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GROWTH, SURVIVAL, PRODUCTION AND DIET OF HATCHERY-REARED RAINBOW TROUT STOCKED IN FULLER POND, MONTMORENCY COUNTY, MICHIGAN[1]

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ABSTRACT

Hatchery-reared rainbow trout were stocked in Fuller Pond in mid-October of 1969 to 1972. Population size, survival rate, growth rate, production, and diet of these fish were monitored, along with pond benthos. Trout survival was about 50% from planting date in the fall to the following spring. Survival from spring to the next fall was about 10%; much of the mortality was due to experimental cropping to monitor trout diet. We experimentally cropped about 140 trout per year, or 28% of the number stocked. Natural mortality tended to increase during the 4 years of the study. Growth of the trout was good, with annual increments of 0.58 to 0.35 pound per fish. Growth rate and condition factor dropped as the study progressed, coincidentally with a reduction of food and with increases in sucker and minnow populations. Production of trout flesh ranged from 7.9 down to 2.7 pounds per acre per year. A decline in production was coincident with a decline in growth, a decrease in food supply, and an increase in the populations of suckers and minnows.

Introduction

Planting of hatchery-reared trout in inland lakes and ponds is an important management procedure used to generate desirable fisheries. This study was conducted to better understand the relationships between trout production, stocking practices, diet, and invertebrate benthos crops.

Rainbow trout were stocked in Fuller Pond each mid-October during 1969 to 1972. Mark-and-recapture population estimates were made in winter, spring, and fall following trout stocking, to determine trout survival. Measurements of trout growth were also made during

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[1] Contribution from Dingell-Johnson Project F-35-R, Michigan.

the population studies. Trout diet and the standing crop of invertebrate food organisms were monitored throughout the growing season--spring to fall. Cropping of trout was regulated over the growing season, and was limited to fish needed for monitoring of diet.

The study site

Fuller Pond is a flowage of 15 acres. It has an earthen dike located in the site of an old beaver dam. Maximum water depth is 5 feet in the former stream channel. The outlet stream discharges about 3 cfs through a fish trapping weir; and the trout population is confined to the pond. Temperature and oxygen regimes in the pond are such that the trout can frequent most areas of the pond throughout the year. The water is clear--except after high winds--and is hard (170 ppm alkalinity). Aquatic macrophytes are fairly abundant, and are composed mostly of bladderwort, pondweed, milfoil, smartweed, sedge, bulrush, and duckweed; Chara and green algae are common. The pond was treated with rotenone to attempt to remove competing fish species at the start of the study.

Methods

Hatchery-reared rainbow trout were stocked in Fuller Pond each October from 1969 to 1972. Trout were stocked at a rate of 500 per year (33.3 fish per acre); these fish averaged 9.6 to 11.2 inches long for the four plantings. The trout were fin-clipped for later identification of the year when planted.

Trout population levels were estimated by mark-and-recapture procedures described by Latta and Myers (1961). Measurements of trout for growth assessment were obtained during population studies and from collections of fish made for diet analysis.

Estimates of trout production were computed as a product of the average weight of the standing crop and the instantaneous growth rate following the method of Ricker (1958). Production here means all trout

flesh grown during the period, including growth of fish that died during the period. Trout cropping was made systematically over the major trout growing season, and was limited to fish needed to monitor diet (about 150 fish per season).

The diet of trout was determined from analysis of stomach contents. Collections of fish were made mostly by gill netting. However the last few fish collected each sampling period were usually taken by angling to prevent exceeding the sample quota.

Invertebrate benthos samples were taken with the Ekman dredge. Five dredge samples were taken monthly during the summer, from each of eight pond locations. Benthic organisms were picked from samples using sugar flotation. Invertebrates were sorted to taxonomic group, counted, and their volumes were determined by fluid displacement.

Results

Mortality

Estimated populations of rainbow trout surviving to various mid-month dates are given in Tables 1-4 for the various plantings. In this study, natural mortality factors alone operated to reduce trout stocks from planting time in mid-October to the following mid-April. During the period from mid-April to mid-October both natural and fishing mortality (netting and experimental angling) operated to reduce the population.

