CONTRIBUTIONS TO THE EARLY LIFE HISTORIES OF SIXTY-TWO SPECIES OF FISHES FROM LAKE ERIE AND ITS TRIBUTARY WATERS[1]

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INTRODUCTION

That tremendous mortality among fishes must occur is evident from the fact that the individuals of many species spawn thousands and often millions of eggs yearly without an appreciable increase in the numbers of adult fish. Undoubtedly a high percentage of destruction is normal and necessary in suppressing overproduction and providing food for other organisms. Sometimes, however, this mortality becomes abnormally large, due either to unfavorable environmental conditions or the inroads of man, and the stock is seriously depleted. It is generally believed that the greatest losses at such periods take place during the egg stage or soon after the free-swimming larva emerges; hence the need for studying early life histories is apparent.

Although much has been done on marine fishes, practically nothing beyond fragmentary notes for a few species has been available on the developmental stages of their fresh-water relatives. No one has previously considered this embryonic, larval, and postlarval community as a whole. The study of early life histories, dovetailed with an investigation of biological, physical, and chemical conditions of the environment, is necessary in order to understand problems of production, abundance, and depletion in fish fauna, to determine the causes of yearly class fluctuations and their ultimate effect upon commercial fishing, or to solve other problems of real economic importance. Such a comprehensive survey has been attempted in Lake Erie, and the present paper is one of a series which will result from that study.[2]

The first step in the fish problem had necessarily to be the identification of the young of each species in various developmental stages. Thus, the following text deals, for the most part, with descriptions of specimens taken in net hauls. Because of this manner of collection the life history series are seldom as complete as desired, but all young fish taken by the cooperative survey of Lake Erie in 1928 and 1929 are included in the distribution tables, and whatever developmental stages were found are described and figured under the various species heads.

Statistics compiled recently by the United States Bureau of Fisheries show the annual value of the Great Lakes fisheries to total nearly nine millions of dollars. In Lake Erie alone in 1927 the catch brought $1,831,284 to American fishermen. Such an industry can not be disregarded, and when it declines noticeably, the need of

[2] Preliminary reports have appeared in Vol. XIV, No. 3, and Vol. XV, No. 1, Bulletin of the Buffalo Society of Natural Sciences, and in "A Biological Survey of the Erie-Niagara System," Supplemental to the Eighteenth Annual Report, 1928, New York State Conservation Department. Further reports will be published in forthcoming Bulletins of the U. S. Bureau of Fisheries.

remedial measures or, at any rate, an understanding of contributing factors toward these losses, is urgently indicated. Because an alarming decrease has occurred during late years in the numbers of commercial fish available from Lake Erie, this survey under the direction of Dr. Charles J. Fish was inaugurated in the spring of 1928 to attempt an explanation of the causes and, if possible, to suggest methods of remedy. Pooling resources, equipment, and workers, the United States Bureau of Fisheries, the New York State Conservation Department, the Ontario Department of Game and Fisheries, the health department of the city of Buffalo, and the Buffalo Society of Natural Sciences launched upon an intensive investigation of these waters.

A steam vessel, the U. S. F. S. *Shearwater*, was used constantly throughout the spring and summer of 1928 in eastern Lake Erie to the westward boundary of New York State and to Long Point on the Canadian shore. Between June 15 and July 26 the New York State gasoline launch *Navette* made observations and collections in shallow water around the margin of the lake.

In 1929 the investigations were continued in similar manner aboard the *Shearwater*. The region surveyed, however, was increased to include the whole of Lake Erie. The State of Ohio joined forces with the previously cooperating institutions, and the waters of the lake were combed for young fish.

In 1930 no active collecting was done, but over 20,000 young fishes which had been taken by the Ohio Division of Fish and Game in the previous year were examined, identified, charted, and described in an attempt to locate formerly undescribed young and further stages of fishes already recorded by the cooperative survey.

COLLECTION OF MATERIAL

Petersen young-fish trawls of quarter-inch square mesh at all depths, silk Helgoland trawls on the bottom, and meter nets at the surface and deeper levels were used during 1928 for the collection of young fish material. The only collecting gear used in the following year were meter nets and occasional dip nets. At each station investigated a typical plankton net of No. 0 and No. 2 silk with a ring 1 meter in diameter was towed for 5 minutes at the surface, and another simultaneously at about 1 meter above the bottom. The samples were preserved in weak formalin at once and examined later in the laboratory. Because of the greater area covered by the survey in 1929 and the large number of observations necessary, the towing of Petersen and Helgoland trawls was omitted, but the use of these specially constructed young-fish nets is strongly recommended for the capture of such material.

Additional specimens studied were collected by members of the staff and reared at the Buffalo Museum of Science. Others were kindly loaned by various State and Federal hatcheries.

LABORATORY TECHNIQUE

When the plankton bottles arrived in the laboratory they were carefully examined, and all young fish and eggs removed. Specimens were preserved in 2 per cent formalin in distilled water, thus preparing them for later staining and clearing if desired.

There is only one character remaining comparatively constant throughout the life of the individual, and that is the vertebral count. Thus in the earliest stages, before the fin rays and other diagnostic characters of the adult are distinguishable, the number of vertebræ is the most valuable hint of identification, and it is with this count that much of the work must be done. There are certain peculiarities for each

species, especially shape and pigment marking, which make them easily distinguished subsequently, but the first attempt at identification of field collections is possible only by counting the vertebræ. This information, together with knowledge of the adult fish fauna of the locality, permits us to narrow down the possibilities and very often to detect the species immediately. Unfortunately, the importance of the vertebral count has only recently been recognized, and thus the older descriptions of fish do not contain it. Wherever possible during the work, we have made these counts of the adults as well as the young. In some small specimens strong light is sufficient to reveal the spinal column, but usually it is necessary to stain and clear, and in larger fishes to bisect. The limited time of the survey prevented extensive staining, and when the spinal column was not readily shown, myomere counts were made which, although not identical, correspond to the vertebral count sufficiently and are constant enough for the usual requirements.

No detailed rules can be laid down for the technique of staining all young fishes, for the variation in size, permeability, and general reaction seems to make each species and often each specimen a problem in itself. Most processes are long and require considerable watching, but painstaking care and patience will surely produce results worth the effort. (See fig. 121 and other photographs of stained and cleared specimens in the following text.) The several methods used with success by the author are briefly outlined below.

VERY SMALL SPECIMENS WITH CARTILAGINOUS SKELETONS

Approved stain.—"New Methylene Blue" (Chromatine Blue Violet), National Aniline & Chemical Co., Buffalo, N. Y.

Preparation of staining solution.—One gram of dry methylene blue dissolved in 400 cubic centimeters of 70 per cent alcohol, acidulated with a few drops of 10 per cent hydrochloric acid. (Do not keep stock solution acidulated but add acid immediately before use.)

Wash formalin-preserved specimens in distilled water and run gradually up to 70 per cent alcohol, then place in staining solution and examine frequently until stained a deep midnight blue. The time varies from a few hours to more than a week. Usually at least 3 or 4 days are necessary. Wash in successive changes of acidulated 70 per cent alcohol until the color ceases to wash out of the tissues. Place in 95 per cent alcohol for 1 to 2 hours, and finally into oil of cloves. Peppermint oil, xylol, and pyridin can be used successfully, but oil of cloves is preferred inasmuch as its clearing powers are very effective, and it can be used directly from 95 per cent alcohol.

LARGE SPECIMENS WITH BONY SKELETONS

Approved stain.—Alizarine sodium sulphonate.

Preparation of staining solution.—Aqueous solution for Method I: Saturated solution of alizarine in distilled water. Alcoholic solution for Method II: Saturated solution of alizarine in 70 per cent alcohol.

Method I (most rapid but apt to be less effective): Soak formalin preserved specimens in distilled water for at least 1 hour. Stain slightly with aqueous alizarine solution (depth of stain must be determined by experiment). Avoid overstaining. Dehydrate, and clear in xylol from absolute alcohol.

Method II: Soak formalin-preserved specimens in distilled water for at least 1 hour, and in 35 per cent alcohol for from 1 to 2 hours. Place for half an hour in 70 per cent alcohol made alkaline by adding a drop or two of the following alkaline alcohol solution: 70 cubic centimeters absolute alcohol, 30 cubic centimeters distilled water, 1 cubic centimeter molecular solution of sodium bicarbonate. Stain with alcoholic alizarine solution diluted with an equal quantity of 70 per cent alcohol, to which is added one or more drops of alkaline alcohol solution until the color is a faint brown. Staining may require from 1 hour to a day or longer, depending upon the size and permeability of the specimen. Place in 70 per cent alcohol until color is washed out of flesh and left only in bones. Run slowly up to absolute alcohol. Clear in oil of cloves, oil of wintergreen, or xylol.

Method III (most effective for transparency of vertebral column): In order to make the stained skeleton distinct the use of potassium hydroxide is highly successful. This transparency method was recommended by Beale as early as 1853, and by Schultze in 1897. The techinque of Schultze has been applied widely since by students of human embryology, (e. g., von Halvar Lundvall, (1905); Eben C. Hill, (1906); Franklin P. Mall, (1906).) More recently, excellent results have been obtained in the study of deep-sea fishes by Dr. William Beebe and Miss Gloria Hollister.

The following modification of the Schultze and Lundvall methods has been used by the author in the present problem: Treat formalin-preserved specimens with 2 per cent potassium hydroxide to which has been added a few drops of alizarine solution (about 1 to 1,000) until bones are stained. The time varies from a few hours to a week, but usually one-half to one day is sufficient. Place in 1 per cent potassium hydroxide until color washes out of soft tissues. Place in glycerine and 1 per cent potassium hydroxide (1 to 5) for 4 to 48 hours, or until tissues are quite clear. Transfer to higher percentages of glycerin at intervals of one day until perfectly transparent.

It is urgent that distilled water be used in all solutions, including the formalin for hardening, since slight impurities may interfere with complete clearing.

Hill (1906) was successful in rendering difficult embryological material transparent by using equal parts of 1 per cent potassium hydroxide and 50 per cent ammonium hydroxide for 5 to 72 hours, then 20 per cent glycerin for 48 or more hours, and ascending percentages of glycerin at intervals of 2 or 3 days.

For staining Hill advocated Doctor Bardeen's alum-cochineal method. Specimens without previous fixing in formalin, are placed in 95 per cent alcohol until shriveled, then stained for 24 hours in alumcochineal and cleared in 1 per cent potassium hydrate.

ADDITIONAL METHODS OF STUDY

The perfect way to identify a young fish with the adult is, of course, to secure a ripe female and male, artificially fertilize the eggs, and study the resultant developmental stages in the laboratory. The difficulty, however, of keeping most larval specimens alive and healthy in the ordinary laboratory for long after the yolk sacs are absorbed and the fish are actively feeding is great. Even when successful the artificially reared specimens are apt to be emaciated and their growth retarded. We can not duplicate exactly their normal conditions of life, and thus the chief source of young-fish material must be the lake itself. By extensive collecting over a period of

time, we strive in the end to secure complete series of stages which will positively link up the earliest larva with the parent form.

The adult fish is usually so very different in coloration, body proportions, and general characters from the younger stages that existing descriptions are often worthless. It seemed wise to attempt a collection of postlarvæ and young adults which might form a connecting link between the very tiny specimens caught in our nets and the older known adults. The Erie-Niagara watershed survey staff of the New York State Conservation Department gave us valuable cooperation in 1928, bringing in 37 species of small fishes. We adopted a special form of description and card-catalogued all species in this way. Thus additional data were recorded, such as the myomere count and chromatophore marking previous to the appearance of scales, which are invaluable for work on the earlier developmental stages.

EXPLANATIONS

At the beginning of the Lake Erie survey it was agreed, for uniformity among the various workers, to use the names of species as they were stated in "A Check-List of the Fishes of the Great Lakes and Tributary Waters, with Nomenclatorial Notes and Analytical Keys," by Carl L. Hubbs, University of Michigan, Museum of Zoology, Miscellaneous Publication No. 15, 1926. Hubbs's nomenclature, therefore, has been used in the present paper, but where the names given certain species in "Check List of the Fishes and Fishlike Vertebrates of North and Middle America North of the Northern Boundary of Venezuela and Colombia," by David Starr Jordan, Barton Warren Evermann, and Howard Walton Clark, U. S. Bureau of Fisheries Document No. 1055, Washington, 1930, differed from that previous list, the later name has been added in brackets below the one used by Hubbs.

Unless otherwise stated, all descriptions and drawings have been made from preserved specimens. Preservation was necessary because the collections in most cases could not be studied until the end of each cruise. The use of weak formalin, however, caused only slight shrinkage, and, except for some opacity, no visible change in the specimens occurred.

In describing the pigmentation of young fishes, the word "subsurface" is frequently used in reference to those chromatophores which lie below the outer surface, such as those distributed often over the air bladder or the intestinal tract. When the specimen has been rendered very opaque by growth or preservation, these pigment spots are not readily seen. Use of the transparency Method III described on page 297, however, will usually make them visible.

The word "incomplete" following a fin-ray count in young specimens means that the fin is not wholly developed and therefore the formula is incomplete.

ACKNOWLEDGMENTS

I am deeply grateful to Vernon S. L. Pate, artist of the report during the three summers of the Lake Erie investigation; and to Dr. Charles J. Fish, director of the cooperative survey, for certain drawings contained in this report, and for continued assistance and helpful suggestions throughout the duration of the work.

I am indebted to E. L. Wickliff and Prof. T. L. Hankinson for data and collections; Dr. John Van Oosten for a very large and complete series of young whitefish; J. L. Hart for whitefish, herring, perch, pike-perch, and muskalonge; J. P. Snyder for

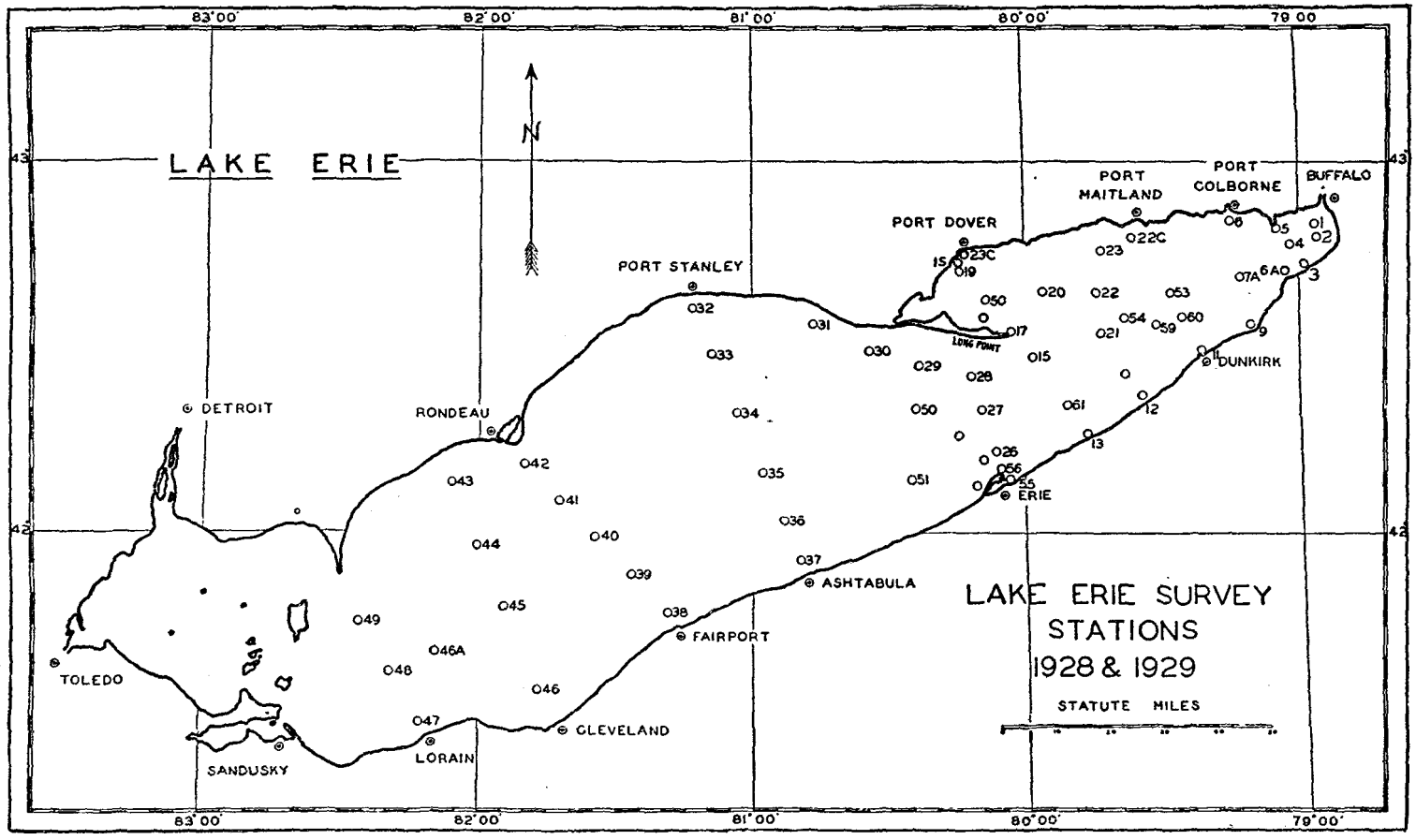

FIGURE 1.—Stations of the cooperative survey of Lake Erie in 1928 and 1929

herring, whitefish, lake trout, black bass, and brook-trout eggs and larvæ; Dr. Emmeline Moore for muskalonge eggs and larvæ; Miss Ida Mellen for brook-trout eggs; F. B. Voegele for whitefish and lake-trout eggs; and A. P. Miller for muskalonge larvæ.

Many notes on distribution and breeding of stream species were supplied through the kindness of Dr. John Greeley.

TABLE 1.—*Record of species of young fishes taken by Shearwater and Navette in 1928*

Species	Number of specimens	Length of specimens, millimeters	Record of capture			
			Depth, meters	Station [1]	Net	Date
Lepisosteus osseus	1	41	0	Navette dock, Buffalo	Dip	July 12
Catostomus commersonii	2	15	6	6A	Meter	June 12
	1	15	3	8A	do	Do.
	30	14–21	0	Sturgeon Point	Dip	June 13
	11	20.5	0	Navette dock, Grand Island.	do	July 9
	42	24.5	0		Seine	Do.
Moxostoma aureolum	1	8	6	13A	Meter	July 11
Notropis hudsonius	Many.	Ripe adults.	0	Sturgeon Point	Dip	June 13
	1	5.2	5	4A	Helgoland	July 12
Notropis atherinoides	1	6.4	60	01.15	Meter	July 30
	1	6.5	17	01.17	do	July 31
	2	4.6–5.5	9	01.18	do	Do.
	2	6.7–9.0	10	01.19	do	Do.
	1	16.5	23	05.12	do	Sept. 1
	2	16–17	0	05.15	Dip	Do.
Perca flavescens	Many.	5.5–12.5	4	4A	Meter	June 12
	14	6.5–13	4	4A	Helgoland	Do.
	23	6–11	6	6A	Meter	Do.
	6	6–12	3	8A	do	Do.
	1	9.2	3	8A	Helgoland	Do.
	2	6.5–9.6	4	17C	Meter	June 13
	2	7–8	6	11A	Helgoland	July 11
	631	[2] 40	8	02.02	Petersen	Aug. 8
	212	[2] 40	20	02.04	do	Do.
Percopsis omiscomaycus	6	7.5	7	7A	Helgoland	June 12
	3	6.3–6.5	3	8A	do	Do.
	1	6	3	8A	Meter	Do.
	1	6.3	6	11A	Helgoland	July 11
	1	9.7	14	01.05	Meter	July 26
	1	6.5	60	01.15	do	July 30
	7	17–25	20	02.04	Petersen	Aug. 8
	1	16	20	02.13	Helgoland	Aug. 9
	1	35	50	02.21	Meter	Aug. 10
Stizostedion canadense griseum	1	15.2	60	01.15	do	July 30
Boleosoma nigrum nigrum	Eggs.	1.4–1.5	0	Sturgeon Point	Dip	June 11
	3	35	7	7A	Helgoland	June 12
	1	5.6	17	14A	do	July 11
	1	14.5	25	02.04	do	Aug. 8
	6	7.5–15.5	16	02.09	do	Do.
Percina caprodes zebra	1	62	15	02.05	Petersen	Do.
	1	25.5	8	02.11	do	Aug. 9
	1	25.5	40	02.17	Helgoland	Do.
Micropterus dolomieu	6	9.5–10	6	11A	do	July 11
Aplodinotus grunniens	1	13.3	17	03.24	Meter	Aug. 16
Cottus bairdii kumlieni	1	9.7	10.5	3A	Helgoland	June 11
Cottus cognatus	2	21–21.5	20	02.04	Petersen	Aug. 8
	1	20	23	02.23	Helgoland	Aug. 10
	1	33.5	20	04.11	do	Aug. 22
	1	22	20	04.12	do	Aug. 23
	1	35	20	04.13	do	Do.
	1	18.5	16	04.25	do	Aug. 25
Cottus ricei	1	27.5	22	04.23	do	Do.
Triglopsis thompsoni	1	13	60	01.15	Meter	July 30
	1	16	20	02.13	Helgoland	Aug. 9
	2	12.5–14	38	02.20	do	Aug. 10
	1	14	33	02.22	do	Do.
Lota maculosa	1	5.8	6	6A	Meter	June 12
	3	3–7.1	15	22C	do	June 18
	1	6.2	5	23C	do	June 19
	2	6–7	14	25C	do	June 20
	14	7–14	60	01.15	do	July 30
	1	10.5	32	01.20	do	Aug. 1
	4	11.5–15	34	01.22	do	Do.
	1	11.5	50	02.15	do	Aug. 9
	4	30.5	-------	Long Point Bay	Seine	Aug. 22

[1] Numbers in this column refer to the stations indicated in fig. 1. The Navette stations are shown by a whole number followed by the letter A or C, indicating American or Canadian inshore waters. The Shearwater stations follow the method commonly used in oceanographic work where the number of the cruise is placed immediately before the decimal point with station number following. This 01.15 means: Shearwater cruise 1, station 15.

[2] Approximate.

TABLE 2.—*Station record of young fishes taken by Shearwater and Navette in 1928*

Station	Net	Date	Species	Number of specimens	Length of specimens, millimeters
3A	Helgoland	June 11	Cottus bairdii kumlieni	1	9.7
4A	Meter	June 12	Perca flavescens	36	5.5–12.5
4A	Helgoland	do	do	14	6.5–13
6A	Meter	do	do	17	6–11
			Lota maculosa	1	5.8
			Catostomus commersonii	2	15
			Notropis atherinoides	1	34
7A	Helgoland	do	Percopsis omiscomaycus	6	7.5
			Boleosoma nigrum nigrum	3	Ripe adults.
8A	Meter	do	Perca flavescens	6	6–12
			Percopsis omiscomaycus	1	6
			Notropis atherinoides	11	(1)
			Catostomus commersonii	1	15
8A	Helgoland	do	Percopsis omiscomaycus	3	6.3–6.5
			Perca flavescens	1	9.2
17C	Meter	June 13	do	2	6.5–9.6
Sturgeon Point	Dip	do	Catostomus commersonii	30	14–21
			Notropis hudsonius	Many.	Ripe adults.
			Notropis atherinoides	Many.	Adults.
Buffalo Harbor	do	do	do	Many.	Do.
Crystal Beach	do	do	do	Few.	Do.
22C	Meter	June 18	Lota maculosa	3	3–7.1
23C	do	June 19	do	1	6.2
			Perca flavescens	3	5.3–6.2
25C	do	June 20	Lota maculosa	2	6–7
			Perca flavescens	1	8.8
11A	Helgoland	July 11	do	2	7–8
			Percopsis omiscomaycus	1	6.3
			Micropterus dolomieu	6	9.5–10
			Egg No. a	2	1.55–1.6
13A	Meter	do	Moxostoma aureolum	1	8
14A	Helgoland	do	Boleosoma nigrum nigrum	1	5.6
4A	do	July 12	Notropis hudsonius?	1	5.2
01.05	Meter	July 26	Percopsis omiscomaycus	1	9.7
01.15	Meter—0m	July 30	Notropis atherinoides	1	6.4
	60m	do	Stizostedion canadense griseum	1	15.2
			Triglopsis thompsoni	1	13
			Percopsis omiscomaycus	1	6.5
			Lota maculosa	14	7–14
01.17	Meter	July 31	Notropis atherinoides	1	6.5
01.18	do	do	do	2	4.6–5.5
01.19	do	do	do	2	6.7–9
01.20	do	Aug. 1	Lota maculosa	1	10.5
01.22	do	do	do	4	11.5–15
02.02	Petersen	Aug. 8	Perca flavescens	631	(2).40
02.04	do	do	do	212	(2).40
			Notropis atherinoides	7	47
			Cottus cognatus	2	17
			Percopsis omiscomaycus	7	18
02.04	Helgoland	do	Boleosoma nigrum nigrum	1	14.5
02.05	Petersen	do	Percina caprodes zebra	1	62
02.09	Helgoland	do	Boleosoma nigrum nigrum	6	7.5–15.5
02.11	Petersen	Aug. 9	Percina caprodes zebra	1	(2).25
02.13	Helgoland	do	Percopsis omiscomaycus	1	16
			Triglosis thompsoni	1	16
			Egg No. b	4	2.1–2.3
					2.1–2.3
02.15	Meter	do	Lota maculosa	1	11.5
02.17	Hegoland	do	Percina caprodes zebra	1	25.5
02.20	do	Aug. 10	Triglopsis thompsoni	2	12.5–14
02.21	Meter	do	Percopsis omiscomaycus	1	35
02.22	Helgoland	do	Triglopsis thompsoni	1	14
02.23	Meter	do	Cottus cognatus	1	20
03.24	do	Aug. 17	Aplodinotus grunniens	1	13.3
04.11	Helgoland	Aug. 22	Cottus cognatus	1	33.5
04.12	do	Aug. 23	do	1	22
04.13	do	do	Lota maculosa	1	19
			Cottus cognatus	1	35
04.23	do	Aug. 25	Cottus ricei	1	27.5
04.25	do	do	Cottus cognatus	1	18.5
05.12	Meter	Sept. 1	Notropis atherinoides	1	16.5
05.15	Dip	do	do	2	16–17

[1] Young adults up to 34 millimeters.

[2] Approximate.

