Food Habits of Larval Yellow Perch as a Potential Indicator of Water and Habitat Quality

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Abstract

We studied the food habits of over 760 larval yellow perch (5.0-9.9 mm, total length) collected during May in 1977 and 1978 in the Detroit River to investigate whether degraded water quality reduces the feeding activity of larval fish and to determine if the kinds and amounts of food eaten by larvae changed as they passed downstream from relatively unpolluted waters near Belle Isle to waters heavily impacted by industrial and municipal waste discharges near Grosse Ile. Larvae in the 5.0-7.9 mm length range collected from the upper (relatively unpolluted) waters and lower (polluted) waters of the river had eaten small copepods, copepod nauplii, and rotifers. Larvae in the 8.9-9.9 mm length range collected from the same waters had eaten primarily large copepods. Although the composition of the diets of yellow perch larvae collected from both portions of the river were similar, the incidence of feeding and the feeding rates of larvae collected from the lower portion of the river were markedly reduced when compared to the feeding behavior of larvae collected from the upper portion of the river. The results of this study suggest that a cause-effect relation exists between reduced water quality in the lower river and reduced feeding rates of larval yellow perch.

Introduction

Laboratory studies (Shelford 1917, Willis 1937, Silver et al. 1963, Alderson 1972, Smith and Oseid 1972) have shown that the larvae of many species of fish are adversely affected by the chemical compounds and elements found in the industrial and municipal wastes present in many of our inland lakes and streams, yet few field studies have been done to demonstrate the impacts of such wastes on fish larvae in natural waters such as the Detroit River. Therefore, we conducted this field study to test the hypothesis that a sensitive and useful indicator of the effects of water pollution on the fisheries resources of an aquatic system might be a change in the feeding behavior of fish larvae exposed to reduced water quality.

The Detroit River has many features that make it feasible to demonstrate the effects of municipal and industrial wastes on the transient populations of fish larvae in that system including: (1) water quality at the head of the Detroit River is relatively high but becomes progressively lower as water passes through the system enroute to Lake Erie (USEPA 1974, Bell 1980); (2) industrial and municipal wastes similar to those found in the Detroit River are known from laboratory studies to adversely affect fish larvae; (3) large numbers of larvae are flushed through the Detroit River annually (Hatcher and Nester, in preparation); (4) the average flushing time of the river is short (19 hours), thereby minimizing natural mortality effects on the transient populations of larvae relative to the effect caused by waste discharges; and (5) transient populations of fish larvae can be followed as they progress through the river to determine if they exhibit any detrimental effects of exposure to wastes during passage.

The yellow perch was selected for study because: (1) it supports valuable fisheries in the Great Lakes, (2) it has a pelagic larva, (3) large numbers of yellow perch larvae are flushed through the Detroit River, and (4) the source of these larvae appears to be spawning grounds in Lake St. Clair.

Material and Methods

The yellow perch larvae on which this study is based were collected with 0.5 m, 355 µm mesh plankton nets on May 11 and 18, 1977, and on May 25, 1978, at 3 stations on each of 2 cross-river transects on the Detroit River (Fig. 1).[1/] Transect V was located in the relatively higher quality waters of the upper Detroit River near Belle Isle and transect VI was located in the more heavily polluted waters of the lower Detroit River near Grosse Ile. Water

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1/ These collections were made to satisfy the requirements of a study designed to determine the status and potential of the Detroit River as spawning and nursery habitat for Great Lakes fishes; detailed descriptions of the study area, the gear used to capture the larvae, method of preparation, and overall study design are given in Hatcher and Nester (in prep.).

quality measurements (chlorides, silica, dissolved oxygen, and turbidity) made in the surface waters of the Detroit River at transects V and VI, April 18-July 28, 1977 (unpublished data, GLFL) indicated that water quality was reduced in the lower Detroit River. The EPA (1974) and Bell (1980) also reported reduced water quality in the lower Detroit River.

