

SS1

## REARING OF LAKE WHITEFISH TO FINGERLING SIZE

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ABSTRACT: Lake whitefish (Coregonus clupeaformis) were reared on zooplankton after hatching until most fish were weaned to a dry diet by 13 weeks of age when they averaged 40 mm total length. Survival to 24 weeks was 4.0% and the fish averaged 115.3 mm. High mortality between 5 and 10 weeks was attributed to insufficient zooplankton caused by the high density of fry in the rearing containers. Gill disease and fin rot also contributed to mortality.

Financial support in 1978 by the Michigan Fish Producers Association, an organization of commercial fishermen, served as the stimulus to research the feasibility of rearing lake whitefish (Coregonus clupeaformis) to fingerling size. The location and water supply of our laboratory, the Aquatic Laboratory of Lake Superior State College, also appeared ideal for this work. The laboratory, located within the Edison Sault Hydroelectric Plant, Sault Ste. Marie, Michigan, receives its water supply from the power canal that originates in eastern Lake Superior. Zooplankton are naturally present in the water and are concentrated with plankton nets for feeding the larval fish.

Extensive plantings of lake whitefish fry in the Great Lakes were made in the past, but no relationship was found between the plantings and whitefish production (VanOosten 1942; Lapworth 1956). Our objective was to explore the feasibility of rearing lake whitefish to fingerling or yearling size as commonly done with trout and salmon. Considerable research on rearing whitefish past the

sac-fry stage has been done in Europe (e.g. Einsele 1963), but work with the lake whitefish has remained unpublished. Louella Cable (Great Lakes Fishery Laboratory, Ann Arbor, Michigan) raised lake whitefish to maturity at Northville, Michigan (1957 to 1963) and James Reckahn (Ontario Ministry of Natural Resources) also accomplished this in recent years at South Bay Mouth, Ontario.

Attempts to start the fry of Coregonus spp. on a dry diet have ended with poor success or failure (Braum 1967; Louella Cable, unpublished manuscript). We decided to supply a live food source at first (zooplankton) and then wean the fish, after several weeks or months, to a commercial diet.

#### EGG INCUBATION

Eggs were collected from eastern Lake Superior lake whitefish taken near Brimley, Michigan on several dates in November, 1978. They were incubated in standard 6-L hatching jars at temperatures ranging from 8°C at the start to 0.5°C. Hatching occurred in April and May, 1979 and hatched fry averaged 14.3 mm total length.

#### LIVE ZOOPLANKTON DIET

##### Methods

Fry were reared in fiberglass window screen baskets (56 x 22 x 22 cm) placed into redwood troughs (305 x 25 x 20 cm) that contained approximately 100L of water (Fig. 1). Each basket filled to a depth of approximately 13 cm and held about 15L of water.

Zooplankton, occurring naturally in our water supply, was concentrated

approximately 140 times by filtering water through 363  $\mu$  plankton nets. The species composition of the zooplankton was essentially the same as reported by Selgeby (1975) and consisted mostly of Diaptomus spp. and other copepods during the first weeks of fry rearing, with a greater variety of zooplankton, including cladocerans, appearing later.

Water with concentrated zooplankton flowed into each basket at a rate of approximately 0.5L/m. Each basket was initially stocked with about 3,500 fry (233 fry/L), but this number was doubled to 7,000 (466 fry/L) two weeks later (May 26) as more fry hatched.

After nutrition and disease problems became apparent the density of fry was reduced (during the 7th week) to 1,500 per basket (100 fry/L). During the 9th week of the experiment the fish were transferred into 300-L stock tanks and fed the Abernathy salmon diet six times daily in addition to zooplankton.

### Survival

Mortality was low until the fry reached an age of 4 to 5 weeks. (Table 1). Many fry began to feed on zooplankton within 24 h after hatching and virtually all were feeding several days after hatching. Fullness of the gut was judged by observing the amount of orange pigment present from the zooplankton.

Mortality increased greatly after 5 weeks (Table 1) and continued high until about the 10th week. During this period the guts of some of the fry contained gas bubbles that, in many cases, left them helpless at the surface. Although the cause of the gas problem went unrecognized at first, we now believe that the fry were swallowing gas bubbles in the water because they were

not getting enough zooplankton. John and Hasler (1956) reported mortality of cisco fry (Coregonus artedii) from swallowing gas bubbles. Fry examined at this time also appeared to have less orange pigment in their guts. Counts of zooplankton entering the baskets during this period indicated that an average of about 50 zooplankters per fish were entering the basket each 24 h. The problem of whether this number is sufficient is discussed later in this report. When the fry were thinned to 1,500 per basket (100 fry/L) during the 7th week, the gas bubble problem disappeared and never reappeared.