TABLE 3.—*Record of young fishes taken by Shearwater in 1929*

Species	Number of specimens	Length of specimens, millimeters	Record of capture		
			Station	Net	Date
Moxostoma aureolum	1	8.4	06.03	Bottom meter	Aug. 6
Cyprinus carpio	11	9.5–17.5	Crescent Beach	Bottom dip	June 29
Erimemus storerianus	1	5	02.30	Bottom meter	June 15
	1	5	02.35	do	June 16
	1	5.7	02.42	do	June 17
	2	6–7.5	04.04	do	July 2
	1	6	04.12	Surface meter	July 5
Rhinichthys cataracatae	1	12.5	Crescent Beach	Bottom foot	June 29
Notropis deliciosus stramineus	1	6.8	06.03	Surface meter	Aug. 6
	2	6–8.5	06.07	Bottom meter	Do.
	1	6.2	06.19	do	Aug. 8
	4	6–10.5	06.20	Surface meter	Do.
	38	5.5–8.9	06.47	Bottom meter	Aug. 19
	85	4.9–10	06.47	Surface meter	Do.
Notropis atherinoides	1	6.7	04.03	do	July 2
	1	6.7	04.11	Bottom meter	July 5
	4	7	04.12	Surface meter	Do.
	1	13	04.36	do	July 11
	72	5–7	04.38	do	July 12
	174	5–7	04.38	Bottom meter	Do.
	1	7	04.43	Surface meter	July 13
	25	6.8–8.4	04.43	Bottom meter	Do.
	8	6.5–9.5	04.47	Surface meter	July 15
	14	6–10.5	04.47	Bottom meter	Do.
	47	6–7	04.48	Surface meter	Do.
	39	4.5–6.5	04.49	Bottom meter	Do.
	480	10.5–22	05.13	Surface meter	July 23
	115	10.5–17.5	05.14	do	Do.
	4	19–20	06.03	do	Aug. 6
	1	10	06.04	Bottom meter	Do.
	1	12.2	06.05	Surface meter	Do.
	5	9–13	06.07	Bottom meter	Do.
	5	9–12	06.12	Surface meter	Aug. 8
	4	11.5–26	06.12	Dip	Do.
	77	5	06.13	Surface meter	Aug. 10
	80	14–29.5	06.13	Dip	Do.
	1	19	06.20	Surface meter	Aug. 8
	12	5.6–12	06.26	do	Aug. 13
	9	23.5–30	06.37	Dip	Aug. 16
	17	12–20	06.38	do	Aug. 17
	1	10.3	06.38	Surface meter	Do.
	100	[1] 14	06.39	Dip	Do.
	116	11–14	06.40	do	Do.
	117	11–15	06.41	do	Do.
	9	6.5–14.5	06.41	Surface meter	Do.
	3	9.5–12	06.42	do	Do.
	138	7–15.5	06.43	Dip	Aug. 18
	1	16.5	06.44	Surface meter	Do.
	4	7.5–9	06.46	do	Do.
	100	12.5–24	06.46	Dip	Do.
	13	4.8–32	06.47	Surface meter	Aug. 19
	46	7.5–17.5	06.47	Dip	Do.
	5	12–16	06.48	do	Aug. 20
	23	8–12.5	06.48	Surface meter	Do.
	21	5–7.2	06.49	Bottom meter	Do.
	81	5–11	06.49	Surface meter	Do.
Notropis cornutus chrysocephalus	1	6	02.49	do	June 19
	9	6	04.17	do	July 8
Fundulus diaphanus menona	6	7.2–12.5	Crescent Beach	Bottom meter, depth, 3 feet.	June 29
Percopsis omiscomaycus	1	8.4	04.38	Bottom meter	July 12
	4	6	04.42	Surface meter	July 13
Perca flavescens	17	6–12	02.02	Bottom meter	June 7
	6	6.5–6.7	02.03	do	Do.
	3	7.2	02.09	Surface meter	June 8
	6	6.5–7.2	02.09	Bottom meter	Do.
	1	6.3	02.11	do	June 10
	5	6–6.5	02.29	do	June 15
	3	5.5–6.5	02.30	do	Do.
	3	5.6–9	02.31	do	Do.
	2	6–6.5	02.51	Surface meter	June 14
	1	7.6	02.52	do	June 11
	5	5–6.7	02.32	do	June 16
	1	6.7	02.33	Bottom meter	Do.
	1	6	02.34	do	Do.
	1	6	02.35	do	Do.
	118	5.6–10	02.42	do	June 17
	1	15	02.47	Surface meter	June 19
	8	9.5–16	02.47	Bottom meter	Do.
	1	13	04.04	do	July 2
	17	6–10.8	04.06	Surface meter	Do.
	1	10.5	04.06	Bottom meter	Do.
	1	12	04.11	do	July 5
	1	12.6	04.12	Surface meter	Do.
	2	14.8–17.5	04.17	Bottom meter	July 8
	9	7.8–14.5	04.32	do	July 11
	1	6	04.35	do	Do.
	1	50	06.03	do	Aug. 6

[1] Approximate.

TABLE 3.—*Record of young fishes taken by Shearwater in 1929*—Continued

Species	Number of specimens	Length of specimens, millimeters	Record of capture		
			Station	Net	Date
Percina caprodes zebra	1	7	06.40	Bottom meter	Aug. 20
Rheocrypta copelandi	2	6	02.05	do	June 7
Cottus bairdii kumlieni	2	6–7	02.02	do	Do.
	1	10.4	02.11	do	June 10
	3	6.5–8	02.29	do	June 15
	10	6.5–7.5	02.30	do	Do.
	5	7–9	02.31	do	Do.
	2	6.5	02.32	Surface meter	June 16
	2	6–8	02.33	Bottom meter	Do.
	5	6–11	02.34	do	Do.
	5	5.8–8	02.42	do	June 17
	2	7.5–9	02.43	do	June 18
	1	10	02.44	do	Do.
	1	10.3	02.48	do	June 19
	2	11.5	04.17	do	July 8
	1	11.5	04.34	do	July 11
Lota maculosa	5	4.1–6	02.02	do	June 7
	2	5.6–6.2	02.03	do	Do.
	2	5	02.05	do	Do.
	1	6.2	02.09	Surface meter	June 8
	1	4.5	02.09	Bottom meter	Do.
	4	4.5–6.2	02.12	Surface meter	Do.
	3	6.3–7	02.14	do	Do.
	2	7–9	02.29	Bottom meter	June 15
	10	5.2–8.6	02.30	do	Do.
	3	6.5–8.1	02.31	do	Do.
	7	5.1–8	02.50	do	Do.
	29	4–7.2	02.51	Surface meter	June 14
	2	6–7	02.51	Bottom meter	Do.
	3	7–8	02.33	do	June 16
	4	6.5–8.5	02.34	do	Do.
	5	4.5–9	02.36	do	Do.
	5	4–8	02.42	do	June 17
	1	12	02.44	do	June 18
	3	10–13	04.21	do	July 5

TABLE 4.—*Station record of young fishes taken by Shearwater in 1929*

Station	Net	Date	Species	Number of specimens	Length of specimens, millimeters
02.02	Bottom meter	June 7	Perca flavescens	17	6–7
			Cottus bairdii kumlieni	2	6–7
			Lota maculosa	5	4.1–6
02.03	do	do	Perca flavescens	6	6.5–6.7
			Lota maculosa	2	5.6–6.2
02.05	do	do	do	2	5
			Rheocrypta copelandi	2	6
02.09	Surface meter	June 8	Perca flavescens	3	7.2
			Lota maculosa	1	6.2
02.09	Bottom meter	do	Perca flavescens	6	6.5–7.2
			Lota maculosa	1	4.5
02.11	do	June 10	Perca flavescens	1	6.3
			Cottus bairdii kumlieni	1	10.4
02.12	Surface meter	June 8	Lota maculosa	4	4.6–6.2
02.14	do	do	do	3	6.3–7
02.29	Bottom meter	June 15	do	2	7–9
			Perca flavescens	5	6–6.5
			Cottus bairdii kumlieni	3	6.5–8
02.30	do	do	do	10	6.5–7.5
			Lota maculosa	10	5.2–8.6
			Perca flavescens	3	5.5–6.5
			Erinemus storerianus	1	5
02.31	do	do	Lota maculosa	3	6.5–8.1
			Cottus bairdii kumlieni	5	7–9
			Perca flavescens	3	5.6–9
02.32	Surface meter	June 16	do	5	5–6.7
			Cottus bairdii kumlieni	2	6.5
02.33	Bottom meter	do	Perca flavescens	1	6.7
			Cottus bairdii kumlieni	2	6–8
			Lota maculosa	3	7–8
02.34	do	do	Perca flavescens	1	6
			Lota maculosa	4	6.5–8.5
			Cottus bairdii kumlieni	5	6–11
02.35	do	do	Erinemus storerianus	1	5
			Perca flavescens	1	6
02.36	do	do	Lota maculosa	5	4.5–9

TABLE 4.—*Station record of young fishes taken by Shearwater in 1929*—Continued

Station	Net	Date	Species	Number of specimens	Length of specimens, millimeters
02.42	do	June 17	Perca flavescens	118	5.6–10
			Lota maculosa	5	4–8
			Cottus bairdii kumlieni	5	5.8–8
			Erinemus storerianus	1	5.7
02.43	do	June 18	Cottus bairdii kumlieni	2	7.5–9
02.44	do	do	Lota maculosa	1	12
			Cottus bairdii kumlieni	1	10
02.47	Surface meter	June 19	Perca flavescens	1	15
02.47	Bottom meter	do	do	8	9.5–16
02.48	do	do	Cottus bairdii kumlieni	1	10.3
02.49	Surface meter	do	Notropis cornutus chrysocephalus	1	6
02.50	Bottom meter	June 15	Lota maculosa	7	5.1–8
02.51	Surface meter	June 14	do	29	4–7.2
			Perca flavescens	2	6–6.5
02.51	Bottom meter	do	Lota maculosa	2	6–7
02.52	Surface meter	June 11	Perca flavescens	1	7.6
Crescent Beach	Bottom meter, depth, 3 feet	June 29	Rhinichthys cataractae	1	12.5
			Fundulus diaphanus menona	6	7.2–12.5
			Cyprinus carpio	11	9.5–17.5
04.03	Surface meter	July 2	Notropis atherinoides	1	6.7
04.04	Bottom meter	do	Perca flavescens	1	13
			Erinemus storerianus	2	6–7.5
04.06	Surface meter	do	Perca flavescens	17	6–10.8
04.06	Bottom meter	do	do	1	10.5
04.11	do	July 5	do	1	12
			Notropis atherinoides	1	6.7
04.12	Surface meter	do	Erinemus storerianus	1	6
			Perca flavescens	1	12.6
			Notropis atherinoides	4	7
04.17	do	July 8	Notropis cornutus chrysocephalus	9	6
04.17	Bottom meter	do	Cottus bairdii kumlieni	2	6–11.5
			Perca flavescens	2	14.8–17.5
04.21	do	July 5	Lota maculosa	3	10–13
04.32	do	July 11	Perca flavescens	9	7.8–14.5
04.34	do	do	Cottus bairdii kumlieni	1	11.5
04.35	do	do	Perca flavescens	1	6
04.36	Surface meter	do	Notropis atherinoides	1	13
04.38	do	July 12	do	72	5–7
04.38	Bottom meter	do	do	174	5–7
			Percopsis omiscomaycus	1	8.4
04.42	Surface meter	July 13	do	4	6
04.43	do	do	Notropis atherinoides	1	7
04.43	Bottom meter	do	do	25	6.8–8.4
04.47	Surface meter	July 15	do	8	6.5–9.5
04.47	Bottom meter	do	do	14	6–10.6
04.48	Surface meter	do	do	47	6–7
04.49	Bottom meter	do	do	39	4.5–6.5
05.13	Surface meter	July 23	do	480	10.5–22
05.14	do	do	do	115	10.5–17.5
06.03	do	Aug. 6	Moxostoma aureolum	1	8.4
			Notropis deliciosus stramineus	1	6.8
			Notropis atherinoides	4	19–20
06.03	Bottom meter	do	Perca flavescens	1	50
06.04	do	do	Notropis atherinoides	1	10
06.05	Surface meter	do	do	1	12.2
06.07	Bottom meter	do	do	5	9–13
			Notropis deliciosus stramineus	2	6–8.5
06.12	Surface meter	Aug. 8	Notropis atherinoides	9	9–26
06.13	do	Aug. 10	do	157	5–29.5
06.19	Bottom meter	Aug. 8	Notropis deliciosus stramineus	1	6.2
06.20	Surface meter	do	do	1	10.5
			Notropis atherinoides	1	19
06.26	do	Aug. 13	do	12	5.6–12
06.37	do	Aug. 16	do	9	23.5–30
06.38	do	Aug. 17	do	18	10.3–20
06.39	do	do	do	100	[1]14
06.40	do	do	do	116	11–14
06.41	do	do	do	126	6.5–14.5
06.42	do	do	do	3	5–12
06.43	do	Aug. 18	do	138	7–15.5
06.44	do	do	do	1	16.5
06.46	do	do	do	100	12.5–24
06.47	do	Aug. 19	do	59	4.8–32
			Notropis deliciosus stramineus	85	4.9–10
06.47	Bottom meter	do	do	38	5.5–8.9
06.48	Surface meter	Aug. 20	Notropis atherinoides	28	8–16
06.49	do	do	do	81	5–11
06.49	Bottom meter	do	do	21	5–7.2
			Percina caprodes zebra	1	7

[1] Approximate.

NUMERICAL SYNOPSIS OF SPECIMENS EXAMINED

Before discussing the species in detail, the following numerical synopsis is given: In 1928, the *Shearwater* and *Navette* plankton nets and young fish trawls yielded 1,049 specimens, representing 18 species. Supplementary collections from hatcheries, streams, and alongshore numbered about 49 more, making a total of 67 species for which descriptions of young forms have been made.

The *Shearwater* collections in 1929 yielded 2,235 specimens, or more than double the number taken in 1928, representing 14 species. Six of these species were not taken previously by the Lake Erie collecting party, and 10 species captured by the *Shearwater* during the same period in 1928 were not among the later collections. Thus, the accidental aspect of our collecting methods and the need for carrying on studies over several years with young-fish nets of every description are strikingly emphasized.

The collections examined in 1930, which had been taken during the previous year in the western part of Lake Erie along the Ohio shore, numbered over 20,000 individuals, representing 17 species.

Counting several new records of distribution added by the present investigation to previous faunal lists of the region, there have been reported 112 species from the Erie-Niagara watershed, 92 of which are found in Lake Erie. Practically all of those species not taken by the cooperative survey are of extremely rare occurrence, and many are represented by a single record which may be questionable.

DEVELOPMENT OF SPECIES

Family LEPISOSTEIDÆ, Gar-pikes

1. Lepisosteus osseus Linnaeus. Long-nosed gar; gar-pike; bill-fish.

RECORD OF CAPTURE

One young fish, 41 millimeters long, was dipped from the surface at Buffalo on July 12, 1928. Adults are moderately common in Lake Erie and the Niagara River.

DESCRIPTION

The young are easily recognized by the greatly prolonged toothed jaws and elongate body, brilliant in seal, reddish-brown, and bronze.

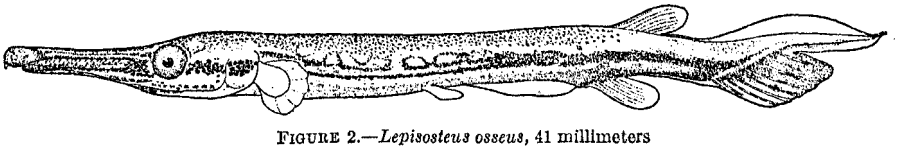

FIGURE 2.—*Lepisosteus osseus*, 41 millimeters

41.0-millimeter stage.—Dorsal, 7; anal, 7 (incomplete). Total length, 41.0; length of head, 12.0; length to vent, 27.5; length to dorsal, 29.0; greatest depth, 3.0; diameter of eye, 3.0 millimeters.

The most remarkable feature of this small and brilliant gar was the prolongation of the notochord into a fleshy filament, apart from the caudal fin, which kept up a rapid vibratory motion. That the caudal fin is not the true termination of the vertebral column, but an appendage to its lower portion, "a true second anal," is thus strikingly demonstrated.

Pigmentation.—There are three distinct shades of brown in the living specimen, which may be described as a dark seal-brown, reddish-brown, and bronze. The bronze has some metallic sheen and the lightest intensity of all. The dorsal surface is covered with closely distributed, tiny, round, reddish-brown chromatophores, those on the prolonged jaws being larger, stellate, and fewer toward the center line. Viewed from the side, some exceptionally large seal-brown chromatophores appear on jaws extending to eye, a narrow line encircling orbit, and thence a broad band of bronze to the posterior margin of head. On either side of this postorbital band is a white band, met above by the reddish-brown dorsal region and below by the dark ventral chromatophores. Behind the head, dorsal chromatophores extend down the sides for one-third of their depth, continuing to extreme tip of body on either side of notochord. Below this is an irregular white band with a very broken bronze band interposed upon it, followed below by a wide median band of deep seal-brown and bronze extending the full length of body, continued to top of lower part of caudal fin. Below the median band, a white band is apparent, which becomes narrower and is lost behind the anal fin, bounded below by the seal-brown ventral region. The underside is characterized by the same white color as the sides (as a pigment, not the opaque, colorless white of young forms). An arrow-shaped patch of white marks the lower surface of head, and behind this the ventral aspect is mostly seal-brown with only small irregular markings of white. Base of pectorals is white with a median-brown band about one-third the width of the base, not extending to tip of fin. Some reddish-brown is evident on dorsal, and the brown ventral chromatophores extend out less than half the distance to tip of anal fin.

BREEDING

The long-nosed gar spawns in late spring and early summer in warm shoal water, often running up smaller streams in company with the sturgeons. The eggs are probably attached to weeds, and the young remain among the weed beds close inshore during their first summer.

Family HIODONTIDÆ, Mooneyes

2. Hiodon tergisus Le Sueur. Mooneye; toothed herring.

RECORD OF CAPTURE

None of this species were taken by townets in the deeper waters of eastern Lake Erie during the survey, but schools of young were found at many places close inshore and at creek mouths. Among the 1929 collections from the western end of Lake Erie were eight larvæ, 12.0 to 15.5 millimeters in length, taken on June 7 at the surface in water of 15 to 19 feet. A 6.5-millimeter larva which seems to be identical with the above was taken on June 10, off the mouth of the Maumee River.

DESCRIPTION

The elongate herringlike body with blunt projecting snout and large mouth at all stages is unlike any other species taken by the survey.

6.5-millimeter stage.—Total length, 6.5; standard length, 6.3; length to vent, 4.3; length of head, 1.16; diameter of eye, 0.3; greatest depth before vent, 0.85; depth behind vent, 0.4 millimeter. Myomeres incomplete at beginning and end of body but

probably about 28 to vent, plus 16 behond. Body very slender and elongate with bulbous forehead; terminal mouth placed very low, with gape to front margin of pupil; pectorals developed by unrayed; marginal fin fold arising dorsally at about sixteenth myomere behind head, low, but slightly higher above vent, very low around caudal, and continued on underside forward past vent to middle of intestine. Although the notochord still is straight, lower caudal rays are developing.

Pigmentation.—Body is colorless except for partially pigmented eyes.

Although the myomere count is somewhat shorter, there are certain very important characters of this larva which seem to indicate that it is identical with the species

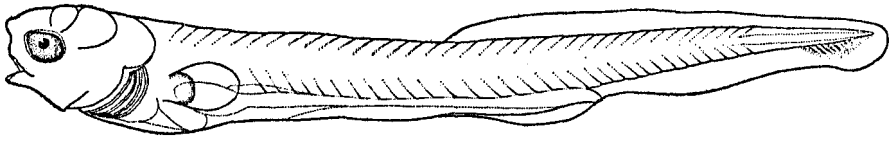

FIGURE 3.—*Hiodon tergisus*, 6.5 millimeters

represented by the 14.2-millimeter specimen, which is the subject of the next description. The exceptionally protruding snout, very large mouth, small eye, elongate body with vent situated far back, posterior insertion of dorsal marginal fin fold with slight elevation above vent, unusually low marginal fin fold around caudal with rays forming in this fin before the notochord bends upward, all point to its identification as *Hiodon tergisus*. The very early stage of the larva may account for the incompleteness of myomeres, and thus it is tentatively assigned to this species.

14.2-millimeter stage.—Total length, 14.2; standard length, 13.2; length to vent, 9.0; length of head, 2.5; snout, 0.6; diameter of eye, 0.85; greatest depth before vent, 2.0; depth behind vent, 1.0 millimeter. Myomeres, 30 to vent plus 21–23 behind. Contour of dorsal fin indicated with elements of 12 dorsal rays and about 20 anal

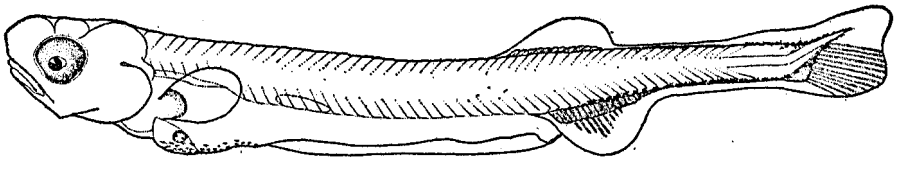

FIGURE 4.—*Hiodon tergisus*, 14.2 millimeters

elements apparent; lower caudal rays developed although tail not yet completely heterocercal. Slender, oblong body; blunt snout much protruding, so that mouth is inferior; lower jaw included; premaxillaries and maxillaries very slender; gape of mouth to distal margin of pupil; wide set, cardiform teeth in premaxillaries, and mandibles proportionately larger at this state than in adult; nostrils large, close together.

Pigmentation.—Brownish chromatophores appear on the ventral surface below the large, anteriorly placed oil globule, and along yolk region a quarter of the distance to vent. A few widely separated subsurface spots are present along dorsal aspect of stomach region. An irregular double line of small chromatophores is seen on dorsal margin from dorsal fin to caudal, and a single partially subsurface series on ventral margin from shortly behind vent to caudal. Small pigment spots are distributed at base of caudal.

BREEDING

Apparently this species was spawning in our region about the first of June. The eggs are known to fall into the abdominal cavity before extrusion, rather than into ducts leading from the ovaries to the outside, as is the case in most fishes (Bean, T. H., 1903).

Family COREGONIDÆ, Whitefishes

3. Leucichthys artedi (Le Sueur). Lake herring; cisco.

RECORD OF CAPTURE

No young herring were taken by the survey during the summers of 1928 and 1929. By the time our collecting trips started the herring had grown to a stage where they were able successfully to escape the trawls used. Consequently, it was necessary to rely upon rather scanty formalin-preserved hatchery material for a study of this species. The following short account will serve only as preliminary data toward a complete developmental history to be made later.

DESCRIPTION

Egg.—Diameter of preserved hatchery specimens examined varying from 2.0 to 2.5 millimeters, mostly 2.25 millimeters. The earliest stage obtained measured

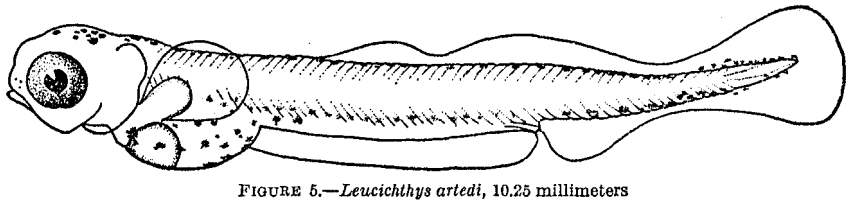

FIGURE 5.—*Leucichthys artedi*, 10.25 millimeters

2.25 millimeters, diameter of yolk, 1.8 millimeters, with a colorless early embryo reaching halfway around the yolk. Myomeres faintly discernible.

Pigmentation.—The eggs, although very opaque from preservation, show about 20 rather large oil globules, deep amber in color on the yellowish yolk. In a later stage when the embryo reaches more than once and a half around the yolk and is apparently ready to hatch, the top of head becomes heavily pigmented and dorsal and ventral brown stripes, characteristic of the newly hatched larva, are prominent. Yolk sac is deep yellow, its anterior part filled with a large oil globule, and dark thickly distributed chromatophores make their appearance on the underside posteriorly. Eyes are dark, and the center of head behind eyes is covered by a diamond-shaped patch of small chromatophores. Chromatophores continue, small and stellate, to form the double dorsal series to end of body, with a similar ventral series behind the vent.

8.5–9.8-millimeter stage.—Newly hatched. Much like following specimen figured, but yolk sac larger and body proportionately more slender. Pigment identical with that of the 10.25-millimeter stage.

10.25-millimeter stage.—Age about 2 days. Total length, 10.25; length to vent, 6.8; greatest depth behind yolk sac, 0.85; diameter of eye, 0.9 millimeter; myomeres, 38 to vent plus 19 behind. Embryonic marginal fin fold complete, starting over seventeenth myomere, rising, then notching over twenty-ninth myomere, rising again

and notching at peduncle; ventrally starting beneath yolk sac, breaking completely at vent, and notching at peduncle; caudal lophocercal; pectorals large, rounded. Head very blunt, its highest point over posterior part of eye; mouth subinferior, jaws equal.

Pigmentation.—The larval *Leucichthys artedi* is opaque white in color, differing from *Coregonus clupeaformis* in the restriction of yellow color to the yolk, whereas in the latter this color is diffused in subsurface streaks about the head, above the

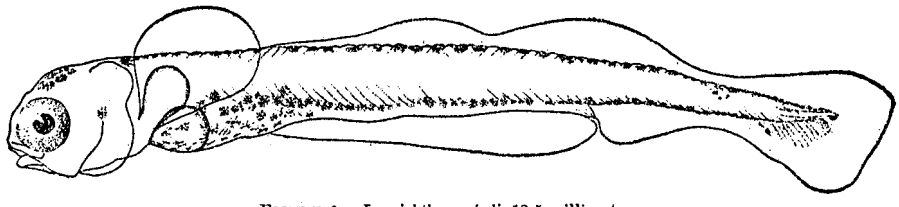

FIGURE 6.—*Leucichthys artedi*, 12.5 millimeters

stomach, and in some specimens over the whole body. In the specimen figured, 2 round areas of chromatophores appear on head followed by a double series of 18 along dorsal aspect to a point opposite vent, thence 24 to tip of tail. These two lines are not even, the chromatophores being sometimes alternate and differing in size and number, thus distinguishing the species from *Coregonus clupeaformis* in which the dorsal series usually are perfectly symmetrical. Lateral and ventral aspects of head are colorless. One very large stellate spot is apparent over pericardiac region at the beginning of the yolk sac. Behind this, two more or less definite lines extend across sac, and a few chromatophores, very linear in shape, are arranged longitudinally on underside of sac. Starting just before end of yolk sac, a series of about 20 large

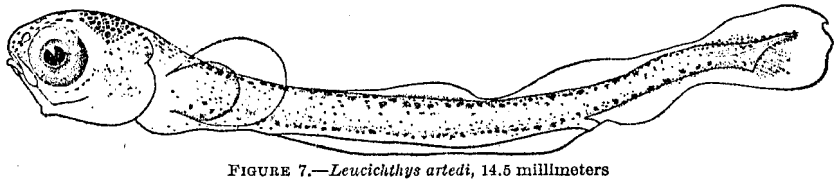

FIGURE 7.—*Leucichthys artedi*, 14.5 millimeters

stellate chromatophores occurs over intestine, and behind vent there is an uneven double line of about 12 intersprinkled with smaller ones to tip of tail.

12.5-millimeter stage.—Total length, 12.5; length to vent, 8.5; greatest depth, 1.6; diameter of eye, 1.0 millimeter; myomeres, 38 to vent plus 19 behind. Immediately after preceding stage yolk beginning to shrink, and at this stage represented by only a fragment showing yellowish through the body wall. Embryonic marginal fin fold unchanged; pectorals enlarged; notochord turning upward very slightly. Head less blunt than before; lower jaw slightly shorter.

Pigmentation.—The linear chromatophores on underside of yolk sac now are more numerous, giving a "pin feather" effect, and those on sides of sac have increased greatly in size and are remarkably stellate in shape; others appear unchanged. All specimens which have been examined show heavy dorsal pigment on head and at the beginning of dorsal ridge, then a break occurs in the series until shortly before vent during which space the chromatophores are quite sparsely distributed. Following the break they are closer together, more numerous, and form a very distinct band.

14.5-millimeter stage.—Total length, 14.5; length to vent, 10.6; length of head, 2.5; greatest depth (head), 1.92; diameter of eye, 1.25; maxillary, 1.1 millimeter. Embryonic marginal fin fold broken dorsally at twenty-ninth myomere and well separated from posterior portion; no rays evident but some concentration in the anterior portion, indicating later position of basal elements; ventrally marginal fin fold much reduced; caudal becoming heterocercal by dorsal extension of notochord, outer contour very slightly notched, and few rays suggested ventrally; no ventrals in this specimen, although development is beginning in another specimen only 13.2 millemeters long. Head more pointed; maxillary to middle of pupil.

Pigmentation.—Chromatophores have increased greatly on top of head, and a double series with 3 or 4 lines of smaller ones between occurs along dorsal ridge of body. There are more pigment spots on sides of body and on dorsal surface of intestine, both surface and subsurface, and a few extend on to caudal.