Trout survival the first 6 months of life in Fuller Pond was 50%, 56%, 49%, and 46% for the four annual plants. This is much poorer survival than the 90% plus survival rate noted for East Fish Lake rainbow trout, which lake is within a mile of Fuller Pond (Alexander, 1975). This natural loss is believed mostly due to predators which are more efficient killers in the shallow waters of Fuller Pond.

Trout survival the second 6-month period (mid-April to mid-October) was only 20%, 32%, 7%, and 7% for the four plants. Both natural mortality and experimental fishing mortality operated to reduce trout stocks during this period with most of the loss due to experimental cropping. This cropping amounted to 74%, 79%, 65% and 47% of the mortality for the

four plants. About 140 trout (28% of the fish planted) were cropped per year. Natural mortality tended to increase during the study.

Rainbow trout survival the first year was low and amounted to 10, 18, 4 and 3% of the fish planted. Few of these carryover trout survived the following fall-to-spring period. Survival was only 14, 10, and 22% for the three groups of older trout, which was considerably poorer than survival of younger fish in the pond. Survival of carryover trout from April to October was nil, with virtually no trout surviving more than 2 years in the pond.

Growth

Average lengths and weights of trout at various mid-month dates are given in Tables 1-4. Growth was fairly good for the October-to-April period (considering the time of year) with trout from the four plants gaining average increments of 0.14, 0.19, 0.08, and 0.13 pound per fish. Average weight increments gained per fish during the second 6-month period (April to October) were 0.45, 0.25, 0.27, and 0.25 pound, respectively, for the four plants. For the year as a whole, the 1969 plant had the best growth increment (0.59 pound); it was 0.44 pound for the 1970 plant, 0.35 pound for 1971, and 0.38 pound for the 1972 plant. Even though the pond was chemically treated with rotenone to remove the competing fish population when the study was started, the competing minnows and white suckers reappeared in 1970. The decline in trout growth was associated with the increase in populations of competing fish.

Growth of carryover trout was varied. Surviving trout of the 1969 plant grew to average weight of 1.44 pounds in their second season. The increment gain during their second growing season was 0.42 pound. Carryover fish of the 1970 plant grew the least in their second year--only 0.21 pound; these trout were the largest fish at planting time. Carryover trout of the 1971 plant had the best second-year growth increment, or 0.53 pound. These trout were the smallest at planting time. Smaller rainbow trout appear to be more efficient converters of

food. (This was also noted by me in a companion study on East Fish Lake; see Alexander, 1975.)

Trout condition

The average condition factor "C" of rainbow trout sampled in summer is given in Table 5. Average condition of first-year trout changed from 37 for the 1969 plants to 34 for the 1972 plants. Condition of carryover trout dropped from 35 in 1969 to 32 in 1971. In general, the condition of carryover trout was poorer than that of first-year fish.

Production

Monthly estimates of rainbow trout production are given in Tables 1-4. First-year production figures for the 1969-1972 plants were 7.0, 7.5, 3.2, and 4.1 pounds per acre, respectively. Production of carryover trout was very low; it was 0.35, -0.54, and 0.23 pound per acre during the 3 years when these older fish were present. Total trout production in pounds per acre for Fuller Pond was 7.0 in 1970, 7.9 in 1971, 2.7 in 1973, and 4.3 in 1974. Production dropped with increased populations of suckers and minnows. Trout production in Fuller Pond was less than one-fourth that measured for East Fish Lake (Alexander, 1969; 1974). It was also considerably less than brook trout production of 10 to 18 pounds per acre measured by Gowing (1974) in the Pigeon River pothole lakes, Michigan.