Gill problems also contributed to the high mortality after the 5th week. The gills appeared swollen and mucus-covered, but microscopic examination revealed no bacteria; we believe the problem was nutritional gill disease. (John Hgnath, Michigan Department of Natural Resources Fish Pathologist, examined some fish in August when the fish were 13 weeks old and confirmed the diagnosis.)

Mortality leveled off after the 10th week except for periods of high mortality during the 13th and 18th weeks. A dip treatment with salt relieved some of the symptoms of gill problems the 13th week, but the weakest fish died. During the 18th week fish were again given a salt dip and fed terramycin because some showed symptoms of tail rot and external hemorrhaging (diagnosed by John Hgnath). Survival to an age of 24 weeks (October 26) was 4.0% and almost no mortality has occurred since then among the fish still being kept at the laboratory. Although Abernathy was fed to the fish after 9 weeks, clear indication that most fish were readily accepting the dry diet was not apparent until the fish were 13 weeks old and averaged 40 mm total length. A small proportion of the fish never accepted the dry diet. The Glencoe Mills dry diet was also tried (Hale 1970 used this

diet for cisco fry and thought it deserved further testing), but Abernathy was chosen because the fish initially seemed to better accept it. After the fish were accepting dry food they readily ate either diet.

#### FROZEN ZOOPLANKTON DIET

Approximately 9,000 fry received a diet of zooplankton that had been frozen during the winter. About 3,000 fry (200 fry/L) were stocked into each of three baskets and fed zooplankton frozen in ice cubes once or twice daily. Although the fry readily ate the zooplankton as it thawed and settled to the bottom, little or no bottom feeding was observed. A system to resuspend the dead plankton with intermittent jets of water from below the baskets was devised (such resuspension of food has been reported successful for striped bass (Lovell, 1977)), and the fish readily fed on the resuspended material. However, the experiment was terminated after 6 weeks because of poor growth and survival.

The reason for poor results is unknown, but may be due to inadequate quantity or quality of food (caused by freezing and thawing). Also, the dead plankton had a tendency to clump and provide a substrate for bacterial and fungal growth; when resuspended it caused fouling of the gills of some of the fry. Gill fouling of hybrid whitefish fry was observed by Garside and Christie (1962) when the fry were fed finely ground raw beef liver; they attributed the mortality to the inability of the fish to close their opercula.

#### GROWTH

About 40 fish were measured weekly to determine growth rates; fish fed live zooplankton grew 5.4 mm during the first 6 weeks (temperature range 4.9 to 9.8°C)

compared to an increase of only 1.9 mm for the fish fed frozen zooplankton (Table 1). The high mortality that occurred during the 5th to 10th weeks when the fish fed live zooplankton probably had insufficient food was not associated with a significantly reduced growth rate. After 24 weeks the fish averaged 115.3 mm; the water temperature reached a peak of 18.3°C during this period and averaged 12.9°C (Table 1).

The length-weight relationship for 67 randomly chosen fish 15 to 136 mm was

$$\text{Log } W = -5.49 + 3.19 \text{ Log } L.$$

The relationship is approximate because the lengths (mm) and weights (g) were mostly of fish that had been preserved in 10% formalin; however, the data points closely fit the regression line ( $r = .994$ ) and live weights determined for 10 fish agreed well with the calculated weights.

#### DISCUSSION

Based on laboratory studies Braum (1967) concluded that food shortage was the most important factor causing mortality of coregonine larvae. Einsele (1963) reported near 100% survival of European whitefish Coregonus spp. under conditions of high zooplankton densities (at least 100 zooplankton/L) and sufficient illumination (over 100 lux).

Adequate daily ration of zooplankton also depends on water temperature and size of fish. Braum (1967; 1978) calculated that C. wartmanni 31 days old eat 265 copepods every 10 hours at 15.6°C. Einsele (1941) reported a requirement of 150 zooplankton per day at 10°C for whitefish 14 days after first feeding. Hoagman (1973) calculated that laboratory-reared lake whitefish averaging

19.6 mm long ate 18.6 copepods per day at 14.4°C.

An estimated 50 zooplankton per 24 hours were potentially available to each of our fish during the 6th week when high mortality was experienced. Although our fish were older than some studies cited above, they averaged only 20 mm and our water temperature averaged only 9.8°C during this week. However, we feel the high density of fry in the holding baskets was the major cause contributing to high mortality. The oxygen in the water was always near saturation, ammonia was not a problem, and the troughs were well-lighted 24 h per day, but the density of the fish probably prevented a normal prey capture response. Much of the zooplankton passed through the baskets uneaten or died and settled to the bottom. Cable (unpublished) worked with Lake Erie and Lake Ontario lake whitefish and reported survival rates of 9.3 to 18.7% to the end of the first year for fish from wild brood stock. The fish were fed various diets beginning with brine shrimp larvae and were converted to a dry diet at a length of 75 to 125 mm.