16.5 millimeter stage.—Total length, 16.5; standard length, 15.25; length to vent, 11.9; length of head, 3.5; length of maxillary, 1.4; diameter of eye, 1.5; greatest depth (head), 2.2; depth at stomach, 1.9; greatest depth behind vent, 0.82 millimeter. Nine dorsal elements and short rays; none in anal; caudal rays developing; small ventrals apparent directly beneath dorsal rays. Intestine still ending away from body

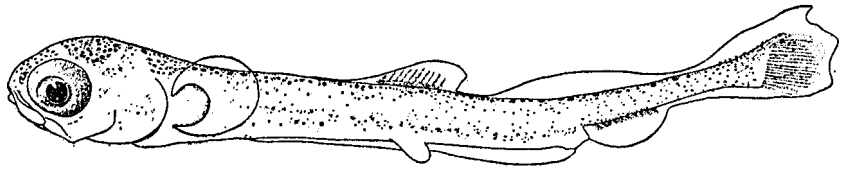

FIGURE 8.—*Leucichthys artedi*, 17.5 millimeters

at margin of embryonic fin fold. Body somewhat heavier than preceding. Pigmentation unchanged.

17.5-millimeter stage.—Total length, 17.5; length to vent, 12.3; length of head, 3.6; length of maxillary, 1.4; greatest depth (head), 2.3; diameter of eye, 1.5 millimeters. Elements complete and 10 dorsal rays visible; 10 anal elements but no rays; ventrals larger but not rayed.

BREEDING

The lake herring spawns in November and early December, coming into shallow water in vast schools for the purpose. The eggs incubate on the bottom during the long winter months, hatching the following spring, the exact date dependent upon the temperature of the waters.

4. **Coregonus clupeaformis** (Mitchill). Whitefish.

RECORD OF CAPTURE

As in the case of the lake herring, the late start of our collecting trips during the summers of 1928 and 1929 prevented the capture of eggs and early young of this species. The following notes are based on a series of preserved eggs obtained from E. L. Wickliff at Put-in-Bay, Ohio, and young from 7 days to 109 days from Dr. John Van Oosten, reared at the New York Aquarium. The later stages described were loaned by J. L. Hart.

DESCRIPTION

Egg.—Diameter after preservation in formalin mostly 2.8 to 3.0 millimeters; perfectly spherical, yolk yellowish or amber with half its surface covered by varying sized oil globules closely crowded together. Immediately after fertilization yolk entirely fills egg, with no perivitelline space apparent except at one pole. At 6 hours average diameter, 3.0; yolk diameter, 2.6 millimeters, with widened perivitelline space and the first concentration of germinal matter to form the blastodisc at center of oil globule mass. Blastodisc continues to form until the beginning of cleavage at 24 hours, when 2, 4, and 8 cell stages are apparent. Blastodisc lenticular by fifth day with oil globules congregated below. On twenty-sixth day an early embryo reaches halfway around egg and shows well developed optic vesicles which are slightly pigmented on inner and upper margins. Oil globules coalescing in part to form

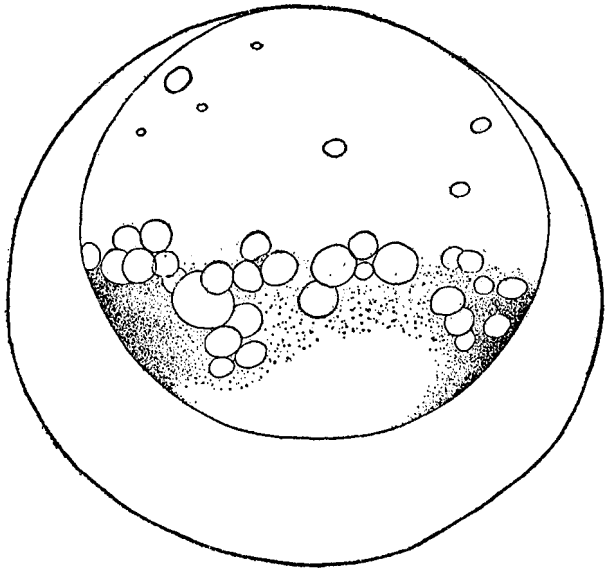

FIGURE 9.—*Coregonus clupeaformis* egg

usually about two very large spheres, with many small ones remaining. At 40 days the embryo extends completely around egg; head much higher and more rounded, eyes larger and black; 1 large oil globule and only a few smaller ones on yolk. First evidence of dorsal and ventral marginal pigmentation evident at 54 days.

Figure 10 shows the embryo in process of hatching on the sixty-first day. Mouth not open; vent at a distance from body, at edge of fin fold; embryonic marginal fin fold completely encircling fish from behind head around lophocercal tail to yolk sac; yolk sac very large, deep yellowish in color, with 1 large oil globule and other smaller ones. Myomeres completely formed. Double series of brown chromatophores on both dorsal and ventral aspects; yolk sac also pigmented posteriorly, near the body. Other eggs in collection not hatched at 131 days.

12.0-millimeter stage.—Less than 1 week old. Total length, 12.0; length to vent, 7.0; greatest depth behind yolk sac, 1.1; diameter of eye, 0.8 millimeter. Body much heavier, the greatest depth behind yolk sac being 10.9 in total length, while in a herring of equal development it is 12. Embryonic marginal fin fold resembling herring, originating over middle of yolk sac, notching somewhat about 11 myomeres before

the vent, rising again to highest point over vent, notching on either side of peduncle, and breaking entirely at vent.

Pigmentation.—The 12-millimeter whitefish is characterized by a large, very yellow yolk sac, and by much yellow diffused in subsurface streaks about the head,

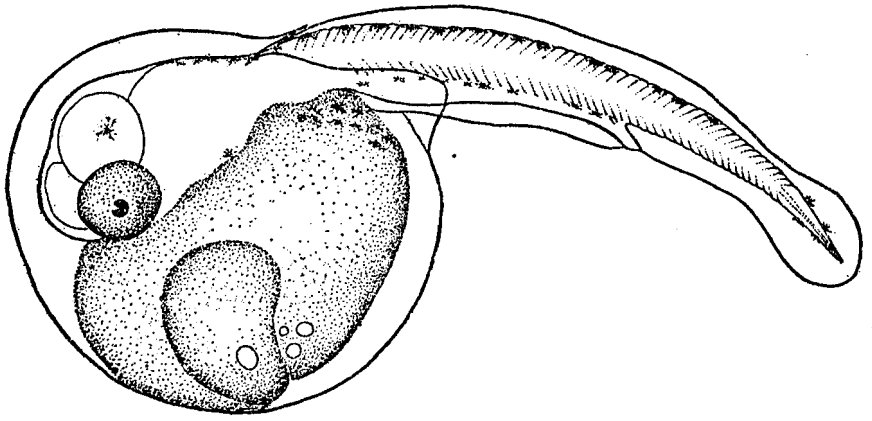

FIGURE 10.—*Coregonus clupeaformis* embryo in process of hatching

above the stomach, and in some specimens over the whole body, thus differentiating it from *Leucichthys artedi* in which this color is less intense and limited to the yolk sac. Chromatophores are distributed essentially as in the herring, but generally they are much larger, darker, and more regularly arranged, consisting of a few large

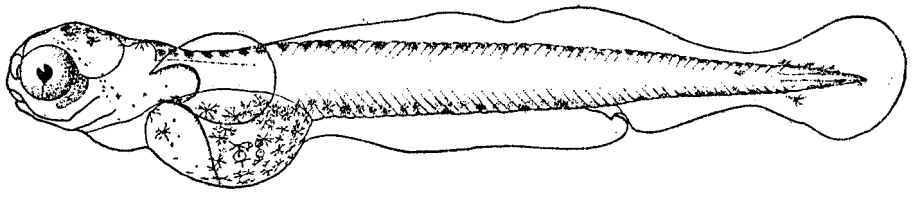

FIGURE 11.—*Coregonus clupeaformis*, 12 millimeters

black stellate spots on top of head and a few very small ones on sides, running into an unbroken double line of about 52 on dorsal aspect, which are very large and square ly stellate. Chromatophores appear on underside of head and continue in a line across yolk sac and on dorsal aspect of intestine to vent, numbering about 28 on each

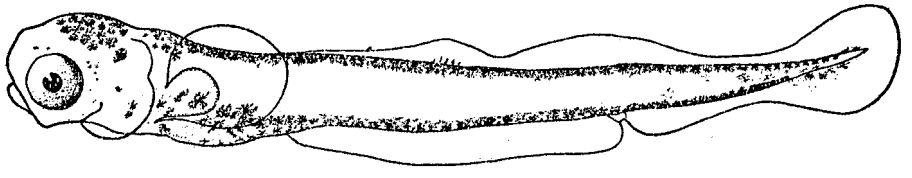

FIGURE 12.—*Coregonus clupeaformis*, 13.5 millimeters

side. Few others are spread over yolk sac, and a double ventral series of about 17, similar to dorsal, is apparent behind vent.

13.5-millimeter stage.—About 1 week old. Total length, 13.5; length to vent, 10.0; greatest depth, 1.6; diameter of eye, 1.25 millimeters. Embryonic marginal fin fold unchanged in shape from preceding stage, but now with slight suggestions of 5 dorsal fin rays in anterior part, pectorals very large; yolk almost completely absorbed.

Pigmentation.—There is still much yellow over yolk region, and whole head is tinged with yellow. Number and arrangement of chromatophores is as in 12-millimeter specimen described above, but the size of all chromatophores is increased until they overlap in marginal series.

18.5-millimeter stage.—Age unknown but similar to specimens 61 days old. Total length, 18.5; standard length, 17.0; length to vent, 13.25; length of head, 4.0; depth

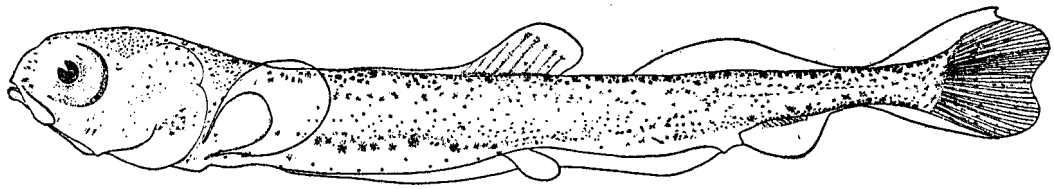

FIGURE 13.—*Coregonus clupeaformis*, 18.5 millimeters

of head, 2.25; greatest depth behind head, 2.0; diameter of eye, 1.6 millimeters. Dorsal rays fairly well developed; embryonic marginal fin fold starting again after wide space behind dorsal, continuing to caudal, complete on ventral side, with basal elements of anal fin developed but no rays; caudal slightly notched dorsally at end of notochord, lower portion becoming forked and rays well formed; ventrals prominent.

Pigmentation.—Dorsal and ventral series of chromatophores are still prominent, but many smaller ones have become scattered over sides of head, body and caudal.

22.0-millimeter stage.—65 days old. All fins fully developed with exception of adipose, in which region a large fragment of the embryonic fin fold remains.

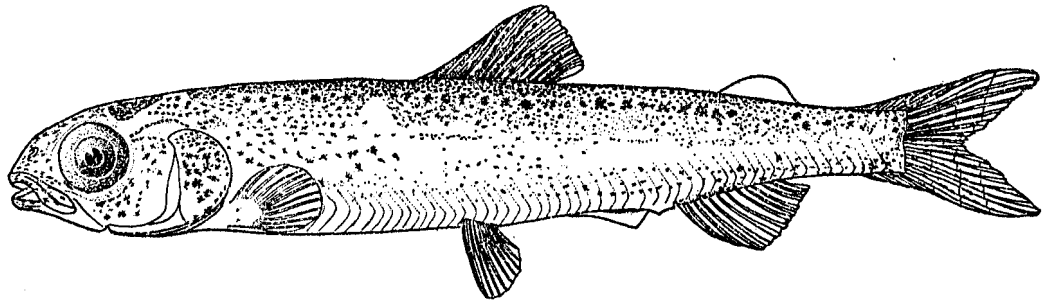

FIGURE 14.—*Coregonus clupeaformis*, 31.5 millimeters

31.5-millimeter stage.—Age unknown but similar to specimens 95 to 109 days old. Total length, 31.5; standard length, 27.0; length of head, 6.75; greatest depth of body, 4.5; diameter of eye, 2.0 millimeters. Assuming shape of adult.

Pigmentation.—The chromatophores are essentially as in younger specimens but they have become more diffused, with dorsal and ventral ridges of body from head to caudal still most deeply pigmented. Black, stellate, dorsal chromatophores continue down the sides of body to lateral line, becoming gradually smaller and wider apart. The lateral line is marked by closely distributed small black spots. A few chromatophores appear on ventral aspect of stomach; none beneath the intestine. The large areas of chromatophores behind eye are still noticeable, and many more, lighter in color, show between and before the eyes, becoming darker at mouth. Dorsal and caudal are speckled with black, following lines of rays. The body, and especially the head, are silvery at this stage.

Upon further development the body becomes deeper, head smaller, and proportions are more like the adult. Tiny chromatophores increase greatly in number from dorsal aspect to lateral line, and the ventral half of body is noticeably light-colored with pigment spots sparsely distributed. At 53 millimeters the anal is speckled with black.

53.0-millimeter stage.—Total length, 53.0; standard length, 47.0; length to vent, 35.0; length of head, 11.8; greatest depth, 11.25; diameter of eye, 3.75 millimeters.

68.0-millimeter stage.—Total length, 68.0; standard length, 58.0; length to vent, 43.5; length of head, 14.5; depth at origin of dorsal, 13.15; diameter of eye, 4.0; length to origin of dorsal, 28.0 millimeters.

83.0-millimeter stage.—Yearling. Total length, 83.0; standard length, 70.5; length of head, 18.5; depth of head, 11.5; length to dorsal, 35.5; greatest length of dorsal rays, 14.25; depth at dorsal, 15.0; length to ventrals, 36.5; greatest length of ventral rays, 12.0; length to vent, 52.2; greatest length of anal rays, 9.5; length to pectorals, 17.5; greatest length of pectoral rays, 12.0; length of maxillary, 7.0;

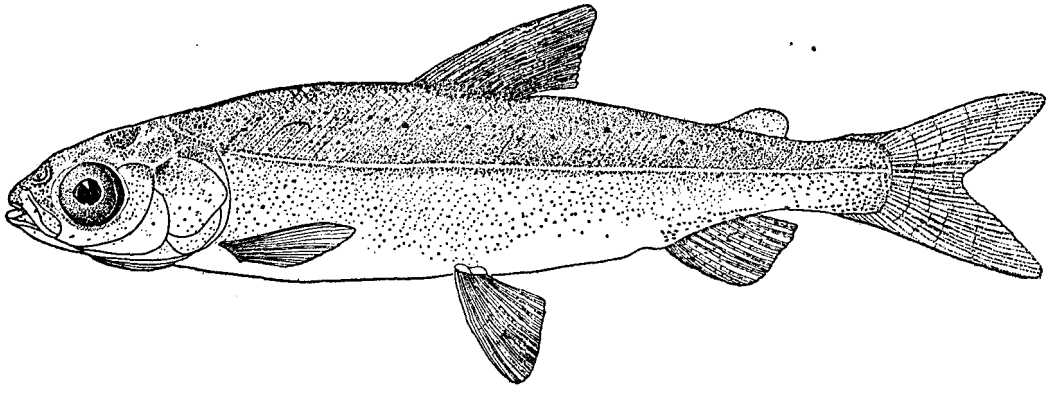

FIGURE 15.—*Coregonus clupeaformis*, 68 millimeters

interorbital width, 6.0; diameter of eye, 5.7 millimeters. Body fully scaled as in the adult.

Pigmentation.—The yearling whitefish is greenish gray above, very silvery on sides and below, with an area of light amber extending from just behind pectorals to lateral line. The eye is blue, edged in black.

The larval stages of *Coregonus clupeaformis* and *Leucichthys artedi* are easily confused, and the very small number of herring obtainable prevented us from formulating any rules of identification. It will be necessary to study many more specimens before we can be sure that the differences noted herein are constant.

I have pointed out a few outstanding characters in the above descriptions, especially the diffusion of yellow color in the whitefish throughout the yolk region, head, and sometimes over the whole body, as contrasted in the herring with the restriction of this pigment to the yolk sac. Furthermore, the double dorsal series of chromatophores in the whitefish is symmetrical, even, and continuous from behind head to tip of tail, while in the herring it becomes broken and uneven from shortly behind head often to a point more than halfway to vent. Although this character is certainly a valuable indication of the species, it can not be depended upon, for in our large collection of whitefish there were many in which the dorsal series was thin and sometimes quite uneven in this region, while among the dozen hatchery specimens

of young herring studied, one had a perfectly continuous line indistinguishable from that of the whitefish. In all our herring specimens the pigment over the intestine was very much less noticeable than in the whitefish.

In the specimens studied, the body of the whitefish was deeper than that of a herring of like size, and usually the latter species was somewhat more advanced in development at the same length. The more elongate body of the herring may be found to be a constant factor when the two species are reared together, subjected to the same temperature and environmental conditions, but only when this is done can complete faith be placed in proportional differences, so great is individual variation within the species. As an example, may I quote Ada Hall (1925) concerning the whitefish: "Fry hatching at 1, 2, and 4 months after spawning differ in size of body but not in size of yolk; those hatching at 4 months are 4 to 6 millimeters longer than those hatching earlier."

With the large number of hatchery herring promised for future study we hope to sift out of the present possibilities whatever differences are constant.

BREEDING

The whitefish spawns in November and early December, as does the herring, the eggs hatching the following spring. The period of incubation is dependent upon temperature.

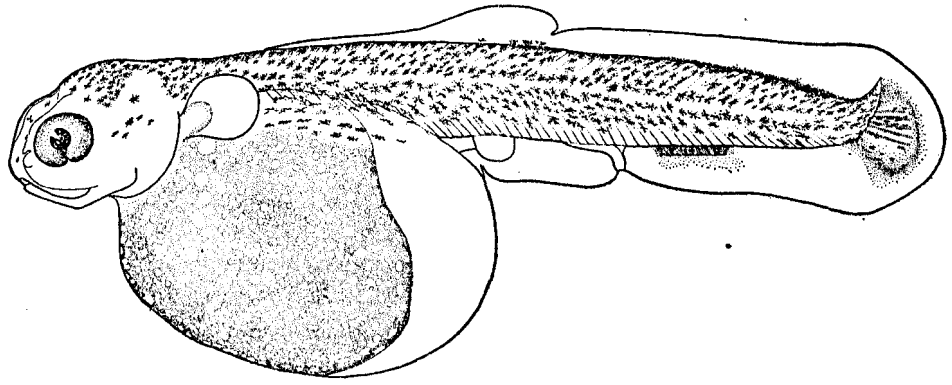

FIGURE 16.—*Cristivomer namaycush namaycush*, 16 millimeters

Family SALMONIDÆ, Trouts

5. Cristivomer namaycush namaycush (Walbaum). Lake trout. [*Cristivomer namaycush* (Walbaum). Jordan, Evermann, Clark, p. 59.]

RECORD OF CAPTURE

None of these uncommon fishes was taken by the *Shearwater* in 1928 and 1929, but eggs and newly hatched larvæ were supplied for study by the Cape Vincent hatchery. The species is restricted to the deeper parts of the lake where it is taken rarely by gill nets.

DESCRIPTION

Newly hatched larva, 16.0-millimeter stage.—Total length, 16; standard length, 14.78; length to vent, 10.3; length of head, 3.0; snout, 0.5; greatest depth before vent, 5.6; greatest depth behind vent, 2.9; diameter of eye, 1.1 millimeters. Myomeres, 42 to vent plus 20+ behind. Characterized by exceptionally large yolk sac,

large mouth, and many myomeres. The appearance of ventrals, elements of the anal, and turned-up notochord are characters rarely found in such an early larva. Dorsal marginal fin fold raised and notched over the middle of body, indicating the position of dorsal fin; adipose not marked out; a few caudal rays forming, but otherwise no rays discernible.

Pigmentation.—Only a few chromatophores are apparent on snout and sides of head, but many large, stellate spots cover top of head, and the dorsal and lateral aspects of body.

21.5-millimeter stage.—Total length, 21.5; standard length, 18.5; length to vent, 13.8; length of head, 4.3; snout, 0.85; diameter of eye, 1.4; greatest depth before vent, 4.8; greatest depth behind vent, 4.0 millimeters. Myomeres, 42 to vent plus 22 behind. The yolk sac much reduced from the preceding stage, but still of considerable size. About 8 rays in dorsal, 9 in anal, and most of the caudal rays visible.

BREEDING

Spawning takes place on rocky shoals and reefs in depths of 77 to 90 feet during October and November. The eggs develop on the bottom of rocky caverns over

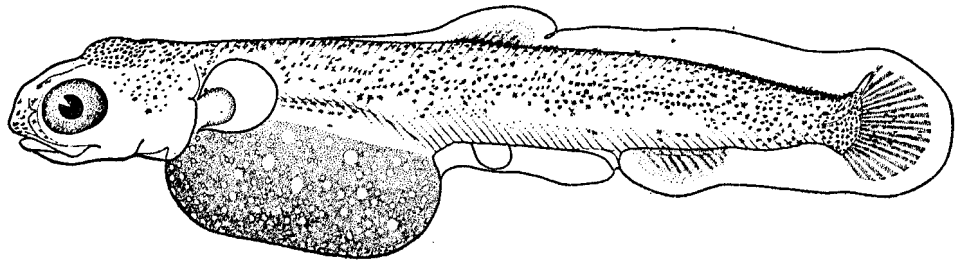

FIGURE 17.—*Cristivomer namaycush namaycush*, 21.5 millimeters

which they are deposited, and hatch in late winter or early spring. At a temperature of 47° F. in the laboratory, the larvæ hatch about the last week of January, but lower temperatures will retard incubation greatly. It is estimated that a 24-pound lake trout may spawn approximately 15,000 eggs.

6. Carpiodes cyprinus (LeSueur). White carp; buffalo mullet; quillback; swordfin.

RECORD OF CAPTURE

No larvæ of this species were taken by townets in Lake Erie, but adults were found commonly in the lake and in most of the larger streams of the region, and young were numerous at the mouths of creeks and on shallow mud flats several miles upstream.

DESCRIPTION

The young quillback resembles the carp (*Cyprinus carpio*) in its elongate dorsal fin, but is readily distinguished by the character of the small inferior mouth, small eye, and relatively long deep cheek. The difference in myomere counts is diagnostic (a 21 millimeter *C. cyprinus* has 25 plus 12+, and a *C. carpio* of equal length 19 plus 15–17 myomeres.)

21.0-millimeter stage.—Total length, 21.0; standard length, 16.5; length to vent, 13.4; length of head, 5.5; snout, 1.25; greatest depth before vent, 4.68; greatest depth

behind vent, 2.5; diameter of eye, 1.5; length to dorsal, 9.0; length to anal, 13.5 millimeters. Myomeres, 25 to vent plus 12+ behind. Dorsal I (very weak), 27; anal I (very weak), 7; ventrals 10, short; caudal forked; pectorals short, low. The falcate dorsal fin well formed, but its anterior rays are not as greatly produced as in the adult. Body oblong, with ventral outline nearly straight and dorsal slightly arched; mouth inferior, small, and horizontal; snout beginning to be pointed at this stage. Air bladder two-chambered.

Pigmentation.—Chromatophores are sparsely distributed on upper jaw, sides and top of head, more numerous over brain region and dorso-lateral aspects of body. A single row of larger spots lies along the dorsal ridge to caudal. Below lateral line chromatophores are scattered more widely. Double series on either side of anal fin is continued to caudal (unfortunately not well shown in specimen, fig. 22). Dorsal

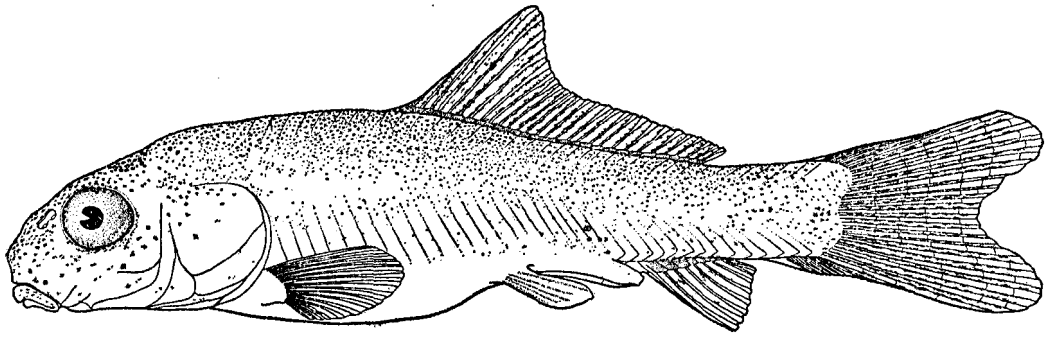

FIGURE 18.—*Carpiodes cyprinus*, 21 millimeters

and caudal are well marked with pigment, but other fins have few chromatophores or none.

Family CATOSTOMIDÆ, Suckers

7. Catostomus commersonii (Lacépède). Common sucker; white sucker; mullet.

RECORD OF CAPTURE

Numerous young, 15 to 25 millimeters long, were taken abundantly in shallow water at the eastern end of Lake Erie by meter nets, dip nets, and seines from the middle of June to the middle of July, 1928. None was taken by the *Shearwater* in 1929, probably because less work was done far inshore during this period. This species is one of the most common and widely distributed in the Lake.

DESCRIPTION

The very long intestine (myomeres, 33 to vent plus 10 behind) differentiates the young suckers at all stages from other species taken by the survey.

Egg.—The unfertilized egg measures 2.5 to 2.82 millimeters in diameter, being round, white, without oil globules, and finely granulate in texture. After fertilization, which occurs a few moments after extrusion, the egg measures 3 millimeters and the vitellus 2.5 millimeters.

The embryology and development have been thoroughly reported upon by N. H. Stewart (1926). It will suffice here to record the measurements and descriptions of two stages during the period of greatest change.

13.75-millimeter stage.—Total length, 13.75; length to vent, 13.0; greatest depth, 1.6; diameter of eye, 1.1; myomeres, 33 to vent plus 10+ behind. Head characterized by terminal, "horseshoe-shaped" mouth, and very large eye. Dorsal marginal fin fold very narrow, the later position of true dorsal indicated by a slight rise; ventral marginal very wide, extending forward almost to base of pectoral; caudal lophocercal with few rays apparent; no ventrals.

Pigmentation.—Body is colorless except for silver eyes edged in black, and black chromatophores distributed in four definite bands: (1) Group of stellate chromato-

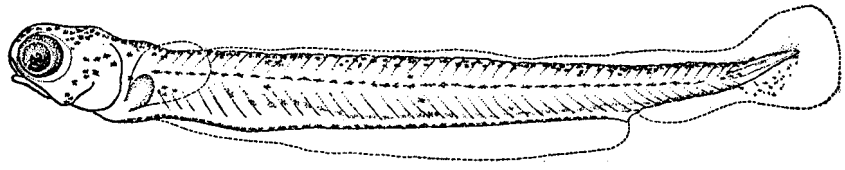

FIGURE 19.—*Catostomus commersonii*, 13.75 millimeters

phores on top of head followed by a triple line along dorsal ridge to end of body; (2) series of linear chromatophores along mid-lateral line of myomeres, about 56 from behind head to end of tail; (3) series starting behind head, congregated over dorsal surface of air bladder and continuing in massed line (about 4 chromatophores wide) to vent, mostly subsurface; and (4) series of about 57–60 large round and stellate pigment spots along ventral ridge from behind head to vent, thence as a massed line of about 4 chromatophores wide to end of body. Caudal fin fold is peppered with very small chromatophores near its base.

14.2-millimeter stage.—Total length, 14.2 standard length, 12.9; length to vent, 10.1; length of head, 2.75; greatest depth, 2.2; diameter of eye, 1.0 millimeters.

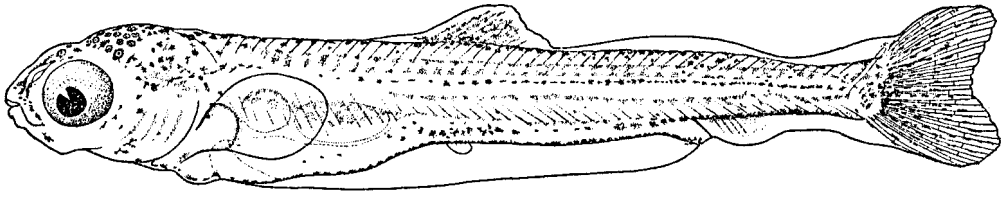

FIGURE 20.—*Catostomus commersonii*, 14.2 millimeters

Myomeres, 33 to vent plus 10+ behind. Snout less blunt; air bladder two-chambered. Dorsal fin developed with evidences of 10 rays, and suggestion of about 4 anal rays; ventrals developing; caudal heterocercal; embryonic marginal fin fold persisting behind dorsal and complete on ventral aspect.