Diet

A total of 545 trout stomachs were analyzed for volume and kinds of food. The breakdown of trout food by taxonomic group is shown in Table 6. Considerable variation between years existed in the relative importance of food types. More than half the trout diet of the 1969 plant was composed of snails. Snails in the diet were 10% or less during the following 3 years. Benthos samples (Table 7) reflect the decreased abundance of snails in the pond. Trichoptera comprised 13% of the trout diet in 1969, but thereafter they were of little importance. Benthos

samples did not indicate a reduction of caddisfly larvae in the pond. Both crustaceans and forage fish tended to increase in the trout diet over the study period. Fair amounts of Odonata and Hemiptera were found during all years, and these organisms contributed about 10% each to the average trout diet. However, Odonata were much better represented in the benthos samples than Hemiptera. About 10% of the material found in the stomachs was unidentifiable remains of invertebrates. Annelida, Ephemeroptera, Coleoptera, Diptera, Amphibia, and various terrestrial insects were eaten but were of minor importance. In general, trout diet was quite diverse in Fuller Pond compared to nearby East Fish Lake.

No strong relationship could be shown between volume of food eaten and growth increment made by the fish; however, there was relatively little variation in the two factors. Fuller Pond data do fall on a regression line determined for the food eaten and growth increment relationship of rainbow trout in East Fish Lake (Alexander, 1975).

Benthos

Bottom samples from Fuller Pond were collected throughout the study. The standing crop, by volume, of the principal types of benthic invertebrates is shown in Table 7. Crayfish are not included because our gear (the Ekman dredge) is inefficient in sampling this animal. Among other crustaceans, scuds were fairly abundant, but only during the first 2 years of the study.

In general, total benthos decreased in abundance after the first year of the study. Annelids, mollusks, crustaceans, hemipterans and dipterans all showed reductions. The dipterans made up the largest portion of the benthos (34 to 48%). Aquatic annelids, odonates, and trichopterans each composed about 10% of the benthic community.

The decline in growth and production of trout was directly related to a reduction in the benthos, which, in turn, coincided with an increase in the sucker and minnow populations.

Conclusions

Hatchery-reared rainbow trout (9 to 11 inches long) planted in Fuller Pond in mid-October had a 50% mortality rate to mid-April. This is a much higher mortality than measured in nearby East Fish Lake. The higher losses in Fuller Pond are believed due to higher kills of trout by natural predators in the relatively shallow water of Fuller Pond.

Trout growth was good with annual increment gains ranging from 0.59 to 0.35 pound. Growth dropped during the study, as the populations of competing fish species increased. The condition factor of trout decreased along with the decline in growth rate.

Annual production of trout flesh varied from 7.9 to 2.7 pounds per acre. This is low compared to other trout waters of the area and is mostly a result of poor survival rates. Competition from suckers and minnows also reduced production substantially.

The average amount of food found in trout stomachs is believed to be directly related to trout growth and condition. The food of trout in Fuller Pond is rather diverse and varies considerably from one year to another. Changes in benthos populations (milliliters per square foot) were generally related to changes in trout growth, condition, and production.

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Table 1.--Estimated monthly and annual production in pounds of rainbow trout from 1969 planting in Fuller Pond, with data on length, weight and standing crop

Mid-month	Average length (inches)	Average weight (pounds)	Estimated number	Standing crop (pounds)	Production (pounds)
First growing season:					
October	10.5	0.43	500	215.0	....
November	10.6	0.44	445	195.8	4.5
December	10.8	0.47	395	185.7	12.5
January	10.9	0.48	353	169.4	3.5
February	11.1	0.50	313	156.5	6.7
March	11.3	0.54	279	150.7	11.8
April	11.6	0.57	248	141.4	7.8
May	12.0	0.64	188	120.3	15.1
June	12.6	0.74	143	105.8	16.4
July	13.1	0.84	108	90.7	12.4
August	13.5	0.91	83	75.5	6.5
September	13.9	1.00	64	64.0	6.6
October	14.1	1.02	49	50.0	1.1
Season total	....	....	...	.....	104.9
Second growing season:					
October	14.1	1.02	49	50.0	....
November	14.4	1.05	36	37.8	1.2
December	14.6	1.09	26	28.3	1.2
January	14.8	1.13	19	21.5	1.0
February	14.9	1.16	14	16.2	0.4
March	15.1	1.21	10	12.1	0.6
April	15.2	1.23	7	8.6	0.2
May	15.4	1.28	5	6.4	0.3
June	15.6	1.33	4	5.3	0.2
July	15.7	1.35	3	4.0	0.0
August	15.8	1.39	2	2.8	0.2
September	15.9	1.41	1	1.4	0.0
October	16.0	1.44	1	1.4	0.0
Season total	....	....	...	.....	5.3