Hale (1970) reported about 90% survival of cisco to 6 months when the fish were held in 106-L tanks and fed brine shrimp; survival was less than 60% in 218-L tanks on the same diet. His fish were weaned to dry food after 4 to 5 months.

In future work we plan to experiment with different rearing containers for the fry, provide more zooplankton to lower densities of fry, and to try to determine the best size or age to wean the fry to a dry diet.

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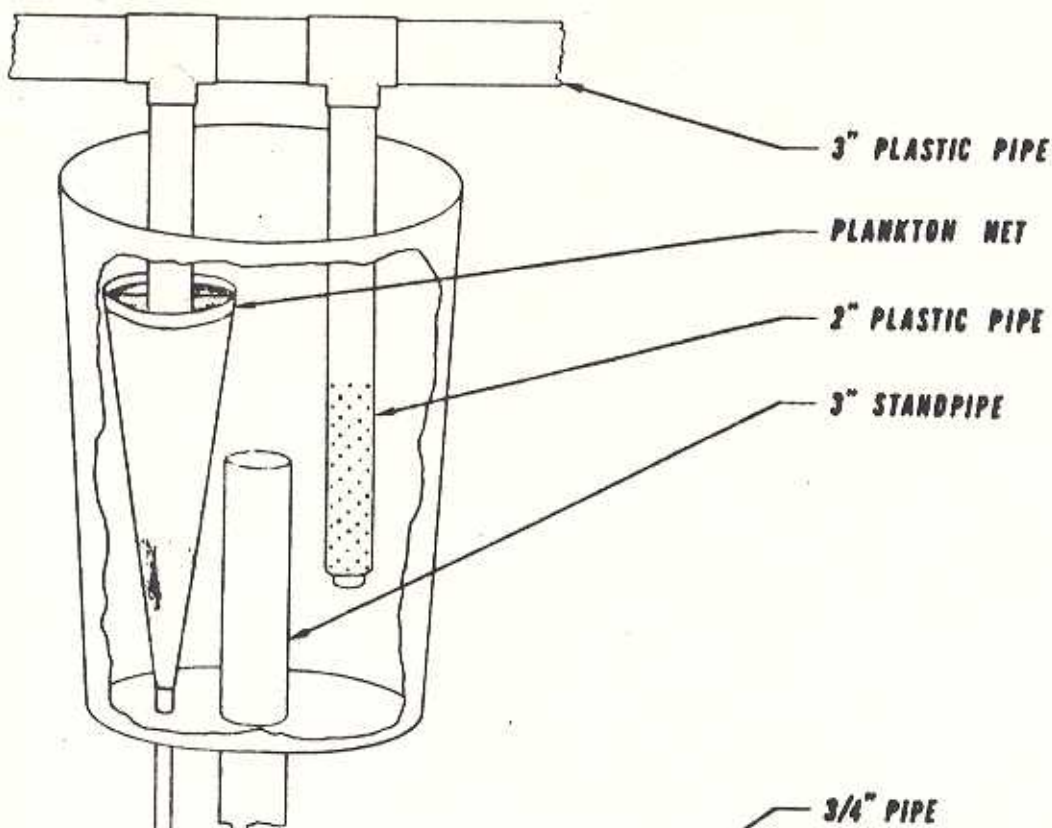
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Figure 1. Apparatus used to concentrate zooplankton and pipe it directly to rearing baskets within redwood troughs.