Pigmentation.—The pigmentation here is essentially as in the previous stage, with the addition of more chromatophores in the caudal, and a few stellate ones in dorsal fin. The extreme transparency of a living specimen reveals many subsurface chromatophores: One series above and another below the nerve chord, connected laterally at intervals corresponding to the myomere interspaces, and a third series marking the ventral aspect of the notochord. Gill arches are likewise margined with subsurface chromatophores.

20.5-millimeter stage.—Dorsal and anal fins complete.

BREEDING

The white sucker spawns in shallow water in April or May, soon after the ice leaves. Its spawning behavior has been thoroughly recorded by J. E. Reighard (1920).

8. Hypentelium nigricans (Le Sueur). Hammerhead; stone-roller sucker; hog sucker.

RECORD OF CAPTURE

This species was taken along the shores of Lake Erie near stream mouths but more commonly in the larger shallow and warm creeks.

DESCRIPTION

The head of the stone-roller differs from other suckers in its flattened contour with interorbital space concave and orbital rims broadly elevated.

21.0 millimeter stage.—Total length, 21.0; standard length, 18.0; length to vent, 13.0; length of head, 5.1; snout, 1.35; diameter of eye, 1.35; greatest depth before

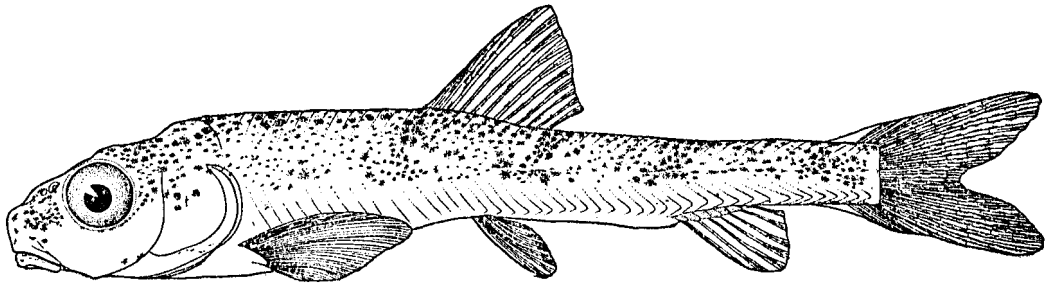

FIGURE 21.—*Hypentelium nigricans*, 21 millimeters

vent, 3.3; greatest depth behind vent, 1.6; length to dorsal, 8.5; to anal, 13.5 millimeters. Myomeres, 30 to vent plus 14–15 behind. Dorsal II (very weak), 11; anal, 7; ventrals, 9; caudal deeply forked; all fins large. Lips large, strongly papillose, wide inferior mouth; eye rather small, near middle of head. Resembles *Catostomus commersonii* in rather short dorsal fin and 2-chambered air bladder, but differs in having head concave above, scales fewer than 48 (60 in the common sucker), and oblique cross bars on body instead of plain or blotched color.

Pigmentation.—Chromatophores appear over snout, upper lip, and top of head, large stellate ones on dorsal aspect to caudal, and smaller ones to below lateral line. Through this upper pigmented region oblique pigment bars pass to below lateral line: 1 behind head, 1 at origin of dorsal, 1 at posterior end of dorsal, another halfway between dorsal and caudal, and the last one at caudal base. The belly is white (differing from *Catostomus* in which there is a prominent ventral line series). Chromatophores are distributed on dorsal, caudal, and pectorals; ventrals and anal are colorless.

BREEDING

The stone-roller sucker is a spring spawner, and the young are found abundantly in small creeks and rivers.

9. Moxostoma aureolum (Le Sueur). Red-fin mullet; red-horse sucker.

RECORD OF CAPTURE

Only one specimen was taken each year by the *Shearwater*, the first at the mouth of Beaver Creek on July 11, 1928, in a meter net at 6 meters below the surface, and the second near Angola on August 6, 1929, at the surface in water of 11 meters. Although mostly an inhabitant of large streams, it is moderately common in Lake Erie.

DESCRIPTION

The red-fin mullet larva suggests that of *C. commersonii* in general characters but is readily distinguished by the foreshortening of the body before the vent, myomeres numbering only 24 plus 13 while in the common white sucker there are 33 plus 10.

7.5-millimeter stage.—Total length, 7.5; standard length, 7.1; length to vent, 5.0; greatest depth, 1.2; diameter of eye, 0.5. Myomeres, 24 to vent plus 13 behind. Low dorsal embryonic marginal fin fold originating over tenth myomere behind head and a slight cell concentration at its beginning indicating the later location of true dorsal; ventral marginal originating in advance of dorsal and much deeper anteriorly,

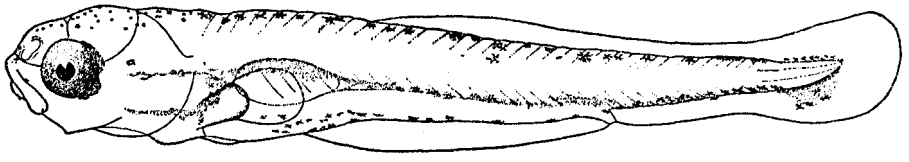

FIGURE 22.—*Moxostoma aureolum*, 7.5 millimeters

identical with dorsal behind vent; pectorals moderate, extending more than halfway to posterior margin of air bladder; caudal lophocercal. Mouth moderate, terminal, upper jaw somewhat projecting, suckerlike; eye moderate; snout almost as long as eye; interorbital space wide; air bladder large, one-chambered at this young stage.

Pigmentation.—Small black chromatophores are evenly distributed over head, followed by a double uneven line of very large stellate ones widely separated from each other on dorsal aspect, numbering about 26–35. From midline of eye backward there appears a subsurface series of many black chromatophores crowded into a continuous line on either side of head, merging into a large black patch over top of air bladder, then continuing along dorsal aspect of intestine to vent and beyond along underside of tail almost to caudal. On underside of stomach region is a very unequal double series sparsely distributed to about middle of intestine, and a few more near the vent. A double line of small chromatophores appears on ventral aspect from vent to caudal, but there are very few chromatophores on the caudal itself. On ventral aspect, subsurface chromatophores are similar to those on sides of head, starting behind eye and extending backward to meet those at anterior margin of air bladder.

The specimen immediately suggests the young of *Catostomidæ* in general characters. It differs, however, from *C. commersonii* in several respects, especially in a myomere count of only 37 contrasted with 43 or more in the latter species. The foreshortening occurs before the vent, having only 24 myomeres in this region while the common sucker has 33–35. The indications are that the dorsal fin will be short and

median and the eye near the middle of the head. Constriction of air bladder has not begun, and it is therefore impossible to use that character for identification purposes.

It is undoubtedly a species of *Moxostoma*, this being the only genus of suckers beside *Catostomus* which is abundant in the region. *M. anisurum*, *M. aureolum*, and *M. lesuerii* were taken here in the same summer. The head is rather long for the last species, which is especially short-headed. The myomere count of a specimen of *M. anisurum* taken near by was 30 plus 13. Because the myomere count of *M. aureolum* is identical, our specimen probably can be attributed to that species.

10. Moxostoma anisurum (Rafinesque). White-nosed red-fin mullet; red-horse sucker.

RECORD OF CAPTURE

Young of this species were found generally at creek mouths during the summers of 1928 and 1929. It is a common species of Lake Erie, Niagara River, and large tributaries.

DESCRIPTION

The 3-chambered air bladder, evident at 19.5 millimeters, and scales in fewer than 50 rows distinguish larvæ of this genus from other suckers, and the dorsal ray count of 14 to 17 identifies *M. anisurum* from other species of *Moxostoma* taken locally.

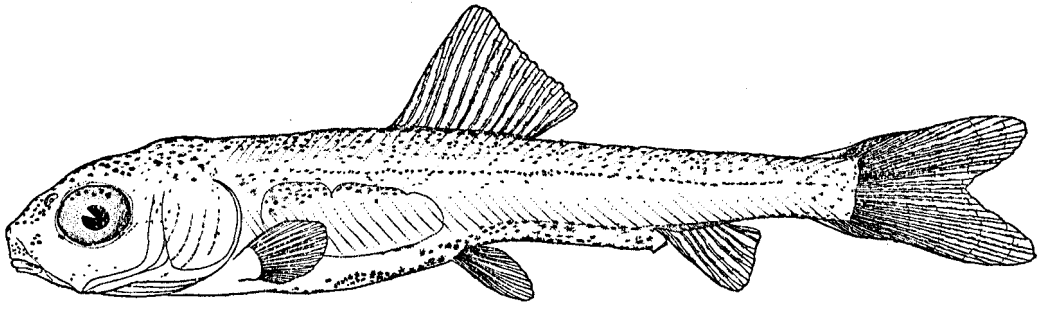

FIGURE 23.—*Moxostoma anisurum*, 19.5 millimeters

19.5-millimeter stage.—Total length, 19.5; standard length, 16.0; length to vent, 12.2; head, 4.5; snout, 1.1; eye, 1.3; greatest depth before vent, 3.0; greatest depth behind vent, 1.55; length to dorsal, 7.5; length to anal, 12.5 millimeters. Myomeres, 29 to vent plus 14 behind. Dorsal 15; anal 8 (with 1 very weak unsegmented ray before); caudal slender, deeply forked. The young white-nosed red-fin mullet strongly resembles the common red-fin mullet (*M. aureolum*), but the great difference in myomere count readily identifies the two. Snout abruptly decurved, mouth wholly inferior, lower jaw included, lower lip with sides widely conjoined. Third chamber of air bladder forming at this stage.

Pigmentation.—Chromatophores are distributed over snout and top of head followed by a very dark double series on dorsal ridge. Smaller ones cover dorso-lateral aspect, and the lateral line is well marked by a single series. Subsurface spots appear outlining gills, over air bladder, and dorsal surface of intestine. There is a ventral irregular series from behind pectorals to vent, thence a double row to caudal. Pectorals and ventrals have few pigment spots, but dorsal, anal, and caudal are well covered.

BREEDING

Like *M. aureolum*, this species runs upstream to spawn, the run being coincident with the leaving of the ice.

Family CYPRINIDÆ, Minnows

11. Cyprinus carpio Linnaeus. Carp, German carp.

RECORD OF CAPTURE

A number of larvæ and young adults of this species were taken in a dip net off Crescent Beach on June 29, 1929. The carp is very abundant and widely distributed throughout the Lake Erie region in nearly all waters except the small rapid creeks. A native of Asia, but introduced into America for pond culture, it is now one of the commonest species of Lake Erie.

DESCRIPTION

The early larva is easily recognized by its comparatively large size, 9 to 10 millimeters, and heavy black pigmentation, and in the postlarval stages by its long

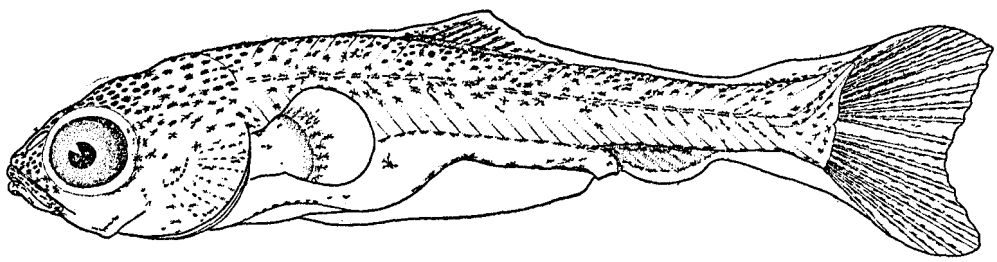

FIGURE 24.—*Cyprinus carpio*, 10 millimeters

dorsal (III, 20) and short anal (III, 5), and the appearance of two barbels on either side of upper jaw. Although the quillback, *C. cyprinus*, has a similarly long dorsal, the large terminal mouth, large eye, and comparatively short cheek of the carp will prevent any confusion. A myomere count of 19 plus 15–17 in the young carp, and 25 plus 12+ in the quillback differentiates them further.

10.0-millimeter stage.—Total length, 10.0; standard length, 8.4; length to vent, 6.4; length of head, 2.5; snout, 0.46; diameter of eye, 0.8; greatest depth before vent, 1.9 millimeters. Myomeres, 18 to vent plus 12 behind. Body stout; head rather small; moderate mouth extending slightly past front of large eye at this stage. Rounded pectorals unrayed; dorsal showing about 10 elements and 6 rays developed; anal elements and rays evident; caudal forked, rays formed; no ventrals apparent.

Pigmentation.—Both jaws, top of head, and dorsal aspect are covered by large stellate chromatophores. Pigment spots are fewer on sides of head and body to lateral line. Lateral line is marked by a double subsurface series, and subsurface chromatophores appear also on gills and on dorsal surface of intestines. There is a broken double ventral series to vent, heavier on ridge behind vent to caudal. All fins are marked with chromatophores.

13.3-millimeter stage.—Total length, 13.3; standard length, 11.1; length to vent, 8.52; length of head, 3.7; snout, 1.1; diameter of eye, 1.0; greatest depth before vent, 2.75 millimeters. Myomeres, 21 (22) to vent plus 13 behind. Differing from pre-

ceding stage principally in further development of dorsal and anal, appearance of ventrals, and heavier pigmentation.

30.75-millimeter stage.—Total length, 30.75; standard length, 25.0; length to vent, 19.5; length of head, 8.5; greatest depth, 8.5; diameter of eye, 2.6 millimeters. Myomeres, 19 to vent plus 17 behind. Dorsal III, 20; anal III, 5. Characterized by a strong serrated spine at beginning of dorsal and anal, and a barbel on either side of upper jaw (2 in adult), distinguishing it from *Carassius auratus* which has no barbels. Body stout, mouth moderate.

Pigmentation.—Chromatophores are thickly massed on upper lip and top of head spreading over snout and below eye. Dorsal edge of iris is speckled. Heavy pigment spots occur on dark background over head and along dorsal aspect to dorsal fin. Chromatophores are heavily distributed to lateral line, scarcer below. Ventral aspect is unmarked except for a few chromatophores near vent and a subsurface series from vent to caudal. All fins, with the exception of ventrals, are marked.

BREEDING

The spawning season of the carp lasts from June until August. They are very prolific and grow rapidly. T. H. Bean (1903) states:

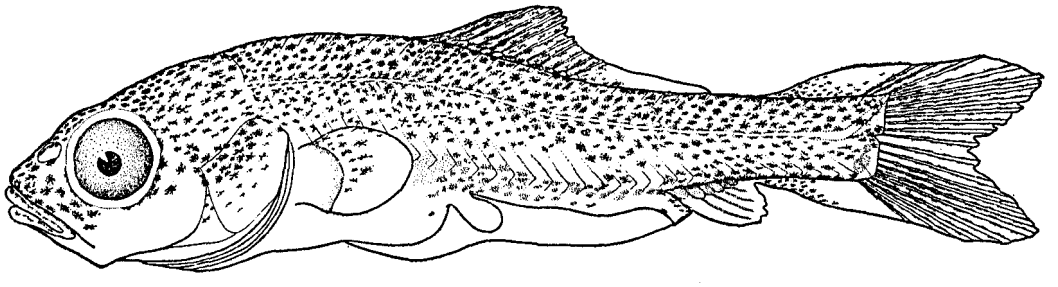

FIGURE 25.—*Cyprinus carpio*, 13.3 millimeters

During the spawning the fish frequently rise to the surface, the female accompanied by two or three males. The female drops the eggs at intervals during a period of some days or weeks in shallow water on aquatic plants. The eggs adhere in lumps to plants, twigs, and stones. The hatching period varies from 12 to 16 days.

12. Nocomis micropogon (Cope). Crested chub, river chub.

RECORD OF CAPTURE

The crested chub was not found in Lake Erie, but was taken commonly by the survey in the warmer tributary streams.

DESCRIPTION

Young fishes of this species are distinguished from the allied genus *Notropis* by the presence of a maxillary barbel. They resemble closely, also, *Semotilus atromaculatus* but differ in the position of this barbel which has its origin at tip of maxillary rather than well in advance of tip.

22.0-millimeter stage.—Total length, 22.0; standard length, 18.0; length to vent, 11.6; length of head, 5.25; snout, 1.25; diameter of eye, 1.6; greatest depth before vent, 4.1; greatest depth behind vent, 3.0; length to dorsal, 11.5; to anal, 12.1 millimeters. Myomeres, 22 to vent plus 15–16 behind. Dorsal III (very weak), 7; anal

II (very weak), 7; ventrals just posterior to front of dorsal. Body scaled at this stage, with abdomen rounded and scaled (scales on lower half of body not shown in fig. 26); scales large, 6–40 to 45–5. Body rather short and stout; mouth large and low; upper jaw almost terminal; conical snout of later stages barely perceptible; preorbital wider than eye; small barbel apparent at tip of maxillary.

Pigmentation.—The young crested chub is white with dorsal aspect of head covered by round black chromatophores. Small, even spots occur on dorsal aspect of body to vent with a double row of larger ones along dorsal ridge. Dorso-lateral aspect has small chromatophores arranged along margins of scales. A heavy lateral stripe extends from tip of snout to base of caudal, forming a darker caudal spot. There are a few chromatophores in ventro-lateral region of tail and around anal, but otherwise the ventral aspect is unpigmented. All fins except ventrals are marked, the pectorals most sparingly. The brilliant colors of the adult are not yet evident.

BREEDING

The name of crested chub arises from the character of the head of the breeding male, for it is swollen into a crest and covered by tubercles. Often a red spot appears

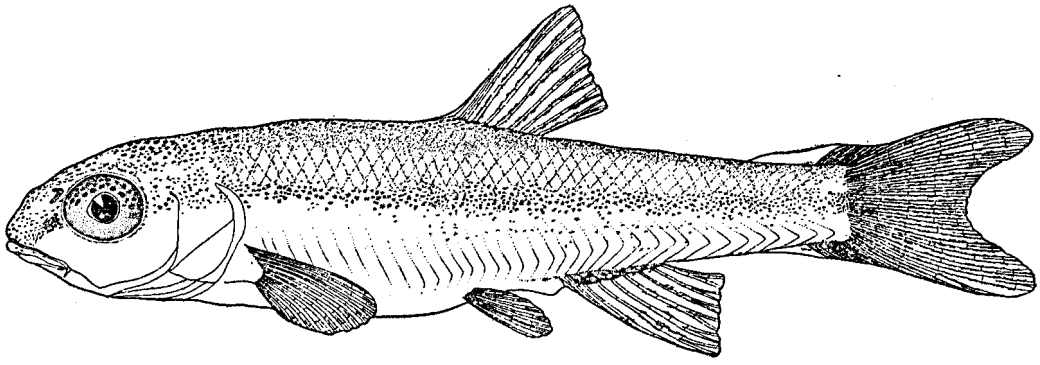

FIGURE 26.—*Nocomis micropogon*, 22 millimeters

on either side of the head. John Greeley (1929) observed a breeding male guarding its nest on July 9, 1928, in Silver Creek, at a temperature of 83° F. The nest was built of pebbles which had been painstakingly picked up and put into place separately. The male chub spawned with each of several females, and after each spawning act piled more stones upon the nest to cover the eggs. After preservation in formalin these eggs measured 2 millimeters in diameter.

13. Erinemus storerianus (Kirtland). Storer's chub.

RECORD OF CAPTURE

Larval stages up to 7.5 millimeters were taken from Buffalo to Rondeau during the latter half of June and the first week of July, usually in bottom hauls in water of from 18 to 20 meters depth. At the western end of the lake in 1929 early larval stages were taken commonly from June 7 until July 2, being most abundant on the latter date. Storer's chub is a common species in the Lake Erie region alongshore, at creek mouths, and ranging out into comparatively deep water.

DESCRIPTION

The earliest larvæ are characterized by a very prominent, overhanging snout, and elongate clear yellow yolk sac with one large oil globule anteriorly placed. In later stages the slightly inferior mouth, very elongate body, and short head with wide interorbital are diagnostic. Myomere count of 19 plus 17, as well as head differences and pigmentation, distinguish the young from those of the equally elongate *N. atherinoides*. (Myomere count of latter, 23 plus 12–13.)

5.0-millimeter stage.—Total length, 5.0; length to vent, 2.6; length of head, 0.73; snout, 0.25; diameter of eye, 0.25; greatest depth before vent, 0.75; greatest depth

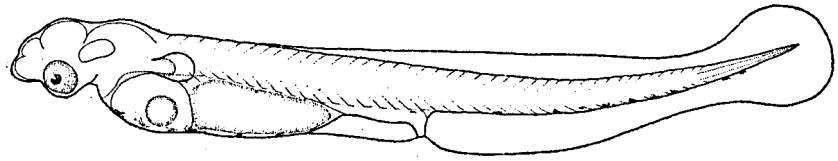

FIGURE 27.—*Erimemus storerianus*, 5 millimeters

behind vent, 0.76 millimeter. Myomeres, 18 before vent plus 21 behind. Characterized by extremely delicate, slender body, clear yellow elongate yolk sac with one large oil globule located anteriorly, rather small eye placed low, dorsal marginal fin fold low, originating shortly before vent, continuous around lophocercal caudal and forward past vent to yolk sac, much wider ventrally, and the very long, overhanging snout without mouth opened.

The newly hatched specimens differ markedly from those of *N. atherinoides* in having the eye fully pigmented, a much shorter intestine, and deeper yolk sac of clear yellow with a large oil globule in anterior region. The sparsely distributed ventral chromatophores behind the vent and on the stomach are characteristic. The size

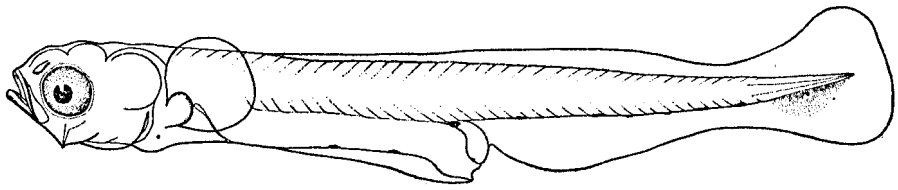

FIGURE 28.—*Erimemus storerianus*, 7 millimeters

is about as in *N. atherinoides*, but these specimens are somewhat slenderer even than that elongate species.

Pigmentation.—Two irregular lines of stellate chromatophores are evident on underside of yolk region, a pair on either side of body where intestine bends downward to vent, and a single series of about 12 small ones on ventral margin, farther apart forward but smaller and near together toward caudal region. In further development these ventral line chromatophores become further embedded below the surface and less conspicuous for this reason.

7.0-millimeter stage.—Total length, 7.0; length to vent, 3.9; length of head, 1.25; snout, 0.23; diameter of eye, 0.38; greatest depth before vent, 1.08; greatest depth behind vent, 1.0 millimeter. Myomeres, 18 to vent plus 21 behind.

Pigmentation.—One chromatophore appears at ventral base of each pectoral, 2 small chromatophores on ventral aspect of intestine, 1 where intestine turns down-

ward to vent, 6 in a single series on ventral ridge of tail (less conspicuous than in 5-millimeter stage), and 1 on caudal. The eye is black.

These specimens are definitely unlike any other species previously taken by the survey, and their small size and lack of any adult characters make the determination extremely difficult. In this, as in similar cases, it is necessary to resort to a process of elimination, narrowing down the possibilities as far as possible and then temporarily choosing one. No young stages of Storer's chub have been described, and since the

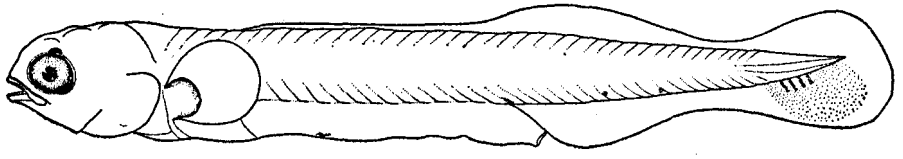

FIGURE 29.—*Erimemus storerianus*, 9.5 millimeters

smallest known specimen available is 21 millimeters, we are unable to tell what the larva may be like. Certain facts, however, suggest this species: (1) Such characters as the elongate body and slender caudal peduncle, rather short head with broad interorbital, large eye placed high, moderate horizontal mouth with lower jaw included, and prominent snout; (2) the great abundance of Storer's chub in Lake Erie. The identification of these specimens as *E. storerianus* must, therefore, be subject to change.

9.5-millimeter stage.—Total length, 9.5; standard length, 9.1; length to vent, 5.7; length of head, 2.0; diameter of eye, 0.5; greatest depth before vent, 1.2; depth behind vent, 0.75 millimeter. Myomeres, 19 to vent plus 19 + behind. Body more robust

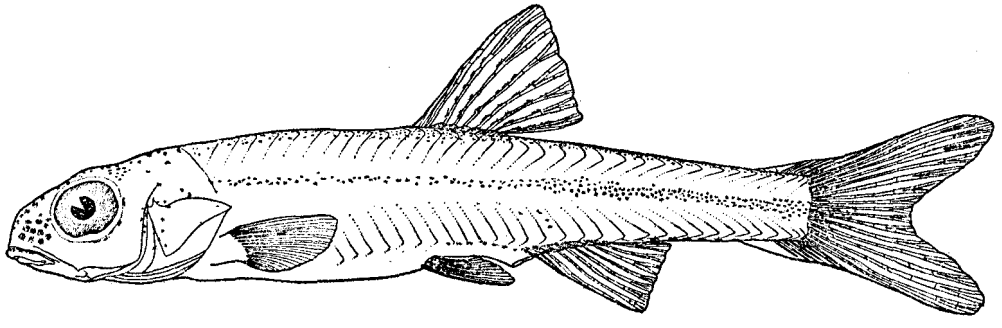

FIGURE 30.—*Erimemus storerianus*, 21 millimeters

than preceding stage but otherwise unchanged. Ray development beginning ventrally at lophocercal caudal.

Pigmentation.—On the surface, 1 chromatophore is apparent at middle of ventral aspect of intestine and below the surface, 1 occurs at ventral edge of body where intestine turns downward to vent, and 2 along middle third of tail. (More of these ventral subsurface spots on tail are evident in other specimens, resembling more closely the prominent series of the 5-millimeter stage which has become almost hidden in larger preserved specimens.)

21.0-millimeter stage.—Total length, 21.0; standard length, 17.0; length to vent, 11.0; length of head, 4.5; snout, 1.2; diameter of eye, 1.4; greatest depth before vent, 3.35; greatest depth behind vent, 2.2; length to dorsal, 9.0; to anal, 11.5. Myomeres, 19 to vent plus 17 + behind. Dorsal II (very weak), 8; anal II (very weak), 8;

pectorals pointed; caudal long and deeply forked; ventrals inserted behind dorsal origin, not quite reaching vent. Characterized by elongate body; short compressed head with cheeks vertical and rather flat interorbital space; eye very large, high, entirely above premaxillary; mouth small, not reaching orbit, horizontal, lower jaw included; snout very abruptly decurved; preorbital bone conspicuous, rather oblong; no scales at this stage.

Pigmentation.—Black chromatophores occur over upper jaw, top, and sides of heads, and two rows along either side of dorsal ridge from behind head to caudal. Three or four rows of very small spots mark the lateral line, but no dark lateral stripe is apparent as in some other cyprinids. There are a few subsurface chromatophores on dorsal surface of intestine near vent, and a double series from vent to caudal on ventral ridge. Heavy chromatophore marking shows at base of dorsal and anal, and the dorsal and caudal fins are marked.

BREEDING

From the present collections it is evident that Storer's chub spawns during June and the first week of July, for all specimens taken throughout this period were in early stages of development.