Table 2.--Estimated monthly and annual production in pounds of rainbow trout from 1970 planting in Fuller Pond, with data on length, weight and standing crop

Mid-month	Average length (inches)	Average weight (pounds)	Estimated number	Standing crop (pounds)	Production (pounds)
First growing season:					
October	11.1	0.48	500	240.0	....
November	11.3	0.51	455	232.0	14.3
December	11.4	0.52	411	213.7	4.4
January	11.6	0.54	373	201.4	7.6
February	11.9	0.59	337	198.8	17.6
March	12.1	0.62	306	189.7	9.6
April	12.4	0.67	278	186.3	14.7
May	12.7	0.72	230	165.6	12.7
June	12.9	0.75	190	142.5	6.4
July	13.3	0.82	157	128.7	12.1
August	13.6	0.88	130	114.4	8.6
September	13.7	0.90	107	96.3	2.4
October	13.8	0.92	89	81.9	1.9
Season total	....	....	...	.....	112.3
Second growing season:					
October	13.8	0.92	89	81.9	....
November	13.9	0.86	62	53.3	-7.9
December	13.9	0.86	43	37.0	0.0
January	13.9	0.86	29	24.9	-0.5
February	13.9	0.86	20	17.2	0.3
March	13.9	0.86	14	12.0	-0.4
April	13.9	0.86	9	7.7	-0.2
May	13.9	0.86	6	5.2	0.1
June	14.1	0.90	4	3.6	0.2
July	14.3	0.94	3	2.8	0.1
August	14.6	1.00	2	2.0	0.2
September	15.0	1.08	1	1.1	0.0
October	15.2	1.13	1	1.1	0.0
Season total	....	....	...	.....	-8.1

Table 3.--Estimated monthly and annual production in pounds of rainbow trout from 1971 planting in Fuller Pond, with data on length, weight and standing crop

Mid-month	Average length (inches)	Average weight (pounds)	Estimated number	Standing crop (pounds)	Production (pounds)
First growing season:					
October	9.6	0.30	500	150.0	....
November	9.7	0.31	444	137.6	4.6
December	9.8	0.32	394	126.1	4.2
January	9.9	0.33	347	114.5	3.6
February	10.1	0.35	308	107.8	6.6
March	10.2	0.36	273	98.3	3.0
April	10.4	0.38	243	92.3	5.1
May	10.7	0.42	157	65.9	7.8
June	11.0	0.45	104	46.8	3.9
July	11.3	0.49	66	32.3	3.2
August	11.7	0.55	42	23.1	3.2
September	12.1	0.60	27	16.2	1.7
October	12.4	0.65	18	11.7	1.1
Season total	....	....	...	.....	48.0
Second growing season:					
October	12.4	0.63	18	11.3	....
November	12.7	0.68	15	10.2	0.9
December	12.9	0.70	13	9.1	0.3
January	13.2	0.76	9	6.8	0.8
February	13.5	0.81	7	5.7	0.5
March	13.7	0.85	6	5.1	0.2
April	13.9	0.88	4	3.5	0.1
May	14.2	0.94	3	2.8	0.2
June	14.4	0.99	3	3.0	0.2
July	14.6	1.01	2	2.0	0.0
August	14.8	1.07	2	2.1	0.1
September	15.0	1.11	1	1.1	0.1
October	15.2	1.16	1	1.2	0.1
Season total	....	....	...	.....	3.5

Table 4.--Estimated monthly and annual production in pounds of rainbow trout from 1972 planting in Fuller Pond, with data on length, weight and standing crop