**WATER SUPPLY**



**TO DRAIN**

**3/4" PIPE**

**CONCENTRATED PLANKTON  
TO BASKET**

**REDWOOD  
TROUGH**

**FIBERGLASS WINDOW SCREEN**

**ALUMINUM TUBING FRAME**

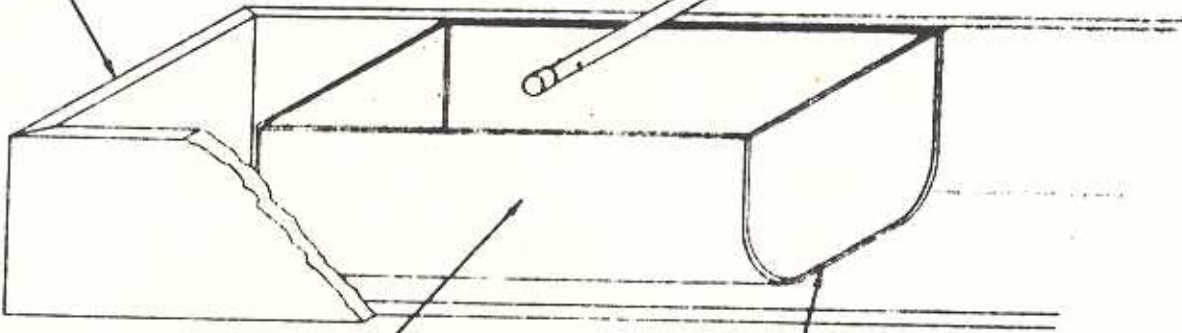


Table 1. Survival and growth of lake whitefish reared at the Lake Superior State College Aquatic Research Laboratory, 1979.

Two-Week Period	% Survival From Hatching and Average Length at the end of Two-week Period				Average Water Temperature (°C)
	<u>Live Zooplankton Diet</u>		<u>Frozen Zooplankton Diet</u>		
	<u>% Survival</u>	<u>Average Length (mm)</u>	<u>% Survival</u>	<u>Average Length (mm)</u>	
May 12 - May 25	99.4	15.4	93.3	14.7	5.2
May 26 - June 8	97.3	18.4	91.4	15.6	6.8
June 9 - June 22	91.2	19.9	36.0 <sup>(1)</sup>	16.2	8.7
June 23 - July 6	34.3 <sup>(2)</sup>	21.5			10.3
July 7 - July 20	13.1	27.7			14.3
July 21 - Aug. 3	11.6 <sup>(3)</sup>	38.8			18.3
Aug. 4 - Aug. 17	9.8	44.0			17.7
Aug. 18 - Aug. 31	9.6 <sup>(4)</sup>	—			16.5
Sept. 1 - Sept. 14	8.8	63.5			16.9
Sept. 15 - Sept. 28	4.1	—			14.8
Sept. 29 - Oct. 12	4.0	—			13.8
Oct. 13 - Oct. 26	4.0	115.3			11.4

<sup>1</sup>Terminated due to poor growth and survival

<sup>2</sup>Stocking density reduced

<sup>3</sup>Transferred into 300-L stock tanks and fed Abernathy

<sup>4</sup>Transition from live zooplankton to dry food

## LITERATURE CITED

- Braum, E. 1967. The survival of fish larvae with reference to their feeding behavior and the food supply. Pages 113-131 in S. D. Gerking, ed. The biological basis of fish production. Blackwell Scientific Publications, Oxford.
- 1978. Ecological aspects of the survival of fish eggs, embryos and larvae. Pages 102-136 in S.D. Gerking, ed. Ecology of freshwater fish production. John Wiley and Sons, New York.
- Cable, L. E. Culture, growth, and reproduction of lake whitefish (Coregonus clupeaformis) reared in captivity (unpublished).
- Einsele, W. G. 1941. Fischereiwissenschaftliche probleme an den duetschen Alpenseen. Fischere-Zeitung 44:1-16.
- 1963. Problems of fish-larvae survival in nature and in the rearing of economically important middle European freshwater fishes. Calif-Coop. Oceanic Fish Invest. 10:24-30.
- Garside, E. T. and W. J. Christie. 1962. Experimental hybridization among three coregonine fishes. Trans. Am. Fish. Soc. 91:196-200.
- Hale, J. G. 1970. Culture of lake herring in the laboratory. Prog. Fish. Cult. 34:217-221.
- Hoagman, W. J. 1974. Vital activity parameters as related to the early life history of fish. Pages 547-558 in J. H. S. Blaxter, ed. The early life history of fish. Springer-Verlag, New York.
- John, K. R. and A. D. Hasler. 1956. Some factors affecting the hatching of eggs and the survival of young shallow water cisco, L. artedii LeSueur, in Lake Mendota, Wisconsin. Limnol. Oceanogr. 1:176-194.

- Lapworth, E. D. 1956. The effect of fry planting on whitefish production in eastern Lake Ontario. J. Fish. Res. Board Can. 13:547-558.
- Lovell, R. T. 1977. Physical aspects of food important in feeding fish. Commer. Fish Farmer Aquacult. News. 3:32.
- Selgeby, James H. 1975. Life histories and abundance of crustacean zooplankton in the outlet of Lake Superior. J. Fish. Res. Board Can. 34(4):461-470.
- Van Oosten, J. 1942. Relationship between the plantings of fry and production of whitefish in Lake Erie. Trans. Am. Fish. Soc. 71:118-121.