14. Rhinichthys atronasus lunatus (Cope). Black-nosed dace. [*Rhinichthys lunatus* Cope. Jordan, Evermann, Clark, p. 140.]

RECORD OF CAPTURE

Although this species strays only rarely into Lake Erie, it may be found in great numbers in all small creeks of the region.

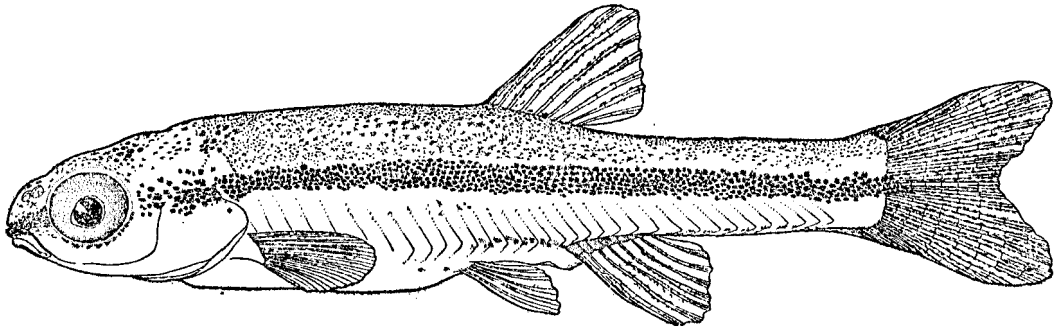

FIGURE 31.—*Rhinichthys atronasus lunatus*, 17.25 millimeters

DESCRIPTION

The black-nosed dace is easily distinguished from the closely allied long-nosed dace (*R. cataractæ*) by the facts that in the former the snout scarcely projects beyond the slightly oblique mouth, and the broad lateral band extends on to caudal.

17.25-millimeter stage.—Total length, 17.25; standard length, 14.25; length to vent, 9.5; length of head, 4.0; snout, 0.75; diameter of eye, 1.3; greatest depth before vent, 3.1; greatest depth behind vent, 2.0; length to dorsal, 8.2; to anal, 9.6 millimeters. Myomeres, 18 to vent plus 17+ behind. Dorsal II (rudimentary), 7 (with last divided at base in transparent specimen, appearing thus as an eighth ray), inserted behind middle of standard length; anal II (rudimentary), 6. Moderately elongate body; mouth small and slightly oblique; snout barely protruding.

Pigmentation.—A broad band of black chromatophores extends from tip of snout to end of body, terminating in a black spot at base of caudal and extending out on to fin. The head and dorsal aspect of body are covered with small chromatophores extending down to meet the lateral band (not so in *R. cataractæ*). Subsurface chromatophores are heavy on dorsal aspect of intestine and a double series (4 chromatophores wide around anal base) occurs on ventral ridge. All fins are marked. No black is evident on lower lip as in *Semotilus atromaculatus*.

BREEDING

The black-nosed dace is a spring spawner, seeking the upper courses of streams over clean gravel. During the breeding season the males have the lateral band, lower fins, and sometimes the whole body colored bright crimson.

15. Rhinichthys cataractæ (Cuvier and Valenciennes). Long-nosed dace.

RECORD OF CAPTURE

One young 18.5-millimeter specimen was taken at the mouth of Eighteen Mile Creek on July 18, 1928, and another 12.5 millimeters long on June 29, 1929, in a foot

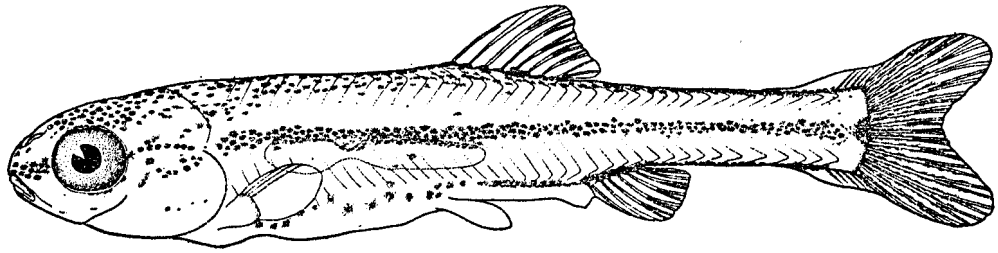

FIGURE 32.—*Rhinichthys cataractæ*, 13.7 millimeters

net towed in 3 feet of water off Crystal Beach. Adults are very common along the lake shore, especially over rocky bottom and in the lower courses of nearly all streams of the region, but this species does not seek the headwaters as does *atronasus*.

DESCRIPTION

The young are characterized by a dusky lateral band and caudal spot which does not extend out on to the fin as in *R. atronasus lunatus*. This band fades in the adult. The protruding snout of the later stages is evident even in these small specimens.

13.7-millimeter stage.—Total length, 13.7; standard length, 12.2; length to vent, 8.5; length of head, 3.1; diameter of eye, 1.0; snout, 0.85; greatest depth before vent, 2.3; depth behind vent, 1.6; length to dorsal, 6.3 millimeters. Myomeres, 22 to vent plus 15 behind. Dorsal I, 7; anal I, 6; ventrals well developed. Body elongate; mouth small, with protruding snout characteristic of later stages evident but not pronounced, lower jaw included.

Pigmentation.—This species is characterized by a dusky lateral band forming a small spot at base of caudal, but this is much fainter than in *R. atronasus*, *Semotilus atromaculatus*, and others. (Lateral band is obsolete in adult.) Chromatophores occur on top of head, along dorsal ridge, and ventral ridge from vent to caudal, and

subsurface chromatophores along dorsal surface of intestine. The lateral surfaces are colorless except for the faint dusky band (unlike *atronasus*). The caudal is the only fin pigmented.

BREEDING

The long-nosed dace is apparently a spring spawner. Breeding males have cheeks, lips, and lower fins bright crimson.

16. Semotilus atromaculatus atromaculatus (Mitchill). Horned dace, creek chub. [*Semotilus atromaculatus* (Mitchill). Jordan, Evermann, Clark, p. 117.]

RECORD OF CAPTURE

Although rarely taken from Lake Erie, the horned dace is common in all its tributaries, especially in the smaller creeks.

DESCRIPTION

Young horned dace are characterized by a very heavy black lateral band from tip of snout to base of caudal, where it widens into a well-defined black spot. Peritoneum typically pale, although in preserved specimens sometimes darkened, while in *Campostoma anomalum* it is always very black. The latter is easily confused with *Semotilus atromaculatus* in the younger stages, but if the specimens are large enough to have the lateral line, that of *Campostoma* will be found straight, while that of *Semotilus* dips abruptly over the first half of the pectoral. Of course, the peculiar elongate intestine of *Campostoma* surrounding the air bladder is always diagnostic, but its investigation necessitates dissection.

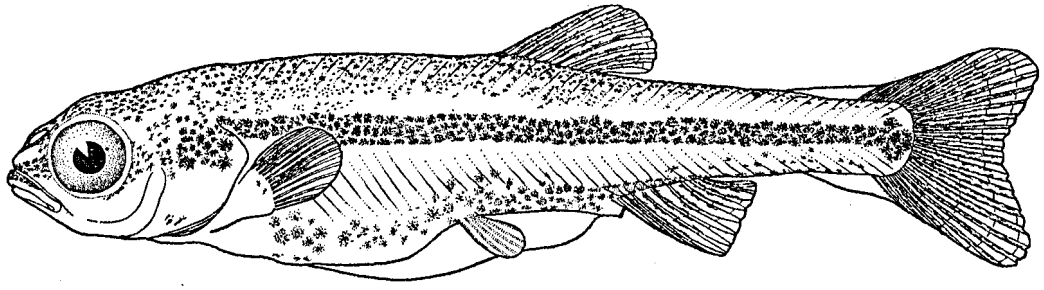

FIGURE 33.—*Semotilus atromaculatus atromaculatus*, 14 millimeters

14.0-millimeter stage.—Total length, 14.0; standard length, 12.5; length to vent, 8.25; length of head, 3.4; diameter of eye, 1.1; greatest depth before vent, 2.8; depth behind vent, 1.7; length to dorsal, 7.0; to anal, 8.5 millimeters. Myomeres, 21 (or 22) to vent plus 20 behind. Fins small; dorsal II, 7, inserted well behind ventrals; anal I, 8 (incomplete?), completely behind dorsal. Forward part of body rather stout but tail compressed, moderately elongate head heavy, rounded above; mouth moderate, oblique, lower jaw included, maxillary to pupil.

Pigmentation.—Both jaws, top of head, and dorsal aspect are covered throughout with large and small chromatophores. A lateral black stripe extends from tip of snout to base of caudal, being composed of 3 lines of heavy spreading chromatophores. The lateral aspect below this band is colorless except for few chromatophores near caudal. A few occur on underside beneath the jaws, pectorals, and one row along either side of ventral line from vent to caudal. About 60 subsurface,

large, round chromatophores are evident over stomach region and intestine. Ventrals are unpigmented but other fins are marked with double series of pigment spots along sides of rays. The chromatophores are thicker on front of dorsal base, indicating later diagnostic dorsal spot.

BREEDING

The horned dace spawns in spring in stony shallow streams. Rosy-tinted belly and coarse tubercles on the snout constitute the breeding dress of the male.

17. Clinostomus elongatus (Kirtland). Red-sided dace.

RECORD OF CAPTURE

The red-sided dace was never taken in Lake Erie but was found frequenting many of its small tributary streams.

DESCRIPTION

This brilliant little species very closely resembles the abundant *Notropis*, but the teeth in main row numbering 5–5 distinguish it from the latter, which usually has 4–4.

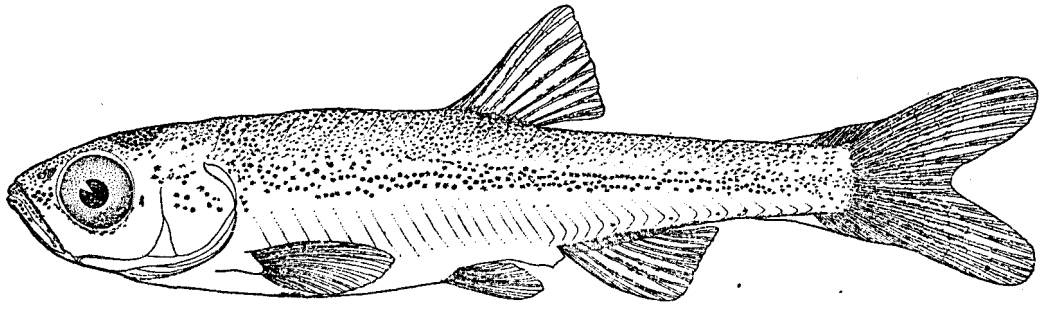

FIGURE 34.—*Clinostomus elongatus*, 23.25 millimeters

23.25-millimeter stage.—Total length, 23.25; standard length, 19.2; length to vent, 12.5; length of head, 5.7; snout, 1.25; diameter of eye, 1.6; greatest depth before vent, 4.2; depth behind vent, 2.6; length to dorsal, 10.1; to anal, 13 millimeters. Myomeres, 19 to vent plus 16 behind. Dorsal II (rudimentary), 8; anal I (rudimentary), 9; ventral origin very slightly in advance of first dorsal ray, ventrals reaching vent; caudal long and deeply forked. Body elongate, fusiform, with slender caudal peduncle; head large; snout long, pointed; mouth large, oblique, lower jaw barely projecting in this stage (projecting strongly in adult); lateral line abruptly decurved over anterior half of pectoral.

Pigmentation.—Both jaws, and dorsal aspect of head are heavily pigmented with round black spots. A band extends the length of dorsal aspect with chromatophores more loosely arranged to lateral line. Below lateral line the chromatophores are heavy again, forming a very inconspicuous band, about 4 chromatophores wide, from head to caudal. Ventrolateral and ventral aspects are without pigment except for about 4 chromatophores beneath abdomen and 4–6 on sides of ventral ridge from anal backward. Subsurface chromatophores occur on gill arches and stomach-intestinal region. Ventrals and pectorals are almost unmarked, but other fins have chromatophores along lines of rays.

BREEDING

This minnow, also, is a spring spawner, and the anterior part of the lateral band becomes bright crimson in breeding males.

18. Notropis heterolepis Eigenmann and Eigenmann. Black-nosed minnow. [*Hybopsis heterolepis* Eigenmann and Eigenmann. Jordan, Evermann, Clark, p. 134.]

RECORD OF CAPTURE

The black-nosed minnow seeks the quiet, sheltered bays of Lake Erie, and the muddy streams and swampy places near by.

DESCRIPTION

The absence of black on the chin readily distinguishes this species from the allied *N. bifrenatus* and *N. heterodon* in which the lateral band passes through the higher mouth, pigmenting both jaws.

20.0-millimeter stage.—Total length, 20.0; standard length, 16.6; length to vent, 11.0; length of head, 4.5; snout, 1.4; diameter of eye, 1.15; greatest depth before

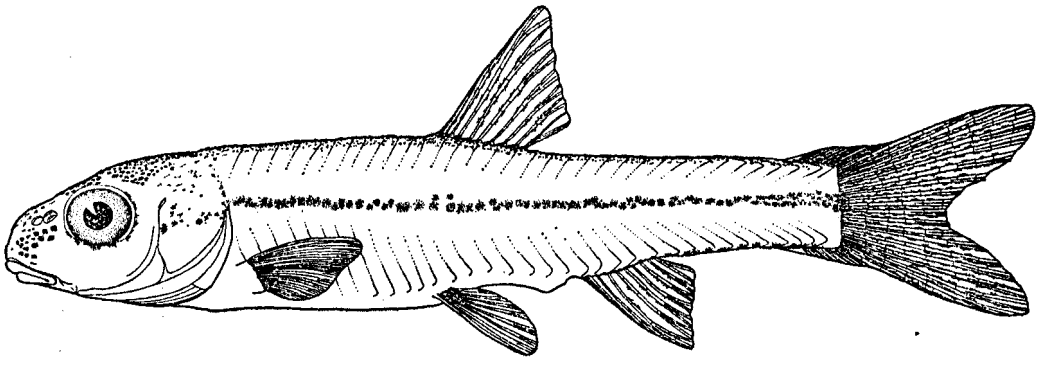

FIGURE 35.—*Notropis heterolepis*, 20 millimeters

vent, 3.3; depth behind vent, 2.4; length to dorsal, 9.1; to anal, 11.2 millimeters. Myomeres, 19 to vent plus 15 behind. Dorsal II (rudimentary), 8 (last divided), slightly nearer caudal than tip of snout; anal II (rudimentary), 8 (last divided); ventrals inserted in advance of dorsal. Body slender; snout longer than eye; mouth subinferior, small, nearly horizontal, lower jaw included.

Pigmentation.—The black-nosed minnow is generally less pigmented than other minnows at this length. Chromatophores are restricted to upper jaw, top and upper half of head, about 4 irregular lines along dorsal ridge to caudal, a single or irregular double series marking lateral line as a continuation of the band which starts at tip of snout, a very few below head and around anal base, and on dorsal, anal, and caudal fins. The white chin is diagnostic.

BREEDING

This species spawns in late spring and early summer. John Greeley (1929) found females in spawning condition on July 26, 1928, in the Niagara River.

19. Notropis deliciosus stramineus (Cope). Straw-colored minnow. [*Hybopsis deliciosa straminea* Cope. Jordan, Evermann, Clark, p. 134.]

RECORD OF CAPTURE

On July 28, 1928, eight small specimens ranging in size from 4.7 to 11.5 millimeters were taken near the mouth of Muddy Creek, and a 16.3-millimeter fish was seined at Long Point Bay on August 22. In 1929 none appeared in our collections until August 6; larvæ and postlarvæ were extremely abundant from Angola to Port Dover in the eastern and about Point Pelee in the western parts of the lake for the next 2 weeks, as many as 85 having been taken in a 5-minute haul at station 06.47. They were found on the bottom as well as at the surface in water of 11 to 34 meters. Adults are found abundantly, especially during late June and early July when they come close inshore for spawning.

DESCRIPTION

The smallest larva is distinguished from the closely related *N. atherinoides* by its shorter, heavier body, pigmented eye, and chromatophore series above and below the intestine and along ventral ridge, and by the location of the vent at the nineteenth

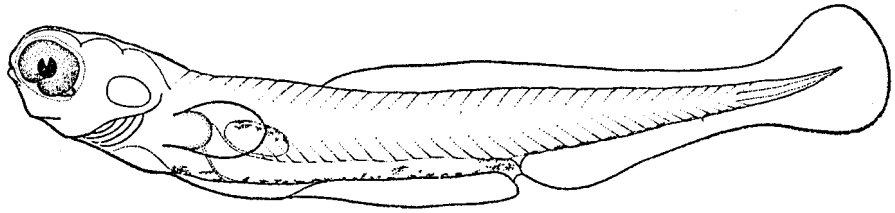

FIGURE 36.—*Notropis deliciosus stramineus*, 5 millimeters

myomere (at twenty-third or twenty-fourth in *N. atherinoides*). In advance stages of development the pigment patterns of the two species become much alike, but the deeper head and body, the different myomere count (19 or 20 to vent plus 16 behind in the present species; 23 to vent plus 12 or 13 behind in *N. atherinoides*), and the insertion of the ventrals in *N. deliciosus stramineus* only 1 myomere before the beginning of dorsal fin (about 4 myomeres distant in *N. atherinoides*) serve to differentiate them, even though the young of both species may be found together.

5.0-millimeter stage.—Total length, 5.0; length to vent, 3.0; length of head, 0.9; snout, 0.05; diameter of eye, 0.35; greatest depth before vent, 0.08; depth behind vent, 0.07 millimeter. Myomeres, 19 (20) to vent plus 16 behind. Yolk sac absorbed; single air bladder; head remarkably broad, broader than deep; snout short, very obtuse; tail lophocercal.

Pigmentation.—The eye is black. Dorsal aspect of air bladder is very dark, and subsurface chromatophores occur above intestine to vent. There are many chromatophores on ventral surface of stomach region, continuing as a very uneven double series to vent. A few appear on ventral ridge behind vent.

6.5-millimeter stage.—Chromatophores larger and arranged in more regular series above and below intestine, and on ventral ridge behind vent. Head still broader than deep as in preceding stage. Slight concentration in marginal fin indicating position of dorsal.

7.5-millimeter stage.—Total length, 7.5; standard length, 7.05; length to vent, 4.7; length of head, 1.5; snout, 0.2; diameter of eye, 0.55; greatest depth before vent,

1.4; depth behind vent, 1.0 millimeter. Myomeres, 21 to vent plus 16 behind. Dorsal concentration increased and position of anal evident; notochord turning upward and some caudal rays developed.

Pigmentation.—A few large round chromatophores occur on top of head, and a broken double series on dorsal ridge. A lateral line series extends from above air bladder backward, and a ventral series from jugular region to caudal, becoming double behind vent.

12.0-millimeter stage.—Total length, 12.0; standard length, 9.5; length to vent, 7.0; length of head, 2.8; snout, 0.6; diameter of eye, 0.8; greatest depth before vent,

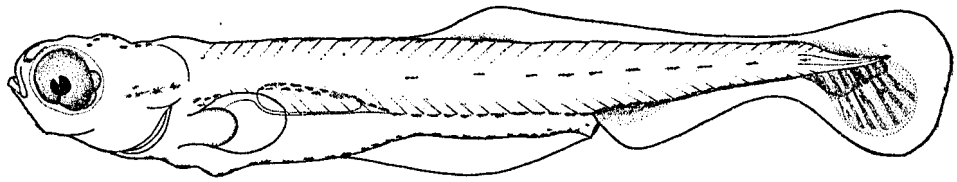

FIGURE 37.—*Notropis deliciosus stramineus*, 7.5 millimeters

2.0; depth behind vent, 1.2; length to dorsal, 5.5; to anal, 7.2 millimeters. Myomeres, 21 to vent plus 16 behind. Dorsal, 9; anal, 7; ventrals apparent immediately before first ray of dorsal (in *N. atherinoides* 4 myomeres before dorsal); caudal fully formed. Air bladder two chambered.

Pigmentation.—Chromatophores are arranged generally as in the preceding stage, but they are larger and more conspicious. Chromatophores occur also on caudal.

28.6-millimeter stage.—Dorsal, 9; anal, 8; caudal deeply forked; ventrals inserted slightly before origin of dorsal. Total length, 28.6; standard length, 22.9; length to vent, 14.4; length of head, 6.4; greatest depth, 4.5; diameter of eye, 2.2 millimeters. Myomeres, 19 to vent plus 17 behind. Body little compressed; head rather broad,

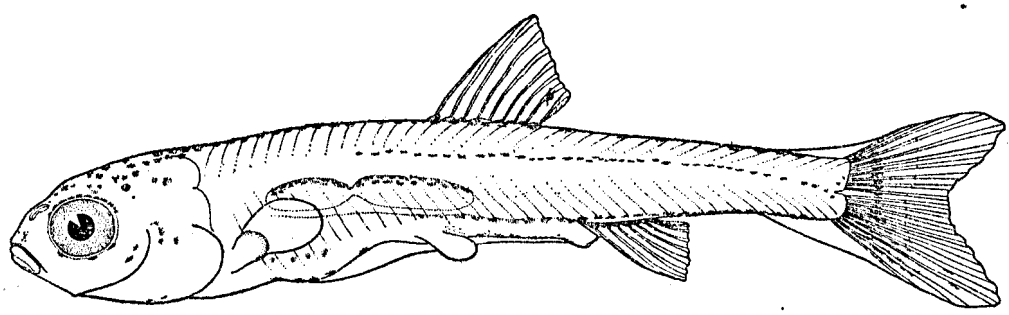

FIGURE 38.—*Notropis deliciosus stramineus*, 12 millimeters

snout very obtuse; mouth small, inferior, horizontal, lower jaw included. Characterized by dusky lateral band, not continued forward definitely through eye.

Pigmentation.—Heavy pigmentation occurs on upper jaw and over head, and is continued along dorsal aspect by 1 to 4 rows of round black chromatophores with small ones between. There is heavy marking around base of dorsal and behind dorsal. The chromatophores form a scalelike pattern to caudal. A few are evident on sides of head. The lateral line is marked irregularly by small light chromatophores to region of vent, then they become larger, blacker, and stellate. The ventral aspect is unmarked except for a double series of chromatophores posterior to vent. Pectorals, dorsal, and caudal are pigmented, but ventrals and anal are plain.

BREEDING

Spawning occurs during late June and early July in shallow inshore waters.

20. Notropis hudsonius (Clinton). Spot-tailed minnow. [*Hudsonius hudsonius* (DeWitt Clinton). Jordan, Evermann, Clark, p. 132.]

RECORD OF CAPTURE

Many ripe adults were taken in dip nets near Sturgeon Point in the middle of June, 1928, and one early larva tentatively assigned to this species, 5.2 millimeters long, was taken in a Helgoland trawl at 5 meters near Athol Spring on July 12. The straw-colored minnow is extremely abundant in the lake, and ascends some of the larger creeks.

DESCRIPTION

The present larva is characterized by a stout body and very blunt, bulbous head with large eyes and wide interorbital space, distinguishing it from *N. atherinoides* and

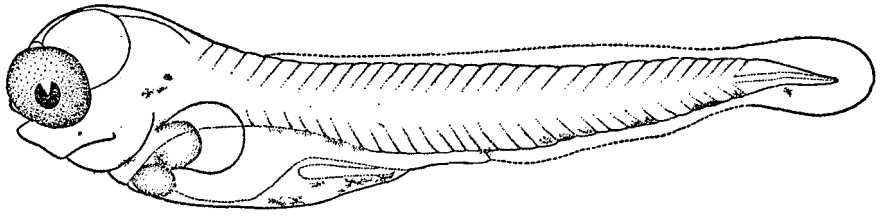

FIGURE 39.—*Notropis hudsonius*, 5 millimeters

N. deliciosus stramineus. Its small size compares unfavorably with specimens of *N. cornutus* of like development.

5.0-millimeter stage.—Total length, 5.0; length to vent, 2.75; greatest depth 0.96; diameter of eye, 0.5 millimeter. Myomeres, 17 to vent plus 15+ behind. Characterized by very blunt, bulbous head, with large eyes at the anterior margin and wide interorbital space; mouth moderate, inferior, lower jaw included. Large yellow oil globule anteriorly placed in stomach region.

Pigmentation.—A few chromatophores appear on sides of head, and many black stellate ones are distributed over ventral aspect to vent. About 4 very large subsurface chromatophores occur over top of stomach region, and 4 long, dark, linear patches behind vent on ventral ridge.

This species has general characters in common with *N. cornutus*, but its very small size compares unfavorably with specimens of like development of the latter. The head is too blunt and body too stout for young *N. deliciosus* or *N. atherinoides*. Quite possibly it is *N. hudsonius*, for many adults with ripe eggs were taken in a dip net near by at this time.

For comparison the description is given of a postlarval *N. hudsonius* taken at the mouth of Eighteen Mile Creek on July 18, 1928.

19.0-millimeter stage.—Dorsal, 8; anal, 9; caudal deeply forked; ventrals just anterior to dorsal origin, rays extending beyond vent. Total length, 19.0; standard length, 16.0; length to vent, 10.5; length of head, 4.2; greatest depth, 3.25 millimeters. Myomeres, 22 to vent plus 18 behind. Conical head with very blunt snout; small, nearly horizontal mouth, lower jaw shorter.

Pigmentation.—The 19-millimeter *N. hudsonius* is characterized especially by a definite black spot at base of caudal. The head is sparsely pigmented, and 3 rows of chromatophores are apparent on dorsal aspect to caudal. Small chromatophores are widely and irregularly placed in dorso-lateral region, and a few surface and subsurface chromatophores over operculum. A few occur below lateral line and subsurface chromatophores throughout its length, ending with a black spot at caudal. A double row extends backward from vent on ventral ridge. Dorsal and caudal are pigmented.

14.25-millimeter stage.—Total length, 14.25; standard length, 11.5; length to vent, 8.0; length of head, 3.0; snout, 0.6; diameter of eye, 1.0; greatest depth before vent, 2.1; depth behind vent, 1.5; length to dorsal, 6.0; to anal, 8.1 millimeters. Myomeres, 21 (22) to vent plus 16 behind. Dorsal I (rudimentary), 8; anal I (rudimentary), 9; ventrals immediately under front of dorsal; caudal rather long and forked. Body moderately elongate; head conical with short, blunt snout; mouth rather small, nearly horizontal; lower jaw very slightly shorter.

Pigmentation.—The head is more sparsely pigmented than in most other species of the genus. Chromatophores occur in about 3 rows along dorsal aspect, a few on operculum, and very many below surface on 2-chambered air bladder. A series

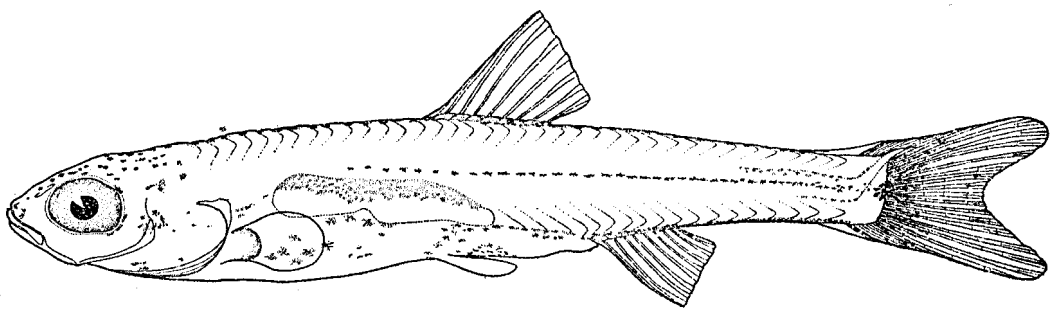

FIGURE 40.—*Notropis hudsonius*, 14.25 millimeters

marks the lateral line, surface and subsurface, and a prominent black spot is apparent at base of caudal. A few chromatophores occur beneath lower jaw, and a double series on ventral line backward from vent. The dorsal and caudal are pigmented.

BREEDING

The spot-tailed minnow spawns alongshore in late June and early July.