Larvae were individually removed from the 30% ethanol in which they had been preserved, placed in a drop of demineralized water on a microscope slide, and measured with a stage micrometer to the nearest 0.1 mm under a dissecting microscope. The presence or absence of a yolk sac was recorded (a yolk sac was recorded as present if oil globules were discernable near the gut). The alimentary canal was then dissected from the larva and retained on the slide. All other parts of the larva were discarded. A longitudinal slit was made along the alimentary canal and the gut contents were gently removed and placed alongside the alimentary canal. A permanent stained microscope slide mount of the alimentary canal and its contents was made by applying a drop of mounting medium and cover slip to the preparation. The mounting medium consisted of 1 part of a 1% aqueous solution of chlorazol black E stain combined with 9 parts Hydramount.[2/]

Gut contents were analyzed using an inverted microscope with a magnification range of 25-1000X. Food organisms were identified and counted as copepods (nauplii, calanoid or cyclopoid), cladocerans, rotifers, or unidentified invertebrates. Algae were not counted because they occurred only within rotifers or in discrete masses which appeared to have been ingested by a rotifer or other invertebrate that was subsequently ingested by the yellow perch larva. The width and length of each invertebrate removed from the gut of a larva was measured to the nearest micron with a calibrated ocular micrometer. Copepods were measured from the cephalothorax to the base of the caudal rami and across the broadest portion of the cephalothorax. Cladocerans were measured from the head to the posterior end of the carapace (excluding the tail) and across the broadest portion of the carapace. Rotifers were measured from the anterior tip of the head to the base of the trunk and across the broadest section of the organism.

Results and Discussion

The 764 yellow perch larvae examined in this study ranged from 5.0 to 9.9 mm in total length[3/]. The length frequency of all larvae examined is given in Table 1. Most larvae in the 5.0-6.9 mm length interval were yolk sac larvae and most longer than 6.9 mm were non-yolk sac larvae. With the exception of the larvae in the 9.0-9.9 mm length interval, there were higher numbers of both yolk sac and non-yolk sac larvae collected from the lower river (transect VI) than the upper river (transect V).

2/ Mention of brand names in this report does not indicate or imply endorsement by the U.S. Government.

3/ Only two larvae were collected which were less than 5.0 mm total length (one 4.6 mm and one 4.8 mm) and the alimentary canals of both were empty.

Food habits analyses indicated that prey organisms first appeared in the alimentary canals of yellow perch larvae in the 5.0-5.9 mm length range before the yolk sac was completely absorbed (which occurred in all larvae by 8.0 mm). Higher percentages of the yolk sac and non-yolk sac larvae were feeding in the upper river than in the lower river, with the exception of yolk-sac larvae in the 7.0-7.9 mm length interval (Table 2). Reduced feeding among larvae in the lower Detroit river may have been a response to the more heavily polluted waters of the lower river.

Yellow perch larvae in the 5.0-7.9 mm length range ate primarily small copepods, copepod nauplii, rotifers, and unidentified invertebrates, whereas larvae in the 8.0-9.9 mm length range ate mostly large cyclopoid and calanoid copepods (Table 3). As the size of the yellow perch larvae increased there was a shift in the composition of the diet from small immature copepods and rotifers to large cyclopoid copepods and calanoid copepods (Table 3). Similar changes in feeding habits by yellow perch larvae have been reported by Siefert (1972), Bulkley et al. (1976), Clady (1977), and Keast (1980). With the exception of the larger number of copepod nauplii eaten by larvae examined from the upper river, the composition of the diet of yellow perch larvae collected from the upper river differed very little from that of larvae collected from the lower river.

With the exception of larvae in the 9.0-9.9 mm length interval, the mean number of organisms ingested by yellow perch larvae was markedly higher in the upper river than in the lower river (Table 4). These data indicate that the reduced water quality in the lower river may depress the feeding rate or abilities of yellow perch larvae.

Yolk sac larvae fed on larger organisms in the upper river than in the lower river (Table 5). The non-yolk sac larvae collected from the lower river, however, ate larger organisms than the non-yolk sac larvae collected in the upper river (Table 5). It is unknown whether these differing trends in the data reflect differences in the relative availability of large and small prey in the upper or lower portion of the river or that the feeding selectivity of the yellow perch larvae from the upper river varied from that of the larvae in the lower river.

The results of this study suggest that degraded water quality in the lower river reduced feeding abilities of yellow perch larvae. This was especially apparent among larvae in the 5.0-7.9 mm length range, the majority of which were yolk sac larvae. Little reduction in feeding was observed among non-yolk sac larvae in the 8.0-9.9 mm length range. Although these results do not verify the hypothesis that reduced feeding incidence and feeding rates of larval fish are reliable indicators of the effects of water pollution on fish populations, they indicate the hypotheses should not be rejected, and indeed suggest that additional study may well result in a confirmation of the hypotheses. If additional studies are undertaken, they should include concurrent sampling of the food source, most likely zooplankton, to determine the composition and abundance of the local zooplankton populations.

