holopedium	0.6	100.0	0.0	0.0	–1.00	–1.00
Leptodora	x	100.0	0.0	0.0	–	–
July						
Cyclopidae	3.4	39.3	0.0	0.0	–1.00	–1.00
Daphnia	12.0	88.1	98.4	100.0	+0.16	+0.17
Diaptomus	1.4	34.8	0.0	0.0	–1.00	–1.00
Epischura	x	100.0	0.0	0.0	–	–
Holopedium	x	100.0	1.6	0.0	–	–
Leptodora	x	100.0	0.0	0.0	–	–
August						
Cyclopidae	5.6**	61.4	0.0	0.0	–1.00	–1.00
Daphnia	9.7	86.2	100.0	100.0	+0.20	+0.20
Diaphanosoma	0.2	24.0	0.0	0.0	–1.00	–1.00
Diaptomus	0.7	0.1	0.0	0.0	–1.00	–1.00
Epischura	x	100.0	0.0	0.0	–	–
Holopedium	x	100.0	0.0	0.0	–	–
Leptodora	x	100.0	0.0	0.0	–	–

*Calculated from the relationship between density of various planktonic Crustacea in the lake and their percentage occurrence in stomach contents of trout from the same lake.
**41 per liter at depth of 30 feet 16 August.
xCrustacea present but too low in numbers to calculate number/liter.

TABLE 12
*Density and Size of Daphnia in Nebish Lake, 1963–1970**

	Depth (in Feet)							
	1		10		20		30	
Date	No.	%	No.	%	No.	%	No.	%
3 Jun 63	0.4	46	9.5	100	13.7	94	–	–
6 Jun 67	0.2	50	x	–	x	–	0.0	–
20 Jun 67	3.3	92	5.0	91	1.3	82	0.2	67
5 Jul 67	0.4	71	2.1	94	6.0	96	2.6	100
20 Jul 67	1.8	67	3.5	92	7.7	96	5.6	98
3 Aug 67	3.7	88	5.1	89	4.6	98	2.4	100
18 Aug 67	13.6	92	10.1	89	5.2	78	9.5	67
5 Sep 67	9.0	86	16.7	91	2.5	98	4.8	90
9 May 68	3.9	52	10.6	58	17.3	71	7.2	71
26 Jun 68	8.3	60	38.7	78	35.8	79	14.0	64
12 Jul 68	00.9	63	12.3	88	8.1	93	28.1	93
19 Jul 68	0.5	65	13.3	93	14.0	94	19.3	68
26 Jul 68	9.9	78	16.2	92	8.9	93	–	–
2 Aug 68	0.2	80	9.2	95	10.5	96	11.3	88
16 Aug 68	3.6	57	10.9	82	11.0	93	14.5	86
23 Aug 68	4.0	63	16.5	76	9.8	94	15.0	88
20 Sep 68	4.6	65	22.1	70	16.6	72	22.6	85
14 May 69	0.4	–	3.9	–	1.5	–	0.7	–
28 May 69	0.4	–	11.0	–	11.3	–	13.2	–
12 Jun 69	x	–	4.5	–	28.8	–	16.1	–
26 Jun 69	0.1	–	0.1	–	4.6	–	10.8	–
26 Jul 69	0.0	–	0.0	–	0.3	–	12.2	–
30 Jul 69	0.1	–	2.0	–	20.2	–	0.1	–
13 Aug 69	9.9	–	8.4	–	13.0	–	0.4	–
28 Aug 69	3.8	–	4.2	–	15.0	–	0.2	–
9 Sep 69	2.3	–	4.3	–	15.2	–	0.1	–
1 Oct 69	11.6	–	16.8	–	5.3	–	1.3	–
15 Oct 69	4.3	–	4.7	–	2.1	–	0.1	–
5 May 70**	x	–	2.9	59	0.8	50	x	–
20 May 70	0.2	83	35.0	68	14.5	90	7.3	83
3 Jun 70	0.4	75	23.0	93	14.6	96	17.1	96
16 Jun 70	x	–	x	–	2.7	95	0.5	90
30 Jun 70	0.2	–	x	–	0.1	50	10.7	53
14 Jul 70	x	–	x	–	x	–	20.1	95
28 Jul 70	x	–	x	–	0.6	0	5.8	92
11 Aug 70	x	–	0.7	14	9.6	78	7.1	***
25 Aug 70	x	–	1.0	76	0.3	33	7.4	83
8 Sep 70	0.0	–	x	–	0.0	–	1.5	82
22 Sep 70	x	–	x	–	x	–	0.0	–
7 Oct 70	x	–	x	–	0.1	–	x	–

*Density and size are given in terms of number per liter and percentage 1 mm and larger.
**Except for a trace of *Daphnia retrocurva* 11 August, *pulex* was the only *Daphnia* in the Clarke-Bumpus sample of 1970.
***Sample bottle accidentally broken before measurement of *Daphnia* size could be made.
x*Daphnia* too low in numbers to calculate number/liter.

TABLE 13
Temperature and Dissolved Oxygen in Nebish Lake, March–May and July–October, 1964

Approx. Depth (ft.)	5 Feb.	4 Mar.	18 Mar.	2 Apr.	6 May	31 July	14 Aug.	31 Aug.	15 Sept.	21 Oct.
Temperature (F)										
1	33	32	34	34	54	74	66	63	62	47
11	39	39	39	40	52	74	66	64	62	47
22	39	39	40	40	46	71	66	64	61	47
33	40	40	40	40	42	51	51	52	60	47
44	41	41	41	41	42	47	46	46	47	47
Oxygen (ppm)										
1	12.6	12.0	11.5	10.0	10.2	8.0	8.0	8.2	9.3	10.2
11	8.8	7.4	6.9	6.4	10.1	8.0	8.0	8.8	9.9	10.2
22	7.4	7.2	6.2	6.6	9.6	7.8	8.0	9.1	8.5	10.6
33	5.9	2.6	4.0	2.1	8.0	0.3	0.6	4.5	7.2	10.6
44	0.2	1.3	0.0	0.3	6.1	0.0	0.0	0.3	0.3	10.2

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