21. Notropis atherinoides Rafinesque. Lake shiner; emerald minnow.

RECORD OF CAPTURE

Only 6 small larvæ were taken in 1928, from July 30 to August 1, in the vicinity of Long Point Bay. During 1929, however, it was one of the most abundant species taken by the survey, as nearly every net towed from July 2 to August 20 contained from 1 to 500 of these larvæ. In the western part of the lake they were even more common between June 19 and August 17, as many as 3,000 being captured in a single tow. Adults are very common in the lake in deep as well as in shallow water.

DESCRIPTION

The newly hatched larva is characterized by its very slender unpigmented body with even the eyes colorless, clear elongate yolk, and myomere count of 23 to vent

plus 12 or 13 behind. It is most easily confused with *N. deliciosus stramineus* (see comparison on p. 332), but the myomere count and position of the ventrals which are inserted about 4 myomeres before the dorsal origin in this species are sufficient differences to distinguish the two.

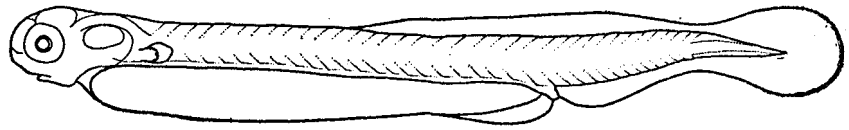

FIGURE 41.—*Notropis atherinoides*, 4.9 millimeters

4.9-millimeter stage.—Total length, 4.9; length to vent, 3.3; length of head, 0.7; snout, 0.08; diameter of eye, 0.22; greatest depth before vent, 0.63; depth behind vent, 0.57 millimeter. Myomeres, 23 to vent plus 13 behind. Dorsal marginal fin fold originating about 12–13 myomeres behind head, narrow, pinching at peduncle and widening around lophocercal tail; ventral marginal corresponding to dorsal contour; pectorals very small. Characterized by the exceedingly elongate colorless body,

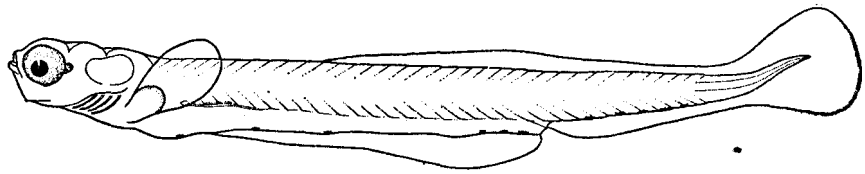

FIGURE 42.—*Notropis atherinoides*, 6.1 millimeters

colorless eyes, very elongate intestine, clear, elongate yolk which is granular in texture, and far inferior mouth.

6.1-millimeter stage.—Total length, 6.1; standard length, 5.9; length to vent, 4.0; length of head, 0.9; snout, 0.15; diameter of eye, 0.32; greatest depth before vent, 0.82; depth behind vent, 0.57 millimeter. Myomeres, 23 to vent plus 12 behind. Mouth small, terminal; marginal fins unchanged from preceding, but notochord turned slightly upward.

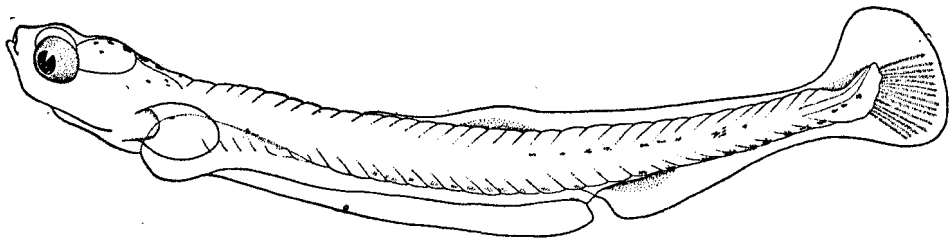

FIGURE 43.—*Notropis atherinoides*, 8.9 millimeters

Pigmentation.—The eye is pigmented with black, and about 9–10 very inconspicuous chromatophores extend along underside of intestine at wide intervals and along ventral ridge behind vent. Pigment on dorsal aspect of intestine is confined to one rather large linear patch at vent.

8.9-millimeter stage.—Total length, 8.9; standard length, 8.3; length to vent, 5.5; greatest depth, 1.0; diameter of eye, 0.4 millimeter. Myomeres, 22 to vent plus about 14 behind. Snout somewhat longer and more pointed than in 6.1-millimeter specimen but still shorter than eye; short head assuming the conic aspect of *N. atherinoides;*

long, slender, sharply compressed body, without elevation of back; very oblique mouth with upper lip on level of upper part of pupil; rather large eye; decurved lateral line; and position of dorsal fin, indicated by a concentration in the marginal fin fold beginning over the seventeenth myomere, identical with the position of the dorsal in adults of that species.

Pigmentation.—At this stage there are about 12 large black chromatophores on top of head, with no other dorsal coloration. Chromatophores occurring over

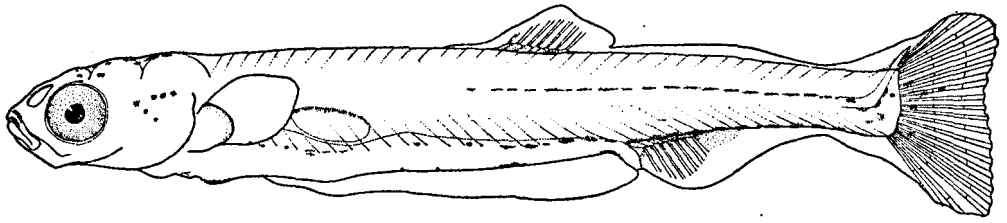

FIGURE 44.—*Notropis atherinoides*, 10.5 millimeters

air bladder and dorsal aspect of intestine are farther imbedded through the growth of the larva and thus are less evident. The chromatophores seen in previous stages along the ventral aspect of intestine have disappeared, with the exception of a very large one just before vent; this one ventral spot is conspicuous in the next stage described and figured. At the posterior end of body the ventral line chromatophores follow the notochord upward. Starting just before the vent, a single series of about 9 linear chromatophores marks the lateral line.

10.5-millimeter stage.—Total length, 10.5; standard length, 9.5; length to vent, 6.7; length of head, 2.0; snout, 0.43; diameter of eye, 0.7; greatest depth before vent, 1.64; depth behind vent, 0.95 millimeter. Myomeres, 22 to vent plus 16 behind.

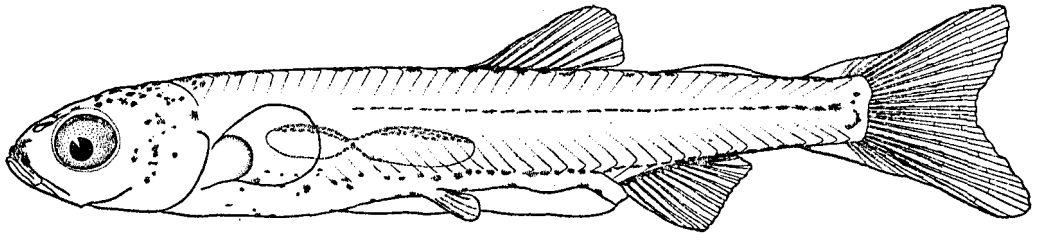

FIGURE 45.—*Notropis atherinoides*, 13.5 millimeters

Marginal fin fold has disappeared dorsally before the origin of permanent dorsal at about the sixteenth myomere. Dorsal definitely shaped with elements and eight partially-formed rays evident. Embryonic fin persisting behind dorsal as a narrow marginal band continuous with the heterocercal caudal; caudal rays formed but distal margin only slightly emarginate. Embryonic marginal persisting ventrally.

Pigmentation.—Chromatophores occur as in preceding stages with additional surface spots on snout and caudal, and subsurface spots in gill and isthmus regions, over 1-chambered air bladder, along dorsal aspect of notochord, and at end of body forming a caudal spot.

13.5-millimeter stage.—Total length, 13.5; standard length, 11.5; length to vent, 8.0; length of head, 3.0; snout, 0.7; diameter of eye, 0.81; greatest depth before vent, 2.0; depth behind vent, 1.5 millimeters. Myomeres, 22 to vent plus 16 behind. Dorsal, 8; anal, 11, completely formed; only tiny portion of embryonic fin fold behind

dorsal, but persisting entirely on underside before the vent; ventrals apparent, placed well forward, about 4 myomeres before origin of dorsal; caudal large and deeply forked. The young fish has most of the characters of the adult at this stage. Body elongate; snout short and somewhat pointed; eye large; mouth oblique, reaching to front of eye.

Pigmentation.—Chromatophores appear on both jaws, over top of head, and in an irregular double dorsal series to caudal, most prominent at base of dorsal and near caudal. A few occur on cheeks and on lateral line in a single series, linear-shaped, becoming larger toward caudal. On sides of stomach before ventrals, there are about 10 at wide intervals on ventral margin before vent, and a conspicuous double series on ventral line from vent to caudal. Subsurface chromatophores are evident on brain, gills, isthmus, over 2-chambered air bladder, covering dorsal surface of notochord, and a group at extreme end of body forming a subsurface caudal spot. The fins are colorless except for the caudal.

BREEDING

Our records show that hatching occurred from the middle of June until after the middle of August.

22. Notropis rubrifrons (Cope). Rosy-faced minnow.

RECORD OF CAPTURE

This minnow is not common in the Lake Erie region. Specimens have been recorded from Lake Erie but the species is limited mostly to several of the larger streams where there is a strong current.

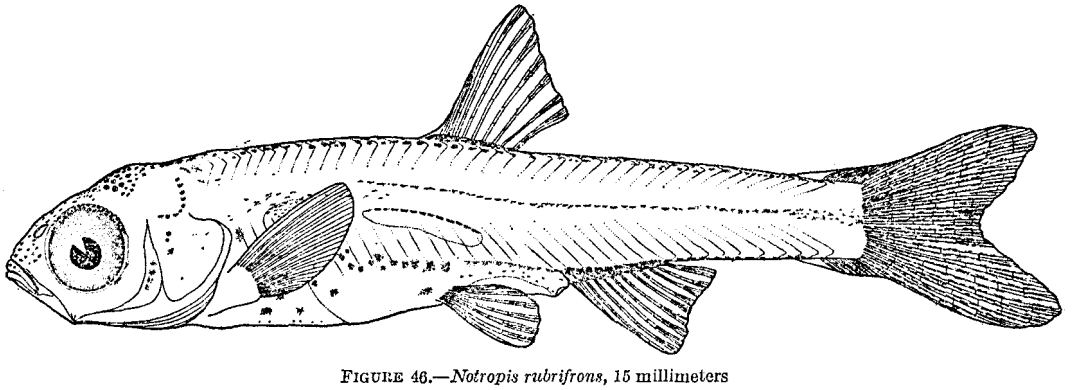

FIGURE 46.—*Notropis rubrifrons*, 15 millimeters

DESCRIPTION

The rosy-faced minnow is distinguished by its comparatively thick heavy body and pronounced sharp snout.

15.0-millimeter stage.—Total length, 15.0; standard length, 12.0; length to vent, 8.0; length of head, 3.2; snout, 0.75; diameter of eye, 1.1; greatest depth before vent, 2.6; depth behind vent, 1.6; length to dorsal, 6.8; to anal, 8.25 millimeters. Myomeres, 22 to vent plus 17 behind. Dorsal II (rudimentary), 8, origin at about middle of body; anal II (rudimentary), 10; caudal moderate. Body moderately stout; head rather large, snout long and pointed; eye large; mouth oblique, maxilla reaching to front of eye.

Pigmentation.—Chromatophores extend across upper jaw, heavily over top of head, and in 3 or 4 uncrowded rows on dorsal line from head to caudal. A few occur in gill region on surface and below surface, and in a single series along lateral line, more numerous near caudal. There are many below the surface in the abdominal region, and one row on either side of ventral aspect backward from vent. The caudal is the only pigmented fin.

BREEDING

This species is a spring breeder, at which time the male develops tubercles on the snout, and crimson color on forehead, opercular region, and base of dorsal.

23. Notropis cornutus chrysocephalus Rafinesque. Common shiner; red-fin shiner. [*Luxilus cornutus chrysocephalus* (Rafinesque). Jordan, Evermann, Clark, p. 128.]

RECORD OF CAPTURE

In 1928 no specimens were taken from Lake Erie, but spawning adults and a large number of eggs and larvæ were found in a tributary creek on June 14. The development of these eggs is recorded in the following stages to 10.5 millimeters. One larva was taken in the lake on June 19, 1929, off Point Pelee at the surface in water 12½ meters deep, and a number in a somewhat later stage of development at the tip of Long Point on July 8. Adults are abundant in the region.

DESCRIPTION

This shiner is most easily recognized at all stages from *N. atherinoides* by its deeper body, but with more difficulty from *N. deliciosus stramineus*. At 7 millimeters pigmentation in the two is alike except that *N. cornutus chrysocephalus* has no dorsal chromatophores behind the head while the other species have a double series to origin of dorsal. In postlarval stages the difference in dorsal and anal fin-ray counts is diagnostic.

Egg.—Mass rather loosely attached, but a few eggs tightly held together with bits of gravel adhering. Diameter of living egg, 1.45 to 1.9 millimeters, mostly about 1.6 millimeters. Diameter of clear, yellow oil globule 0.5 to 0.6 millimeter. Eggs in early cleavage seem to have very little oil diffused through yolk, and embryo stages have one large globule and often many tiny ones closely associated with it and over yolk.

Figure 47*A* shows the earliest stage observed, with blastodisc well formed. There seems to be a small amount of oil diffused through yolk.

Figure 47*B* with the embryo completely circling yolk, shows brain well formed, eyes lightly pigmented in black, and small, black stellate chromatophores over yolk. Both of the above stages were observed on June 18.

One week after the stage shown in Figure 47*B* two specimens were hatched and thriving, swimming rapidly around the aquarium and almost constantly on their sides. The larva (fig. 48) was very transparent, only the yellowish yolk and dark eyes being evident to the naked eye of the observer. The measurements were: Total length, 6.9; length to vent, 3.6; greatest depth, 1.75; diameter of eye, 0.4 millimeter. Large oil globule persisting in anterior region of yolk; black chromatophores over yolk sac and an uneven series along ventral ridge of tail, extending up a little over sides. Two days after hatching the total length of the larva had not increased,

but the body was much deeper behind vent. Total length of preserved specimens, 6.5; length to vent, 3.7; greatest depth, 1.9; diameter of eye, 0.5 millimeter. Myomeres, 14 to vent plus 19 behind (not completely developed). Yolk much smaller, having changed its rounded egglike shape for an almost square contour with only

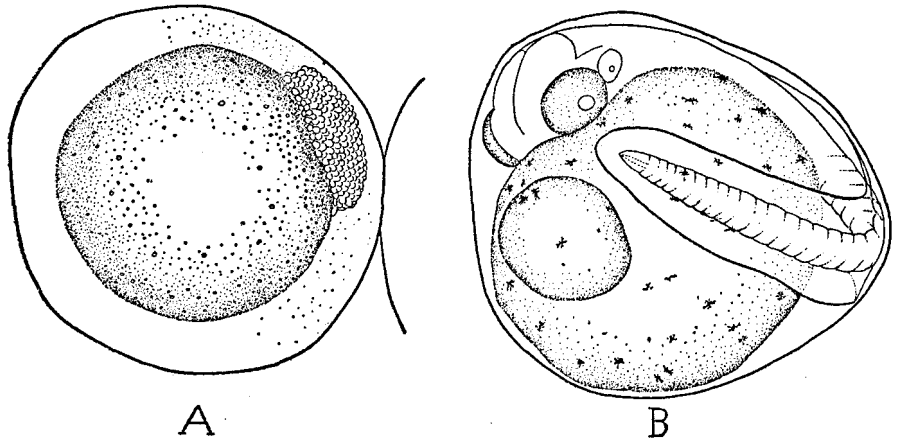

FIGURE 47—*Notropis cornutus chrysocephalus*. A, egg with blastodisc formed. B, egg with late embryo

the corners rounded; oil globule anterior to yolk, not contained within it as in the previous stage.

Pigmentation.—Yellow chromatophores occur over oil globule and head as before, but many large gray stellate ones are added over top and sides of head. Chromatophores persist on underside of yolk and those on sides of embryo are arranged in an irregular double line from the antero-ventral region of yolk sac to its postero-dorsal limit, becoming continuous with the ventral ridge series. Toward the end of tail 5 or 6 chromatophores follow up the grooves of the myomeres as black

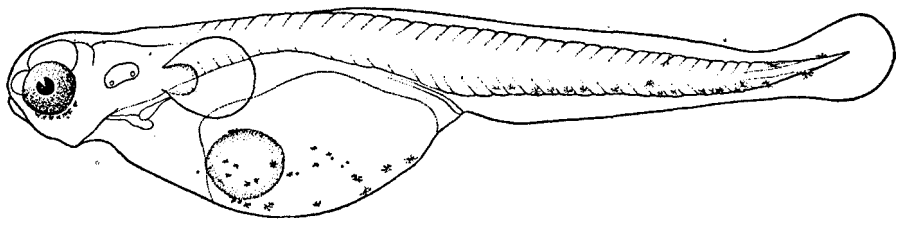

FIGURE 48.—*Notropis cornutus chrysocephalus*, larva immediately after hatching, 6.9 millimeters

streaks, almost to lateral line. A subsurface series starts at base of brain and continues along dorsal surface of nerve chord almost to tail, made up of about 17 to 20 very large roundish stellate chromatophores appearing gray through the myomeres. Another group (both surface and subsurface) extends along lateral line (about 10 to 14), and a third subsurface series starts over yolk sac and continues to caudal about halfway between the ventral ridge and the lower margin of notochord.

7.0-millimeter stage.—Total length, 7.0; length to vent, 4.6; length of head, 1.3; greatest depth, 1.0; diameter of eye, 0.5 millimeter. Myomeres, 21 (22) to vent plus about 14 behind (incomplete). Head blunt, eye very large, jaws equal; mouth terminal, median; air bladder large, one chambered at this 3-day-old stage.

Pigmentation.—The air bladder is covered dorsally by very large, black, roundish chromatophores. About 12 large, round, black chromatophores occur on top of

head, large stellate subsurface ones on underside of brain, and 2 on dorsal ridge near caudal. There are subsurface chromatophores at base of pectorals and a double arrow-shaped series on underside in gill region. The underside of stomach region has 2 to 4 uneven rows of rather small, round chromatophores, becoming irregular and single from intestine to vent (about 17 in this single series). The large air-bladder patch is continued as a double line of subsurface chromatophores to vent, thence as a double line of smaller surface ones to end of body (about 16). A few

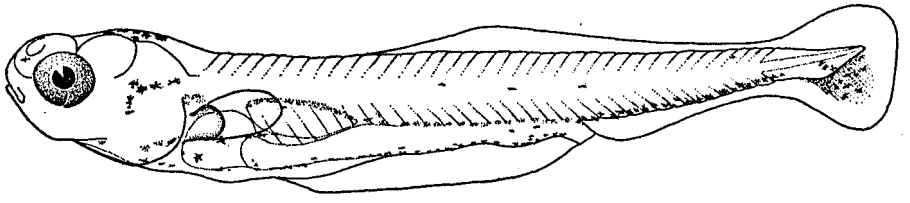

FIGURE 49.—*Notropis cornutus chrysocephalus*, 7 millimeters. (Drawn from living specimen)

appear on caudal. The oblique line over yolk sac of younger stages is represented by a very few (about 6) chromatophores in the same position across the stomach. The marking is considerably variable in individuals, especially that on lateral line. In some 7-millimeter specimens the line is completely marked by linear chromatophores, while in others of larger size only a few such spots appear, and in a few none. The dorsal marking varies likewise. In some specimens this aspect is colorless, while in others a double line of rather large chromatophores occurs toward the anterior end.

7.5-millimeter stage.—A very slight concentration at future location of dorsal and anal fins discernible; caudal still lophocercal, but with a few rays developed ventrally.

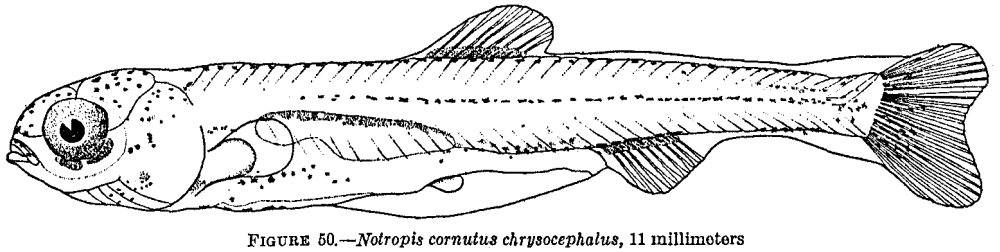

FIGURE 50.—*Notropis cornutus chrysocephalus*, 11 millimeters

8.5-millimeter stage.—Concentration greater in embryonic marginal fin-fold but no rays; fin fold, however, more pinched; notochord turned abruptly upward at caudal.

10.5 millimeter stage.—All elements of dorsal and anal complete, and about half of dorsal rays developed; no sign of ventrals.

11.0-millimeter stage.—Dorsal, 8; anal, 9; elements and fin-rays complete. Total length, 11.0; standard length, 9.9; length to vent, 7.0; greatest depth, 1.7; diameter of eye, 0.9 millimeter. Myomeres, 21 to vent plus about 17 behind. Air bladder constricted considerably. Ventrals apparent, but very small and unrayed, with embryonic marginal fin fold persistent beneath them from below constriction of air bladder to vent.

Pigmentation.—The marking here is essentially as in previous stages. The snout, interorbital region, and top of head are covered with very large, roundish chromatophores. Subsurface series occur below brain and gill regions and very

small surface chromatophores on sides and beneath head. The lateral line is well marked by about 45 chromatophores, starting over anterior portion of air bladder. Subsurface chromatophores appear over forward part of stomach region, becoming very numerous and heavy over both lobes of air bladder, and are continued behind over dorsal aspect of intestine to vent. About 12 surface chromatophores, also, occur along intestine. The lateral stomach series is continuous with the subsurface gill series. Ventral chromatophores start between pectorals and run in a most irregular, usually single but sometimes double line to vent. Anteriorly, these ventral spots are rather large, but as the line approaches the vent, they become very small and numerous. From the vent backward a double series of large stellate chromatophores extends on ventral ridge to end of body (about 22). The pigmented caudal has many small chromatophores concentrated at its base but not in great enough numbers to indicate a caudal spot. Two subsurface longitudinal series parallel with the lateral line are faintly distinguishable through the myomeres, one halfway between dorsal and median lines, and the other between median and ventral lines. These last series were first seen in the 2-day stage.

13.2-millimeter stage.—Total length, 13.2; standard length, 11.5; length to vent, 8.1; head, 3.0; snout, 0.55; diameter of eye, 1.1; greatest depth before vent, 2.3;

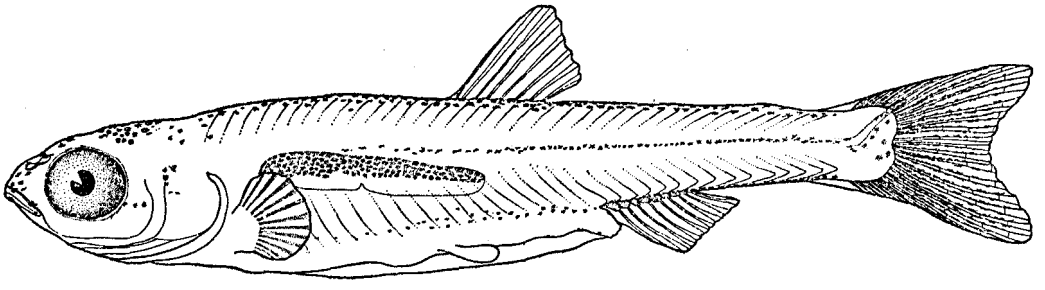

FIGURE 51.—*Notropis cornutus chrysocephalus*, 13.2 millimeters

depth behind vent, 1.4; length to dorsal, 6.0; to anal, 8.2 millimeters. Myomeres, 21 to vent plus 15+ behind. Dorsal, 8; anal, 9. Differs from preceding stage in the completion of the vertical fins, further development of ventrals, and more adult aspect of the head.

Other specimens of 18.5 and 21.3 millimeters in collection show no essential changes in pigmentation.

BREEDING

The common shiner spawns during June and the first half of July on shallow gravel bottom. Breeding activity is interestingly recorded by Dr. G. C. Embody and W. J. Hamilton, jr. (Greeley, 1927). Many adults of *Notropis cornutus frontalis*, seined on July 9, 1928, at Grand Island, contained ripe ova. Spawning of the latter upstream subspecies was observed by members of the survey group on June 17, 1928, in Little Buffalo Creek and on July 9 in Silver Creek (Greeley, 1928).

24. Notemigonus crysoleucas crysoleucas (Mitchill). Golden shiner. [*Notemigonus crysoleucas* (Mitchill). Jordan, Evermann, Clark, p. 115.]

RECORD OF CAPTURE

This species is commonly taken in weedy, sheltered bays of Lake Erie and in many weedy streams and ponds.

DESCRIPTION

A very significant field character in the specimens at hand is the golden tinge which covers more or less of the whole body, always deep through head region, on all fins, and caudal peduncle. The profile of the head is quite concave above in the younger stages, and the upper lip is on a level with the upper margin of pupil.

18.0-millimeter stage.—Total length, 18.0; standard length, 14.5; length to vent, 9.6; length of head, 4.0; snout, 0.6; diameter of eye, 1.5; greatest depth before vent, 3.2; depth behind vent, 2.1; length to dorsal, 8.0 millimeters. Myomeres, 20 (21) before vent plus 17 behind. Dorsal I (rudimentary), 8; anal I (rudimentary), 11–12; all fins rather long. Characterized by comparatively short head (although proportionately larger than in later stages) with pointed snout; small, terminal, oblique mouth barely reaching front of large eye. Body slender, elongate, somewhat compressed, especially slender in tail region. Dorsal higher than long, situated in middle

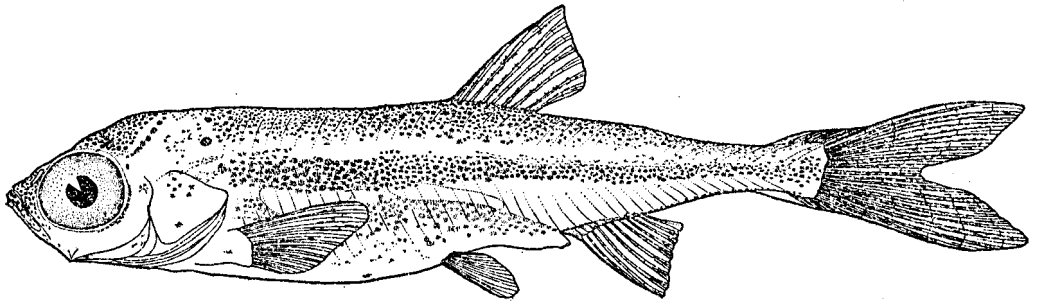

FIGURE 52.—*Notemigonus crysoleucas*, 18 millimeters

of body opposite space between ventrals and anal; anal longer than dorsal; caudal long and deeply forked.

Vertebræ in stained specimen, 21 plus 19. The character of the head, as described above, is diagnostic.

Pigmentation.—Brownish-black chromatophores appear thickly on both jaws, top of head, dorsal aspect extending down over the sides and in a broad lateral band from head to caudal. Below the surface they occur abundantly in the abdominal region. There is a double series on ventral aspect from vent backward, and all fins are pigmented. A brilliant golden tinge completely covers some specimens, and all are colored thus about the head, the fins, and caudal peduncle.

The 24-millimeter specimen, which is fully scaled, shows a fleshy keel on the belly behind the ventral fins, over which the scales do not pass. In this stage, too, the head is becoming conic.

BREEDING

The golden shiner spawns from May until early summer.

25. Hyborhynchus notatus (Rafinesque). Blunt-nosed minnow.

RECORD OF CAPTURE

The blunt-nosed minnow is common in sheltered bays of Lake Erie and in the larger streams and ponds near-by. The eggs and young described here were taken in Sister Creek on July 13, 1928, from a nest guarded by a male *H. notatus* (described under Breeding, p. 347).