Mid-month	Average length (inches)	Average weight (pounds)	Estimated number	Standing crop (pounds)	Production (pounds)
First growing season:					
October	10.5	0.38	500	190.0	....
November	10.6	0.41	438	179.6	14.0
December	10.8	0.43	386	166.0	8.2
January	10.9	0.44	340	149.6	3.5
February	11.1	0.46	298	137.1	6.2
March	11.2	0.48	262	125.8	5.7
April	11.4	0.51	231	117.8	7.2
May	11.6	0.53	146	77.4	3.7
June	11.8	0.56	97	54.3	3.6
July	12.2	0.61	62	37.8	3.9
August	12.6	0.67	41	27.5	3.1
September	12.8	0.72	26	18.7	1.6
October	13.1	0.76	17	12.9	0.8
Season total	....	....	...	.....	61.5

Table 5.--Average condition factor "C" of rainbow trout in Fuller Pond, 1969-1972

Season after planting	1969	1970	1971	1972
First year	37	35	34	34
Carryover (2nd year)	35	32	32	--

Table 6.--Mean volume in ml, and volume by percentage, of food in stomachs of rainbow trout, Fuller Pond, 1970-1973

Taxonomic group	Volume in ml				Volume by percentage			
	1970	1971	1972	1973	1970	1971	1972	1973
Annelida	0.022	0.031	0.007	0.004	0.9	2.6	0.7	0.2
Mollusca	1.297	0.120	0.043	0.150	53.3	10.1	4.1	6.1
Crustacea	0.013	0.004	0.095	1.614	0.5	0.3	9.0	65.3
Ephemeroptera	0.008	0.001	0.022	0.213	0.3	0.1	2.1	8.6
Odonata	0.192	0.222	0.120	0.014	7.9	18.7	11.4	0.6
Hemiptera	0.138	0.313	0.236	0.063	5.7	26.3	22.4	2.6
Coleoptera	0.033	0.012	0.011	0.008	1.4	1.0	1.0	0.3
Trichoptera	0.327	0.032	0.037	0.001	13.4	2.7	3.5	tr*
Diptera	0.053	0.011	0.010	0.049	2.2	0.9	1.0	2.0
Terrestrial	0.013	0.005	0.026	0.024	0.5	0.4	2.5	1.0
Fish	0.014	0.226	0.275	0.193	0.6	19.0	26.1	7.8
Amphibia	0.045	0.081	0.016	0.034	1.8	6.8	1.5	1.4
Other	0.004	0.001	0.001	0.000	0.2	0.1	0.1	...
Unidentified	0.273	0.129	0.153	0.105	11.3	11.0	14.6	4.1
Total	2.432	1.188	1.052	2.472	100	100	100	100

* tr = trace

Table 7.--Mean volume in ml, and volume by percentage, of invertebrate benthos per square foot of pond bottom, Fuller Pond, 1970-1973

Taxonomic group	Volume in ml				Volume by percentage			
	1970	1971	1972	1973	1970	1971	1972	1973
Annelida	0.122	0.044	0.037	0.058	16.1	9.8	7.0	13.4
Mollusca	0.058	0.002	0.009	0.017	7.6	0.4	1.7	3.9
Crustacea	0.148	0.062	0.005	0.004	19.5	13.8	1.0	0.9
Ephemeroptera	0.008	0.009	0.031	0.028	1.1	2.0	5.9	6.5
Odonata	0.042	0.090	0.112	0.069	5.5	20.1	21.2	15.9
Hemiptera	0.020	0.004	0.001	0.001	2.6	0.9	0.2	0.2
Coleoptera	0.004	0.029	0.006	0.005	0.5	6.5	1.1	1.2
Trichoptera	0.056	0.054	0.075	0.056	7.4	12.0	14.2	12.9
Diptera	0.302	0.155	0.252	0.196	39.7	34.5	47.7	45.1
Hydracarina	tr	tr	tr	tr	....	....	....	....
Total	0.760	0.449	0.528	0.434	100	100	100	100

tr = trace

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