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Literature Cited

Alderson, R. 1972. Effects of low concentrations of free chlorine on eggs and larvae of Plaice, Pleuronectes platessa L. Pages 312-315 in Marine pollution and sea life. Fishing News, Ltd., Lond.

Bell, G. L. 1980. Lake St. Clair and St. Clair and Detroit Rivers chemical and physical characteristics data for 1974. U.S. NOAA Data Report ERL, GLERL-12.

Bulkley, R. V., V. L. Spykermann, and L. E. Inmon. 1976. Food of the pelagic young of walleyes and five cohabiting fish species in Clear Lake, Iowa. Trans. Am. Fish. Soc. 105(1):77-83.

Clady, M. D. 1977. Crustacean zooplankton populations and concurrent survival of larval yellow perch in Oneida Lake. N. Y. Fish Game J. 24(1):46-52.

Hatcher, C. O., and R. T. Nester. Status and potential of the St. Clair-Detroit River Ecosystem as a spawning and nursery habitat for Great Lakes Fishes. USFWS, Great Lakes Fishery Laboratory, Admin. Rep. (In prep.).

Keast, A. 1980. Food and feeding relationships of young fish in the first weeks after the beginning of exogenous feeding in Lake Opinicon, Ontario. Environ. Biol. Fish. 5(4):305-314.

Shelford, V. E. 1917. An experimental study of the effects of gas waste upon fishes, with especial reference to stream pollution. Bull. Ill. Nat. Hist. Surv. 13:25-42.

Siefert, R. E. 1972. First food of larval yellow perch, white sucker, bluegill, emerald shiner, and rainbow smelt. Trans. Am. Fish. Soc. 101(2):219-225.

Silver, S. J., C. E. Warren, and P. Doudoroff. 1963. Dissolved oxygen requirements of developing steelhead trout and chinook salmon embryos at different water velocities. Trans. Am. Fish. Soc. 92:327-343.

Smith, L. L., Jr., and D. M. Oseid. 1972. Effects of hydrogen sulfide on fish eggs and fry. Water Res. 6:611-720.

U.S. Environmental Protection Agency. 1974. Water pollution investigation: Detroit and St. Clair Rivers. Great Lakes Initiative Contract Program. EPA-905/9-74-013.

Willis, M. M. 1937. Detection and measurement of stream pollution. Bull. U.S. Bur. Fish. 48:365-437.

Table 1. Length frequency distribution of yolk sac and non-yolk sac yellow perch larvae on which this study is based. (Larvae were collected at transects V and VI in the Detroit River in 1977-78. Percentages of yolk sac and non-yolk sac larvae in each length interval, by transect, are given in parentheses.)

Length intervals (mm)	Number of larvae in length interval					
	Transect V			Transect VI		
	Yolk sac	Non-yolk sac	Total for transect	Yolk sac	Non-yolk sac	Total for transect
5.0 - 5.9	46 (94)	3 (6)	49 (100)	57 (97)	2 (3)	59 (100)
6.0 - 6.9	61 (73)	22 (27)	83 (100)	89 (70)	28 (30)	127 (100)
7.0 - 7.9	15 (15)	85 (85)	100 (100)	17 (17)	84 (83)	101 (100)
8.0 - 8.9	0 (0)	87 (100)	87 (100)	0 (0)	92 (100)	92 (100)
9.0 - 9.9	0 (0)	43 (100)	43 (100)	0 (0)	23 (100)	23 (100)
Total	122 (34)	240 (66)	362 (100)	163 (41)	239 (59)	402 (100)

Table 2. Incidence of feeding among yolk sac and non-yolk sac yellow perch larvae by length interval and transect. (Tabular values show the percent of larvae in each category that had eaten at least one food organism.)

Length intervals (mm)	Yolk sac larvae		Non-yolk sac larvae	
	Transect V	Transect VI	Transect V	Transect VI
5.0 - 5.9	28	9	100	50
6.0 - 6.9	87	34	95	45
7.0 - 7.9	93	94	96	83
8.0 - 8.9	--	--	98	95
9.0 - 9.9	--	--	98	96

Table 3. Numbers of organisms eaten by yellow perch larvae of different length intervals at transects V and VI in 1977-78. (Tabular values are numbers of organisms eaten and, in parentheses, percent of total for transect.)