DESCRIPTION

Egg.—Outer diameter of egg, 1.5 millimeters; diameter of yolk, 1.3 millimeters in specimens having large blastodisc formed; yolk very granular, yellowish.

Figure 53 shows egg with outer diameter, 1.5 millimeters; inner diameter, 1.05 millimeters; embryo about two-thirds around egg; anterior portion of yolk very large and round, followed by an elongated portion beyond which the tail is free; myomeres evident from the end of bulbous portion of yolk to tip of tail; optic vesicles, brain divisions, and notochord apparent. No chromatophores; yolk yellow.

The stage shown in Figure 55 has the embryo coiled more than once around egg, tail reaching to back of head; pectorals very well developed; myomeres completely formed; pigment confined to eyes.

Newly hatched larva.—Total length, 4.6; length to vent, 3.0; greatest depth, 1.25; diameter of eye, 0.45 millimeters. Myomeres, about 20 to vent plus about 12 behind (very incomplete). Characterized by very large club-shaped yolk sac, consisting of

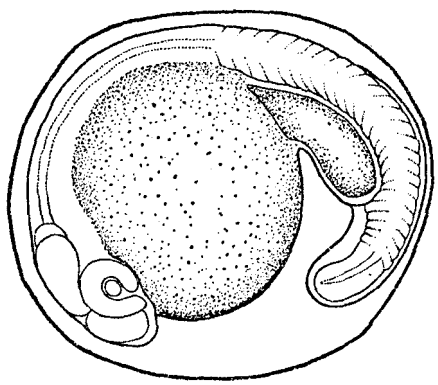

FIGURE 53

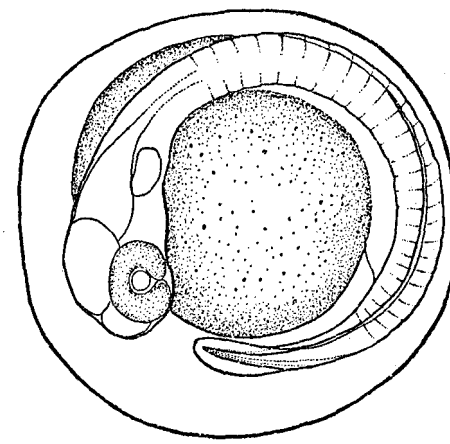

FIGURE 54

Hyborhynchus notatus eggs showing typical formation in the embryo. (Drawn from living eggs)

large bulbous portion without definite oil globules but with some oily substance throughout, and narrow, extended posterior portion reaching to vent. Mouth and vent not open. Tail lophocercal; embryonic marginal fin originating at about the tenth myomere, low and even, continued around caudal to vent; pectorals developed but small.

Pigmentation.—The larva is colorless, except for deep gray eyes with a golden tinge, some deep orange over yolk, and two very large stellate chromatophores on underside of yolk sac at vent, barely discernible.

Larva 1 day old.—Total length, 5.0; length to vent, 3.0; greatest depth, 1.0; diameter of eye, 0.4 millimeters. Myomeres, 19 before vent plus 14 behind (incomplete). Bulbous part of yolk sac reduced and posterior part heavier. Marginal fin fold intact, slightly raised before vent, and somewhat notched at caudal peduncle.

Pigmentation.—A very few large delicate chromatophores occur beneath and on sides of yolk sac (some specimens without), an uneven series on ventral aspect from vent backward and two chromatophores on lateral line just before vent.

3 days old.—Total length, 5.5 to 5.7 millimeters. Body much heavier; interorbital space wide; yolk sac greatly reduced, retaining elongated shape, now tapering

slightly and evenly to vent without constriction; marginal fin fold intact; pectorals larger but not rayed.

Pigmentation.—The yolk is yellowish in color. Ventral chromatophores are now arranged in a double row of large stellate spots from before middle of yolk to vent, and are continued in a double row behind, much closer together. Many chromatophores occur over air bladder, and a row of 4 over last one-third of yolk sac. Over these last, and corresponding in position, there is a row of 5 chromatophores on lateral line. Two chromatophores are apparent before each pectoral and 2 behind.

4 days old.—Total length, 6.0 millimeters. Body very deep with yolk sac almost if not entirely absorbed. Marginal fin fold intact, continued forward on the ventral side corresponding to the dorsal; pectorals very large.

Pigmentation.—The eyes are metallic blue and black, and the cardiac region and blood stream are greenish yellow. Chromatophores grouped as before.

1 week old.—Total length, 6.0; length to vent, 3.75; greatest depth, 0.9 millimeter. Myomeres, about 21 to vent plus about 13 behind. Total length of larva not changed since the age of 4 days, but body assuming more advanced development and proportions; yolk absorbed; vent somewhat farther back and more myomeres developed forward.

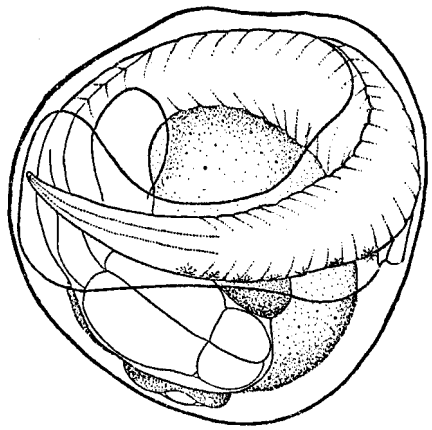

FIGURE 55.—*Hyborhynchus notatus* egg with late embryo. (Drawn from living egg)

Pigmentation.—The pigmentation is generally unchanged in this stage, but intensified, consisting of chromatophores sparsely distributed on top of head and anterior dorsal aspect, a few on sides of head, a series of large chromatophores rather far apart along lateral line from behind air bladder to end of body, and 1 large subsurface spot at base of pectoral. The top of air bladder is very darkly pigmented, and 3 large round chromatophores follow the curve of gill arch below on each side of throat region. Behind and parallel with these, and before the air bladder occur a double series of about 6 to 8 large stellate spots. On the under side, from middle of stomach region to vent, about 4 lines of similar chromatophores appear, followed by a conspicuous double series on ventral ridge to end of body. A few are evident on ventral part of caudal.

2-weeks old.—Total length, 6.5; length to vent, 4.0; greatest depth 0.82; diameter of eye, 0.4 millimeter. Myomeres, about 21 before vent plus about 15 behind (incomplete). General shape and pigmentation unchanged, except that more color is evident.

Pigmentation.—A yellowish tinge extends over top of head and along dorsal ridge to end of body. The top of stomach region is faint yellowish with numerous, small, raised yellow spots as though superimposed upon the heavy black chromatophores of the air bladder. The eye is very iridescent with lavender, pink, blue, and yellow casts on a brilliant silver background. Over the air bladder a short region of iridescence similar to that of the eye is evident on a line with the median black chromatophores running along top of intestine. This is apparently the beginning of the silvery adult condition.

The influence of artificial rearing upon the normal growth of the larva was evident with these specimens. One little fish was kept living for 10 weeks during which time it fed actively on prepared crushed insect food. The fins and other adult characters

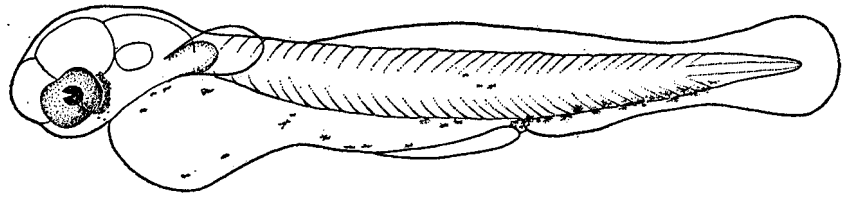

FIGURE 56.—*Hyborhynchus notatus* larva, 1 day old, 5 millimeters. (Drawn from living specimen)

developed normally, but the young fish grew only to a length of 10 millimeters. Under natural conditions it would undoubtedly have been very much larger.

12.0-millimeter stage.—Total length, 12.0; standard length, 10.25; length to vent, 7.0; length of head, 2.6; snout, 0.45; diameter of eye, 1.0; greatest depth before vent, 1.6; depth behind vent, 1.0; length to dorsal, 5.5; to anal, 7.1 millimeters. Myomeres,

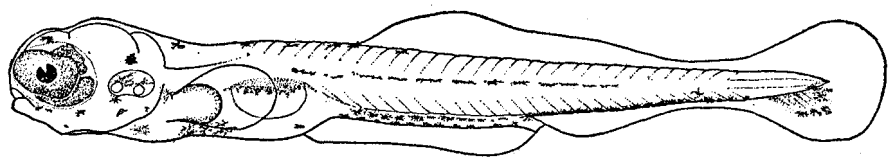

FIGURE 57.—*Hyborhynchus notatus*, 1 week old, 6 millimeters. (Drawn from living specimen)

21 to vent plus 15 behind. Characterized by abruptly decurved snout, inferior horizontal mouth with lower jaw included; slender body and somewhat depressed back; slender caudal peduncle; light peritoneum (although in 17.75-millimeter specimen quite dark). Dorsal I (rudimentary), 8; anal I (rudimentary), 7.

Pigmentation.—The 12-millimeter specimen is characterized by a black spot at base of caudal as in many cyprinids, and the fact that although diffuse chroma-

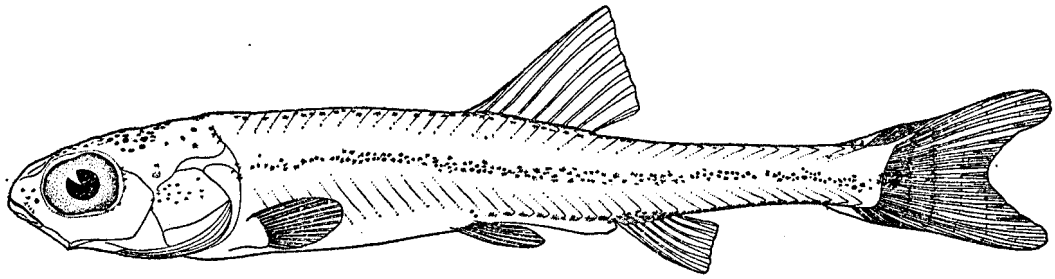

FIGURE 58.—*Hyborhynchus notatus*, 12 millimeters

tophores over snout and cheek suggest a band, the real lateral band starts most decidedly behind the head and is less conspicuous than in the other lateral-banded cyprinids. Chromatophores occur also on top of the head and along the whole dorsal aspect in irregular longitudinal rows, more concentrated at base of dorsal and below the surface dorsally on the intestine. Many are grouped on surface around base of anal and thence in a double row to base of caudal. A few appear on pectorals and caudal. Sides of body, except for lateral band, and belly are colorless.

Young adult stage.—Dorsal, 9 (first ray enlarged); anal, 7; caudal forked; ventrals midway between pectorals and anal. Total length, 17.75; standard length, 14.5;

length of head, 3.75; length to vent, 10.25; greatest depth, 2.8; diameter of eye, 1.5 millimeters. Myomeres, about 23 to vent plus 16 behind. Mouth inferior, horizontal, lower jaw included; snout abruptly decurved; body slender with depressed back and slender caudal peduncle.

Pigmentation.—The young adult is characterized by a very prominent round black spot at base of caudal, and a lateral pigment band, which starts behind the head and is narrower and less noticeable than in *Semotilus, Campostoma,* and other banded minnows. The top of head has many round chromatophores and smaller, longitudinal rows extend along dorsal aspect of body, irregularly marked, with a concentration of larger ones at base of dorsal fin. Above the lateral band only a very few scattered pigment cells are present, and none below, with the exception of a series 2 to 4 chromatophores in width at anal base, and a double line on ventral edge behind vent to caudal. Dorsal, caudal, and pectorals are marked. The peritoneum is blackish.

BREEDING

The breeding season of the blunt-nosed minnow extends from late spring until late summer. During this time the male develops 14 to 17 large tubercles on snout, the head and front part of dorsal fin become black, and often the lower fins take on an orange hue. John Greeley (1929) observed the eggs near the mouth of Sister Creek on July 13.

> They adhered, individually, to the underside of a large, flat stone, and covered an area 7 by 4½ inches. The total number, accurately estimated, was 11,812. These were laid by more than one female, judging by the fact that some were hatching when found, and others were far less advanced. The eggs were guarded, when found, by a male fish approximately 3¼ inches long, whose position was directly under the stone. The water temperature was 82 degrees. It is interesting, in its bearing on the subject of the efficiency of natural fertilization of fish eggs, to note that everyone of these was fertile with live embryo.

26. Pimephales promelas promelas Rafinesque. Fat-head minnow; blackhead minnow. [*Pimephales promelas* Rafinesque. Jordan, Evermann, Clark, p. 145.]

RECORD OF CAPTURE

The fat-head minnow was found commonly at the mouths of several tributaries to Lake Erie, and in greater numbers in several small ponds nearby.

DESCRIPTION

The present species differs from the closely related *H. notatus* in its much stouter, shorter body and lack of a very distinct round black spot at base of caudal. Although there are some chromatophores in *Pimephales* in this region, they are mostly subsurface and the lateral band is considerably lighter.

11.6-millimeter stage.—Total length, 11.6; standard length, 10.2; length to vent, 6.8; length of head, 2.65; diameter of eye, 0.8; greatest depth to vent, 2.19; depth behind vent, 1.35; length to dorsal, 5.25; to anal, 7.0 millimeters. Myomeres, 20 to vent plus 16 behind. Dorsal I (rudimentary), 8; anal I (rudimentary), 7; ventrals small, unrayed, inserted immediately below dorsal origin; caudal moderately forked. Body rather robust; head short with obtuse snout; mouth very small, terminal, oblique.

Pigmentation.—Chromatophore marking is not heavy but limited principally to snout, top of head, a wide dorsal series (3–6 lines wide) to caudal, and a single series along lateral line to caudal, in which the spots are rather close together, being round anteriorly and more linear posteriorly. Many occur also below the surface over stomach-intestinal region, followed by a double surface series on dorsal ridge from vent to caudal, spreading rather widely around anal base. There is a subsurface concentration at base of caudal. A few chromatophores are evident on dorsal and many on caudal.

BREEDING

The fat-head minnow spawns throughout the summer, at which time the head of the male becomes jet-black, the caudal peduncle dusky, and the snout covered with

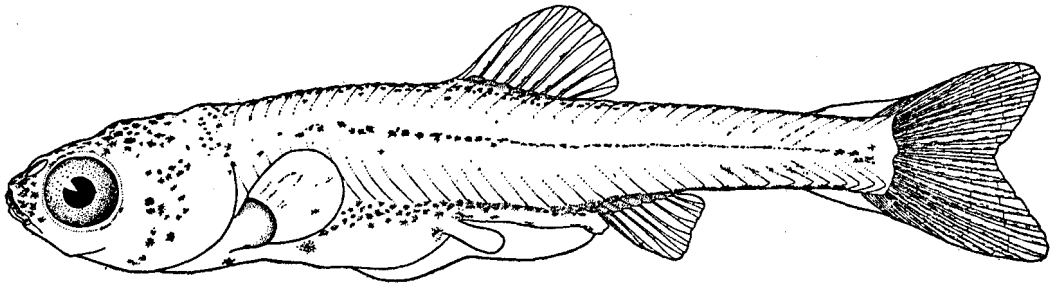

FIGURE 59.—*Pimephales promelas promelas*, 11.6 millimeters

about 14 coarse tubercles. Greeley (1927) reported spawning on June 22. The round opaque eggs, one-sixteenth inch in diameter, were attached side by side in a mass to the underside of a stick immersed in 8 inches of water at a temperature of 67° F. There were approximately 700 eggs in the mass.

27. **Campostoma anomalum** (Rafinesque). Stone-roller minnow.

RECORD OF CAPTURE

Although straying rarely into Lake Erie, the stone-roller minnow frequents warm, shallow streams.

DESCRIPTION

The remarkably elongate intestine which winds in spiral fashion around the air bladder is peculiar to *Campostoma*. The differences between this species and *Semotilus atromaculatus atromaculatus*, with which it is readily confused, are discussed on page 329.

9.75-millimeter stage.—Total length, 9.75; standard length, 9.2; length to vent, 6.35; length of head, 1.9; diameter of eye, 0.7; greatest depth to vent, 1.3; depth behind vent, 0.6 millimeter. Myomeres, about 24 to vent plus 14+behind. Marginal fin fold frayed but probably arising over air bladder and extending to caudal, low; somewhat broader ventrally; caudal heterocercal with rays forming. Body moderately elongate at this stage; snout obtuse; mouth small, terminal; peritoneum black.

Pigmentation.—Black chromatophores are heavy on lips, snout, top and sides of head, and in a double series of about 50 on dorsal ridge. These ridge chromatophores are exceptionally large and have about 3 other rows between the double

series. A single series occurs on lateral line from behind head to caudal, representing the broad lateral band of the adult. Others are apparent over gill region, stomach region, and along dorsal aspect of intestine below the surface, a few below head, followed by a short double series of about 9 in the jugular region, and a prominent double series to caudal.

BREEDING

The stone-roller minnow spawns in the spring, running up small brooks for the purpose, depositing its eggs among the stones near shore. In the breeding season the males have the head or even the whole body covered with large, round tubercles,

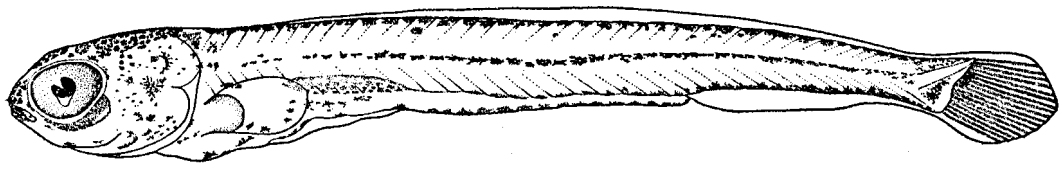

FIGURE 60.—*Campostoma anomalum*, 9.75 millimeters

which are more extensively developed than in other cyprinids. The iris becomes orange, and the dorsal and anal fins on either side of the dusky crossbar are fiery red.

Family AMEIURIDÆ Catfishes

28. Ictalurus punctatus (Rafinesque). Spotted catfish, silver cat; channel cat.

RECORD OF CAPTURE

This catfish is common in Lake Erie, the Niagara River, and the larger tributary streams of the Niagara. Its young frequent sheltered bays and the mouths of creeks.

DESCRIPTION

The more slender, elongate body, compressed posteriorly, and the forked tail, as well as the joining of supra-occipital and predorsal processes to form a bony ridge between head and dorsal fin, and the free posterior margin of adipose distinguishes it from *Noturus* and *Schilbeodes*.

32.6-millimeter stage.—Total length, 32.6; standard length, 26.9; length to vent, 13.0; length of head, 7.8; greatest depth before vent, 6.3; depth behind vent, 5.0; diameter of eye, 2.0 millimeters. Vertebrae, about 16 to vent plus 28 behind. Dorsal I, 6; anal 24 (26 apparent in stained specimen); posterior margin of adipose free; caudal forked. Body slender; head slightly convex above; very long maxillary barbels, longer than head; pectoral spine about two-thirds length of head; slender humeral process about one-half length of pectoral spine.

Pigmentation.—The body is nearly white with tiny brownish chromatophores sparsely distributed over entire surface. The heavier subsurface spots occurring over stomach region are emphasized by clearing. All fins are marked with very small chromatophores.

BREEDING

The spotted catfish spawns in June in weedy places near shore.

29. Ameiurus nebulosus (LeSueur). Common bullhead; horned pout.

RECORD OF CAPTURE

The common bullhead is restricted to the sheltered bays of Lake Erie, and the larger, sluggish streams and ponds of the region.

DESCRIPTION

The bullhead is easily distinguished from *Ictalurus* by its rounded or truncate tail, broad head, and a complete separation of supra-occipital and predorsal processes; from *Villarius* (which also has separate processes) by its rounded tail; from *Noturus* by the free posterior margin of adipose; and from *Ameiurus natalis* by the anal rays, 21 to 24 (*natalis* usually has 25 or 26), and by its gray to black mental barbels, usually white in *natalis*.

22-millimeter stage.—Total length, 22.0; standard length, 18.5; length to vent, 9.9; length of head, 5.7; greatest depth before vent, 4.5; depth behind vent, 3.5; diameter of eye, 1.05 millimeters. Vertebræ apparent, 14 to vent plus 26 behind. Dorsal I, 6; anal 21; caudal short, stout, and rounded or square. Eight barbels; maxillary barbels about as long as head.

Pigmentation.—The body is entirely covered with small, round, close-set chromatophores giving an even gray color. The chromatophores are heaviest over top and sides of head, on dorsal aspect of body, and fins and lightest in belly region. All barbels are dark.

BREEDING

C. W. Nash (1908) describes the spawning of the bullhead thus:

> Early in June, when about to spawn, the catfishes select a spot in quiet shallow water near aquatic weeds and there they make a nest, from eight inches to one foot in diameter, by clearing out a slight depression in the mud or sand. In this nest about two thousand eggs are deposited, over which the parents keep guard, the male being most assiduous in the work of protection. In about a week the eggs are hatched and the young, which look very like little black tadpoles, follow the parent fish along the shores until nearly the middle of July, when they are left to shift for themselves; after this the fry soon scatter and disappear into deep, weedy water. They grow rapidly, and, under favorable circumstances, are said to attain maturity in three years.

30. Ameiurus natalis (LeSueur). Yellow catfish.

RECORD OF CAPTURE

This catfish is much rarer than the common bullhead, being found by the survey only at Dunkirk Bay in Lake Erie, and in Muddy and Little Sister Creeks.

DESCRIPTION

The yellow catfish is distinguished from the common bullhead by anal rays, 25 or 26 (*nebulosus* has 21 to 24), and white mental barbels (gray to black in *nebulosus*). An exception occurs when the specimen is found on a dark bottom, in which case these barbels may be dusky. Distinguishing characters of the genus are considered under *A. nebulosus*, above.

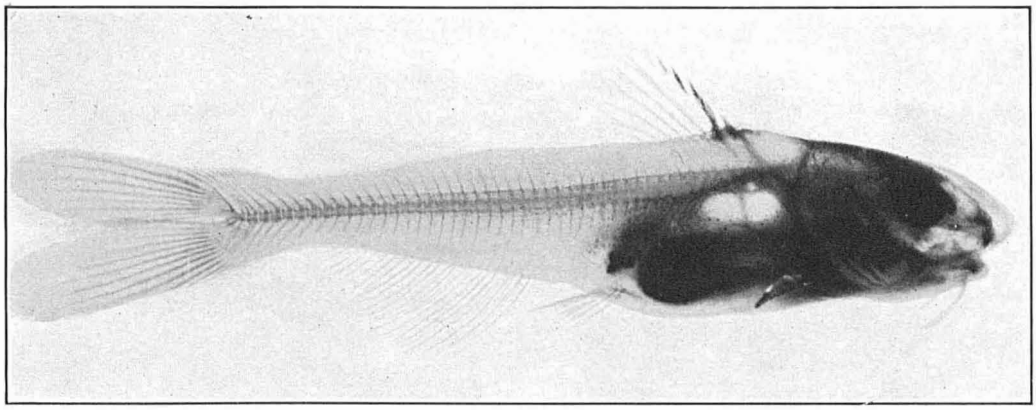

FIGURE 61.—*Ictalurus punctatus*, 32.6 millimeters. Specimen stained and cleared

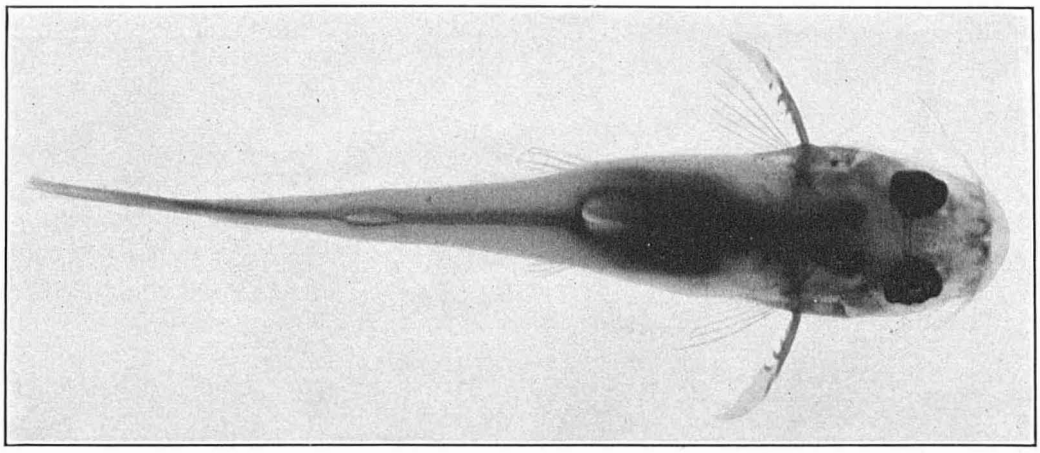

FIGURE 62.—*Ictalurus punctatus*, 32.6 millimeters. Dorsal view of cleared specimen

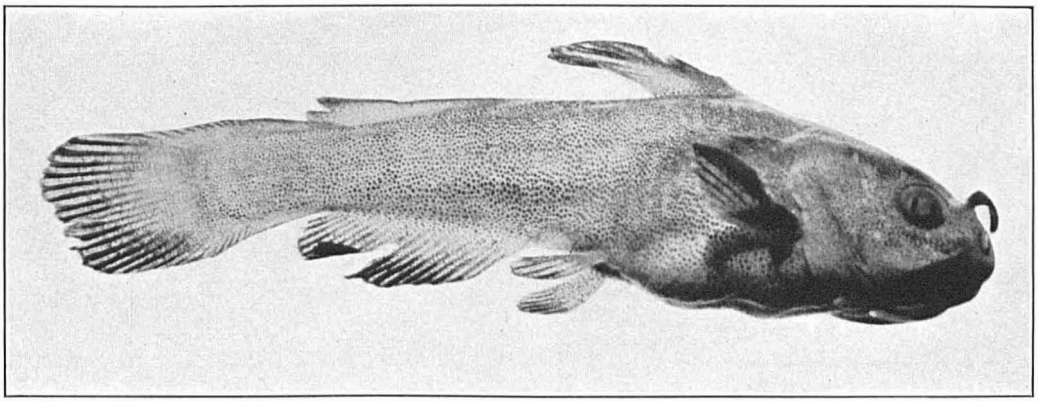

FIGURE 63.—*Ameiurus nebulosus*, 22 millimeters

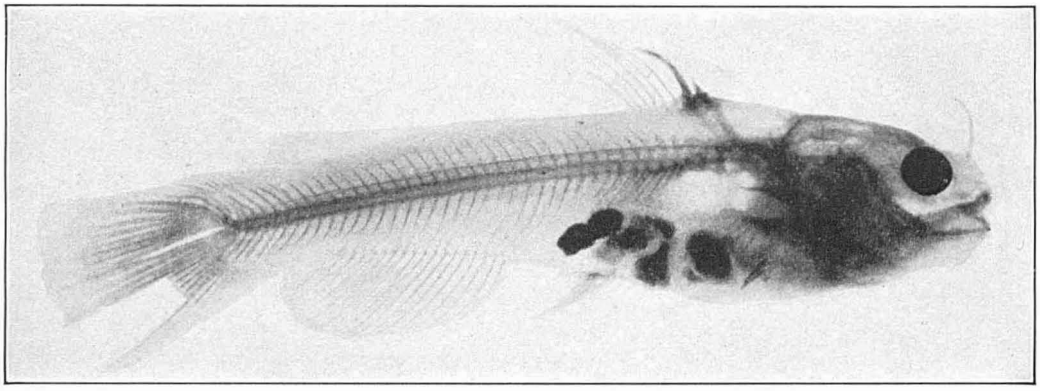

FIGURE 64.—*Ameiurus nebulosus*, 24 millimeters. Specimen stained and cleared

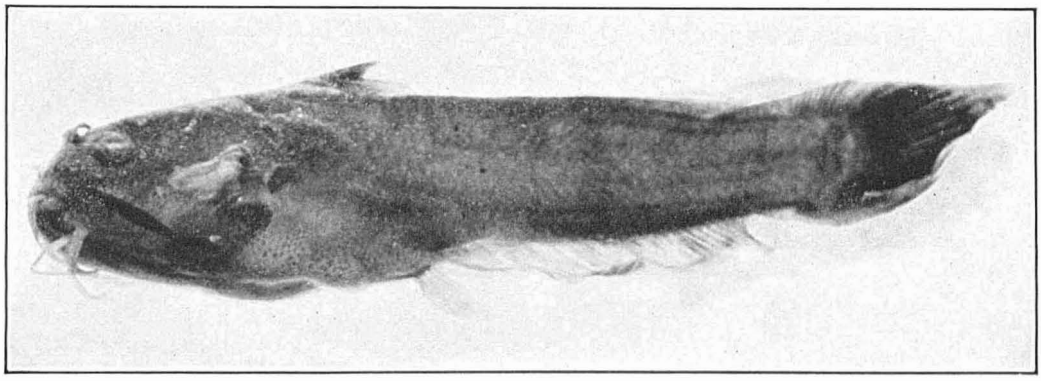

FIGURE 65.—*Ameiurus natalis*, 17 millimeters

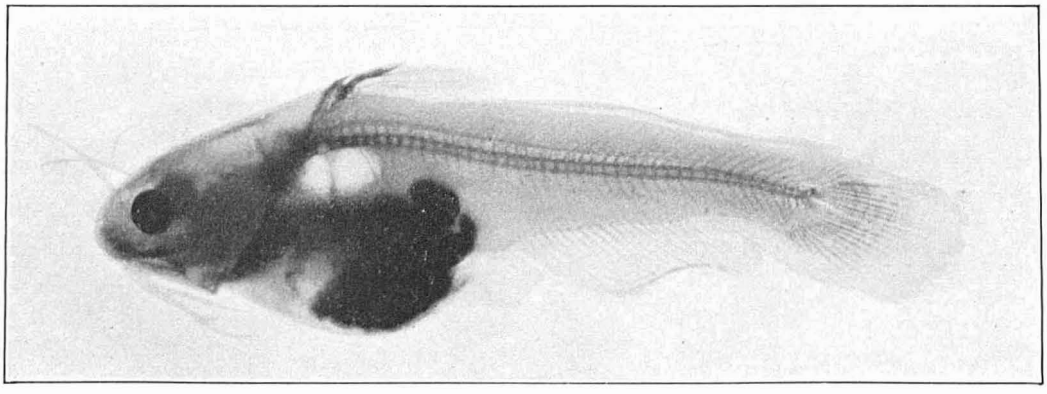

FIGURE 66.—*Ameiurus natalis*, 17 millimeters. Specimen stained and cleared

17-millimeter stage.—Total length, 17.0; standard length, 14.0; length to vent, 7.6; length of head, 4.5; greatest depth before vent, 5.0; depth behind vent, 2.8; diameter of eye, 0.9 millimeter. Vertebræ, about 15 to vent plus 27 behind. Dorsal I, 6; anal, 24; caudal, rounded. Body heavy; head broad; maxillary barbel as long as head; dorsal and pectoral spines very strong, shorter than soft rays.