Transect	Length intervals (mm)	Copepod nauplii	Cyclopoid copepods	Calanoid copepods	Unknown copepods	Clad-ocera	Roti-fers	Unidentified invertebrates	Total
V	5.0 - 5.9	1	4	0	8	0	5	19	37 (3)
	6.0 - 6.9	27	46	5	44	0	23	94	239 (20)
	7.0 - 7.9	50	161	41	49	2	12	17	332 (28)
	8.0 - 8.9	45	214	95	43	0	2	7	406 (34)
	9.0 - 9.9	3	73	78	25	2	0	1	180 (15)
Total		126 (11)	498 (42)	219 (18)	169 (14)	2 (<1)	42 (4)	138 (12)	1194 (100)
VI	5.0 - 5.9	1	1	0	1	0	1	4	8 (1)
	6.0 - 6.9	2	20	8	7	0	7	25	69 (10)
	7.0 - 7.9	4	101	37	27	6	12	17	204 (29)
	8.0 - 8.9	6	152	132	26	10	7	2	335 (47)
	9.0 - 9.9	3	46	39	4	0	0	2	94 (13)
Total		16 (2)	320 (45)	216 (30)	65 (9)	16 (2)	27 (4)	50 (7)	710 (100)

Table 4. Mean numbers of organisms ingested by yellow perch larvae in different length intervals on transects V and VI in 1977-78.

Length intervals (mm)	Transect V	Transect VI
5.0 - 5.9	2.3	1.3
6.0 - 6.9	3.4	1.5
7.0 - 7.9	3.5	2.5
8.0 - 8.9	4.8	3.8
9.0 - 9.9	4.3	4.3

Table 5. Mean length (μm) of organisms ingested by yolk sac and non-yolk sac yellow perch larvae of different lengths on transects V and VI in 1977-78.

Length intervals of larvae (mm)	Yolk sac larvae		Non-yolk sac larvae	
	Transect V	Transect VI	Transect V	Transect VI
5.0 - 5.9	379.1	350.9	228.4	699.6
6.0 - 6.9	369.2	327.2	516.3	617.5
7.0 - 7.9	489.3	357.8	508.7	640.7
8.0 - 8.9	---	---	624.5	766.1
9.0 - 9.9	---	---	683.8	822.8

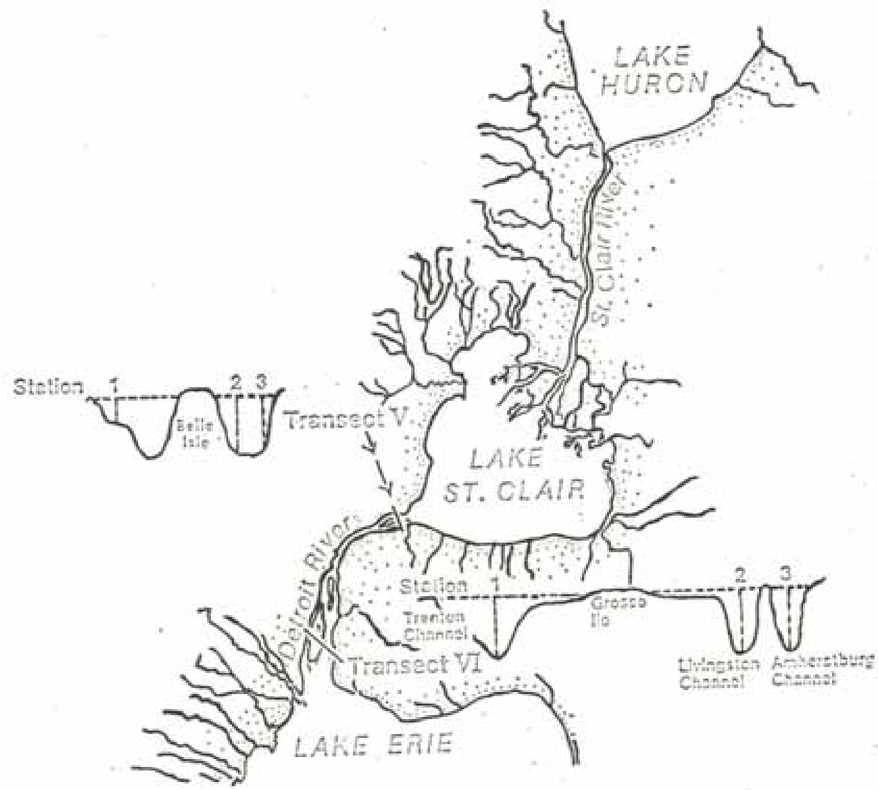

Figure 1. 1977-78 Sampling Locations