Pigmentation.—The young *A. natalis* is covered with small, round, closely set chromatophores which give a gray color to head, body, and fins, as in *A. nebulosus*, but it differs from the latter in having the whole underside of head and stomach from behind lower jaw to vent perfectly colorless. The white barbels below the chin are an easy field character for identifying this species.

BREEDING

The yellow catfish spawns in June, and its breeding habits are probably similar to those of *A. nebulosus*.

31. Noturus flavus Rafinesque. Stonecat; mongrel bullhead; deep-water bullhead.

RECORD OF CAPTURE

The stonecat is common in Lake Erie along rocky shores, ranging out into water at least 30 feet deep, and in the larger tributary streams over stony bottom.

DESCRIPTION

The yellow stonecat is distinguished immediately from other catfishes, except *Schilbeodes*, by the fact that the adipose fin has its posterior margin adnate to back, separated from margin of caudal only by an incomplete notch, if at all. The premaxillary teeth have backward lateral extensions which differ from the more delicate, smoother ones of *Schilbeodes*.

20.0-millimeter stage.—Total length, 20.0; length to vent, 10.1; length of head, 4.9; snout, 2.1; eye, 1.2; greatest depth before vent, 4.05; depth behind vent, 2.8 millimeters. Dorsal I (short), 6; anal, 16; low adipose begins over origin of anal, continuous in this specimen to caudal; pectoral spine retrorsely serrate in front, slightly rough behind. Body elongate, head very depressed, flat, nearly as broad as long; barbels short.

Pigmentation.—The little stonecat is yellowish with small black chromatophores uniformly distributed over top and sides of body, thickest over head. The belly is white. Chromatophores extend from body on to adipose and caudal. Other fins are unmarked. The barbels are very lightly spotted with chromatophores.

BREEDING

John Greeley (1929) reports two egg masses of the stonecat found during the survey under flat stones in lower Sister Creek on July 13, 1928, at a temperature of 82° F. Two fishes, probably the parents, guarded one mass, while the male was hidden beneath the other. The eggs were yellow, opaque, from 3.5 to 4 millimeters in diameter, about 500 of them held together in a round mass by an adhesive jelly.

Family UMBRIDÆ, Mud minnows

32. Umbra limi (Kirtland). Mud minnow.

RECORD OF CAPTURE

The mud minnow is sometimes found in weedy bays of Lake Erie, but is more common in the sluggish, weedy tributaries and near-by ponds.

DESCRIPTION

The mud minnow is most readily distinguished from the true minnows (Cyprinidæ) by its rounded caudal fin.

24.75 millimeter stage.—Total length, 24.75; standard length, 20.5; length to vent 14.0; length of head, 7.25; greatest depth, 4.75; eye, 2.0 millimeters. Cycloid scales in lateral line, 18 plus 17=35. Dorsal, 14; anal, 10 (rudimentary) spine before both dorsal and anal); pectorals very low, rounded, rather small; ventrals, 6, much posterior to pectorals, inserted very slightly before dorsal; caudal, rounded. Distinguished by short, oblong body, rounded tail, and black bar at base of caudal. Mouth terminal, lower jaw slightly projecting; no lateral line.

Pigmentation.—The body is well covered with very small gray chromatophores, except on ventral surface from behind head to vent. Top of head, dorsal ridge, and ventral ridge from vent to caudal are especially dark. A very dark spot occurs at base of caudal and all fins are marked.

Family ESOCIDÆ, Pickerels

33. Esox lucius Linnaeus. Pickerel, northern pike. [*Esox lucius americanus* (Gmelin). Jordan, Evermann, Clark, p. 173.]

RECORD OF CAPTURE

The pickerel is not taken in Lake Erie except at the mouths of certain creeks, but is common in the larger streams among weeds.

DESCRIPTION

The pickerels will not be confused with other genera because of their ducklike snouts. The various species are distinguished chiefly by the degree of scaliness of cheeks and opercles, a criterion which can not be used in the identification of very young specimens. However, the dorsal ray and branchiostegal counts are sufficiently different to be used as distinguishing characters.

Unfertilized egg.—Eggs stripped from a ripe female at Irving, N. Y., on April 8 measured 2.2–2.4 millimeters after expansion in water. Round, translucent, usually very slightly yellowish and often bright yellow. Surface covered with small colorless oil globules; yolk granular.

Early development.—Ehrenbaum (1911) describes and figures the larval and postlarval stages of the same pike in European waters. There the larva is 9 to 10 millimeters at hatching, with large yolk sac and inferior mouth. At 15 millimeters the lower jaw has begun to protrude, but the snout is very short. Tiny ventrals are apparent, but the wide marginal fin fold is intact. When the postlarva reaches 20 millimeters the snout is considerably lengthened, the notochord turns definitely upward, and the marginal fin fold is persistent but deeply notched. At 26 millimeters the permanent fins are formed and the young fish has a mature aspect.

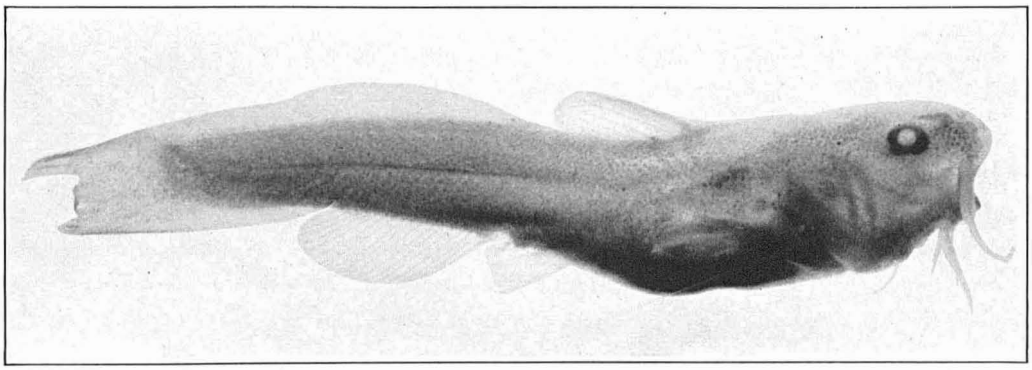

FIGURE 67.—*Noturus flavus*, 20 millimeters

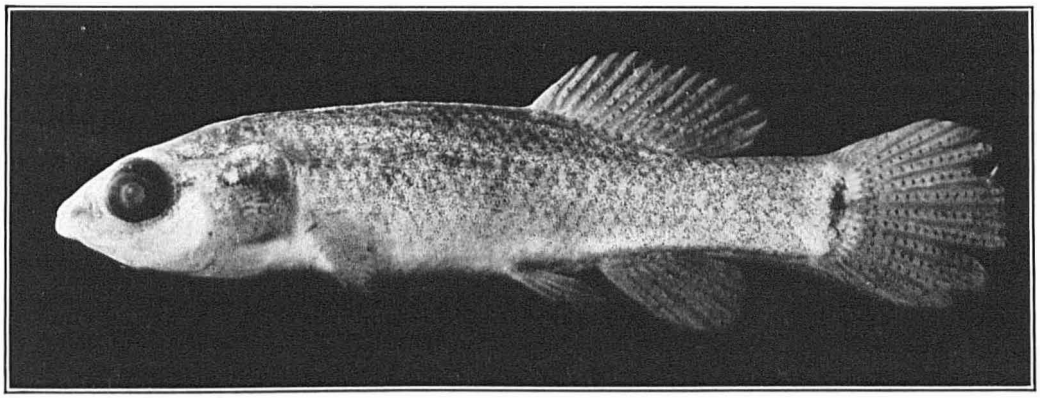

FIGURE 68.—*Umbra limi*, 24.75 millimeters

50.5-millimeter stage.—Total length, 50.5; standard length, 44.5; length to vent, 33.5; length of head, 16.0; depth of head, 6.0; greatest depth, 7.7; diameter of eye, 3.7 millimeters. Dorsal, 16 (last 3 not complete); anal, 16; branchiostegals, 15.

This specimen differs from a 35-millimeter muskalonge principally in its proportionately shorter snout, somewhat heavier body, dorsal and anal fin counts, and especially in number of branchiostegals (17 in muskalonge). The caudal peduncle is more slender and caudal fin not as deeply forked.

Pigmentation.—A dark band extends from tip of upper jaw through eye to posterior margin of operculum, as in the muskalonge, but the pickerel lacks the parallel band below this one, which is evident in the latter. Instead the ventro-lateral aspect of head has sparsely distributed chromatophores in 2 or 3 irregular vertical bands, radiating more or less from eye. Whereas, in the muskalonge the ventral half of body is much darker, here the dorsal half has more numerous tiny pigment spots to lateral line. From the region of ventrals backward the latter are arranged in short oblique bars, about 8 to posterior margin of dorsal, which are opposite similar darker spots below the comparatively light lateral line region, the whole

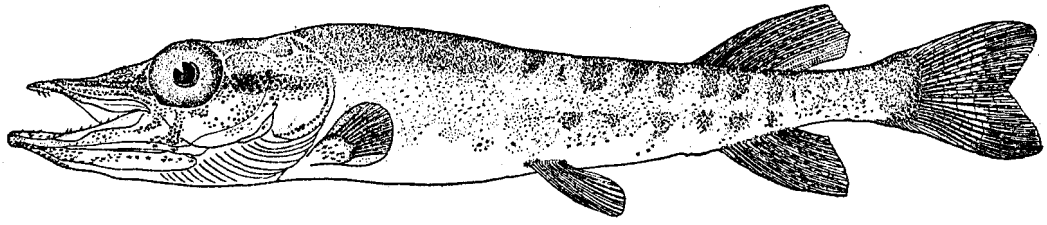

FIGURE 69.—*Esox lucius*, 50.5 millimeters

giving an obliquely striped effect. The belly is colorless with only a few chromatophores arranged along base of anal. All fins are spotted.

BREEDING

The pickerel spawns on grassy or rush beds in early spring as soon as the ice breaks up.

34. Esox masquinongy Mitchill. Muskalonge, muskallunge.

RECORD OF CAPTURE

The muskalonge occurs sparingly in weedy, sheltered spots of Lake Erie and the Niagara River. The larval specimens described here are preserved hatchery material.

DESCRIPTION

Adult muskalonge are distinguished from their near relatives the pickerels by having the lower half of the cheeks scaleless. Their branchiostegal rays number 17 to 19, whereas in the pickerels there are 11 to 16, and the dorsal rays about 17, instead of 11 to 14.

Egg.—Eggs of the Lake Chautauqua muskalonge measured 2.85 to 3.2 millimeters (usually 2.99) in diameter after preservation, with reddish-brown blastodisc. One egg taken on May 18 had an early embryo apparent with some small round black chromatophores along dorsal surface. Other eggs on May 26, however, containing embryos in a somewhat later stage, were totally colorless. The late embryo shows

the typical dark chromatophore marking seen on the ventro-lateral aspect of the newly hatched larva, and the small black pigment spots extend far out over the yolk. The incubation of muskalonge eggs requires approximately 12 to 20 days, and the yolk is absorbed in about 12 days after hatching.

11.6-millimeter stage.—Total length, 11.6; length to vent, 8.5; length of head, 1.65; snout, 0.15; diameter of eye, 0.58; greatest depth before vent, 1.95; depth behind vent, 1.55 millimeters. Myomeres, 45 to vent plus about 21+ behind. Marginal fin fold intact from shortly behind head around lophocercal caudal and

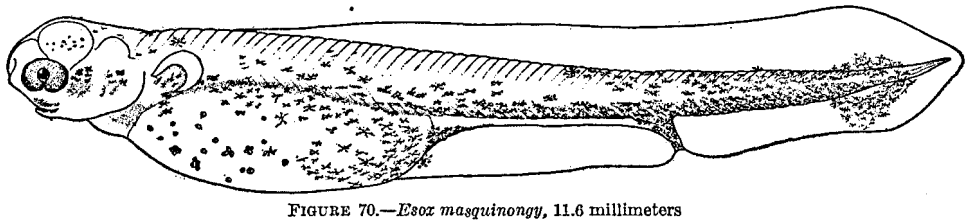

FIGURE 70.—*Esox masquinongy*, 11.6 millimeters

forward ventrally to yolk sac, with little elevation. Pectorals developed but small. Vent situated at some distance from body, at edge of marginal fin, and very evidently marked by the dark pigmentation of intestine. A large reddish yolk sac with many rather small, clear oil globules present.

Pigmentation.—The dark median band so characteristic of later stages is evident now, beginning behind eye and running over yolk sac into ventro-lateral aspect of body, which region is closely and darkly pigmented below lateral line from yolk sac almost to tip of tail. Dorsal half of body has chromatophores sparsely distributed before vent but more numerous behind, extending out on marginal fin fold above and below in caudal region. The eye is darkly pigmented. Many stellate chromatophores occur over top of yolk sac.

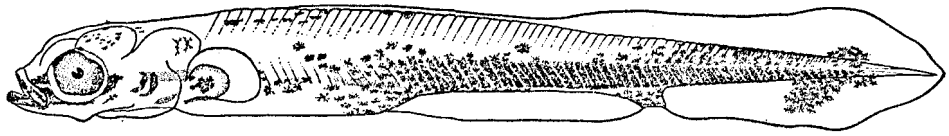

FIGURE 71.—*Esox masquinongy*, 13.9 millimeters

13.9-millimeter stage.—Total length, 13.9; length to vent, 9.4; length of head, 2.7; snout, 0.55; diameter of eye, 0.73; greatest depth before vent, 1.65; depth behind vent, 1.8 millimeters. Myomeres, 45 to vent plus 23 behind. Marginal fin reduced, especially dorsally anterior to vent; pectorals larger but unrayed; notochord straight. Although the yolk is not entirely absorbed in this stage, radical changes are occurring in the development of head. Snout longer, and profile behind tip of upper jaw slightly concave to its highest point at anterior margin of eye; lower jaw projecting; maxillary to just beyond anterior margin of eye. Vent still at ventral margin of embryonic fin fold. A few globules on ventral aspect constitute the only remaining oil in the yolk.

Pigmentation.—Chromatophore grouping is essentially as in the 11.6-millimeter stage. The lateral pigment band now starts at tip of jaws, and extends below the surface over cheeks. The chromatophores through the body region are arranged more in oblique series covering each myomere.

14.0-millimeter stage.—Total length, 14.0; length to vent, 9.4; length of head, 3.2; snout, 0.76; maxilla, 0.87; diameter of eye, 0.85; greatest depth before vent, 1.75; depth behind vent, 1.9 millimeters. Myomeres, 45 to vent plus 23 behind. Marginal fin intact, caudal lophocercal. The greatest change from the preceding stage lies in the gradual lengthening of snout.

Pigmentation.—About as the preceding stage.

15.0-millimeter stage.—Total length, 15.0; length to vent, 10.5; length of head, 3.3; snout, 0.85; diameter of eye, 0.88; maxilla, 1.8; greatest depth before vent, 1.7;

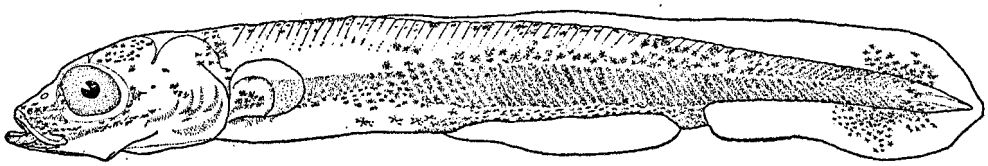

FIGURE 72.—*Esox masquinongy*, 14.0 millimeters

depth behind vent, 1.75 millimeters. Myomeres, 46 to vent plus 26 behind. Marginal fin reduced anteriorly, only slightly notched at peduncle, and still apparent before vent. Further lengthening of snout and jaws constitute the greatest change.

Pigmentation.—Unchanged from preceding except for slightly increased number of chromatophores over dorsal aspect.

33.8-millimeter stage.—Total length, 33.8; standard length, 31.2; length of head, 11.5; snout, 5.0; eye, 2.0; greatest depth before vent, 4.0; depth behind vent, 3.1 millimeters. Characterized by very much produced snout with lower jaw strongly projecting; mouth very large with maxilla extending almost to posterior margin of eye; eye large; formidable teeth on jaws, tongue, roof of mouth, pharynx, and gill arches. Marginal fin still apparent from middle of stomach to ventrals, thence to anal. Dorsal 17 (in stained and cleared specimen, elements of 3 more); anal 16 (with

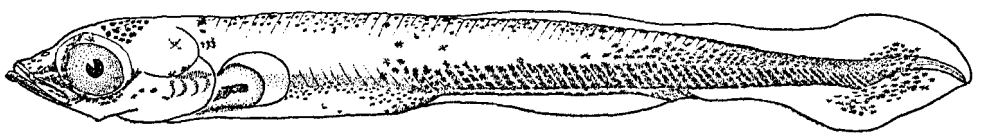

FIGURE 73.—*Esox masquinongy*, 15.0 millimeters

2 more in stained specimen); branchiostegals 17; vertebrae about 43 plus 21 (not completely ossified).

Pigmentation.—This specimen is characterized by a dark band as in younger stages from tip of snout through center of eye to posterior margin of operculum. A second band parallel to this extends from tip of lower jaw straight across head, touching the lower margin of eye without greatly diminishing its width, and terminating shortly behind eye. Top of head and dorsal aspect to lateral line are quite closely peppered with small round black chromatophores, becoming few only at base of middle third of dorsal. Below lateral line in trunk region and the whole tail have become thickly covered with larger stellate spots interspersed among small ones Base of anal and fin itself, and posterior margin of caudal, are without pigment.

BREEDING

The muskalonge is reported to start spawning in normal years a few days after the ice disappears and to continue until the latter part of April in shallow, muddy water from 10 to 15 feet deep, usually where logs and dead branches clog the bottom.

Family CYPRINODONTIDÆ, Killifishes

35. Fundulus diaphanus menona Jordan & Copeland. Barred killifish; grayback minnow. [*Zygonectus diaphanus menona* (Jordan & Copeland). Jordan, Evermann, Clark, p. 178.]

RECORD OF CAPTURE

The barred killifish is not abundant in Lake Erie, but can be found in sheltered bays and water only a few inches deep in the upper Niagara River. The specimens described were taken off Crescent Beach on June 29, 1929, in water 3 feet deep.

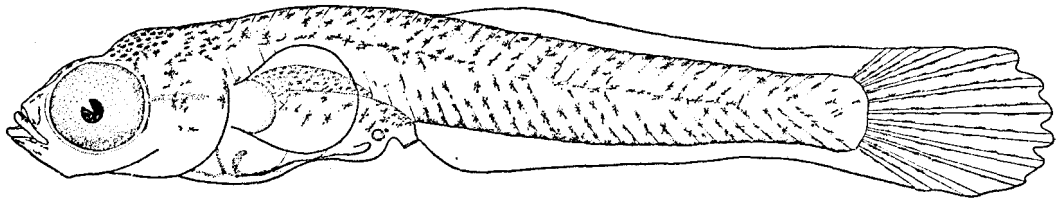

FIGURE 74.—*Fundulus diaphanus menona*, 7.1 millimeters

DESCRIPTION

The stout body and rounded caudal of the young killifish suggest *Umbra limi*, but they differ in having dorsal and anal fins inserted only slightly behind middle of body, whereas in the mud minnow the dorsal is well behind the middle and the short anal is on the last third of the body.

7.1-millimeter stage.—Total length, 7.1; standard length, 6.0; length to vent, 2.8; length of head, 1.6; snout, 0.25; diameter of eye, 0.7 greatest depth before vent, 1.1; depth behind vent, 1.0 millimeters. Myomeres, 10 to vent plus 22 behind. Low dorsal marginal fin fold originates at about thirteenth myomere behind head, continuing

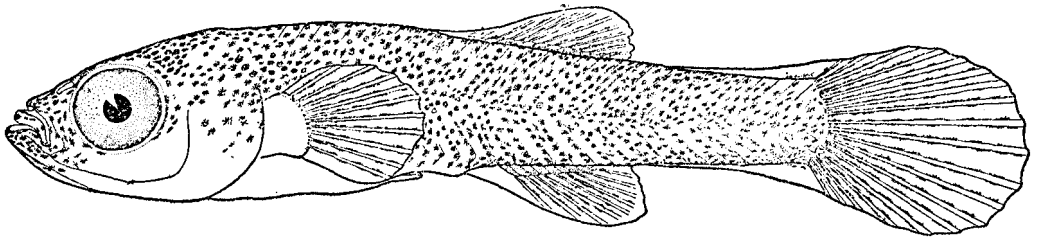

FIGURE 75.—*Fundulus diaphanus menona*, 12.3 millimeters

without a notch at peduncle into heterocercal, rayed tail; distal end of caudal notched between rays; ventral marginal identical with dorsal, originating at vent.

Pigmentation.—Chromatophores are distributed over whole body, especially on top of head and in irregular series on dorsal and ventral ridges. Lateral chromatophores are very stellate, delicate, more numerous along lateral line and distributed along line of each myotome. Much heavy pigment occurs at isthmus, continuing along mid-ventral line of stomach. There are a few chromatophores on unrayed pectorals, and the margin of each caudal ray is pigmented.

12.3-millimeter stage.—Total length, 12.3; standard length, 11.1; length to vent, 5.8; length of head, 3.4; snout, 0.75; diameter of eye, 1.1; greatest depth before vent, 2.2; depth behind vent, 1.8 millimeters. Myomeres, 10 to vent plus 20 to 22 behind.

Dorsal about 10, incompletely formed; anal about 9, incompletely formed; marginal fin fold gone; caudal fully rounded, as adult; pectorals large, rays reaching to ventrals; ventrals budding shortly before vent. Differs from preceding stage in comparatively smaller eye longer snout, more superior mouth, longer lower jaw.

Pigmentation.—Chromatophores have increased in number so that the body is quite evenly covered with stellate chromatophores, except beneath the stomach. Dorsal, anal, and pectorals have chromatophores arranged along rays, similar to caudal.

BREEDING

The barred killifish apparently breeds in June locally. No data are available concerning the duration of the breeding season, but in the Chesapeake Bay region it is reported to spawn from April until September. At mating time the males are olive-colored with about 20 pearly-white or silvery crossbars.

Family PERSOPSIDÆ, Trout-perches

36. *Percopsis omiscomaycus* (Walbaum). Trout-perch.

RECORD OF CAPTURE

Although young ranging from 6 to 35 millimeters were taken frequently at the eastern end of the lake from June 12 to August 10, 1928, usually near shore in water

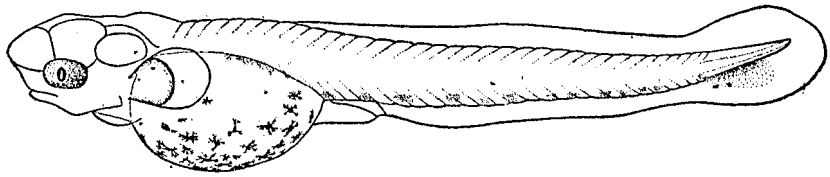

FIGURE 76.—*Percopsis omiscomaycus*, immediately after hatching, 6 millimeters

less than 20 meters deep, only a few under 8.4 millimeters were taken during 1929, on one occasion near Fairport, Ohio, on July 12, and again off Rondeau, Ontario, on the following day. At the western extremity of the lake, however, in 1929 a ripe female was taken on May 6 and eggs of this species were abundant in the tow on that date and at intervals until June 7. The only larva was taken in this region on June 29. It measured 6.5 millimeters. The trout-perch is one of the commonest Lake Erie species, being distributed in rather deep water except during the breeding season.

DESCRIPTION

The large head, deep short body, and especially the small number of myomeres (13 plus 15) make the young of this species easily distinguishable from others.

Eggs.—Freshly spawned eggs measured 1.36 to 1.85 millimeters, and contained much oil distributed in numerous globules in unfertilized specimens, but usually mingled into one large globule up to 0.7 millimeters in diameter after fertilization.

Newly hatched larva.—Total length, 6.0; length to vent, 3.0; greatest depth, 1.1; diameter of eye, 0.5 millimeters. Myomeres, 13 to vent plus 21 behind. Characterized by much-prolonged, pointed snout, with rather small, inferior mouth; small, oval eye much lower than in adult, and later developmental stages showing a gradual movement upward; snout about equal to eye. Embryonic marginal fin

originating over seventh or eighth myomere, rather low and even to lophocercal tail, thence forward to yolk sac past vent, which ends at a distance from body at edge of fin fold; pectorals developed but small, unrayed, inconspicuous, held tightly against yolk sac.

Pigmentation.—There are no dorsal or lateral chromatophores, but many large, black, stellate ones occur over ventral and lateral aspects of the yolk sac, and a row of 15 along ventral edge of myomeres from behind yolk sac to end of tail.

6.0-millimeter stage (somewhat older than preceding).—Total length, 6.0; length to vent, 3.0; greatest depth, 1.15; diameter of eye, 0.5 millimeters. Myomeres, 13 to

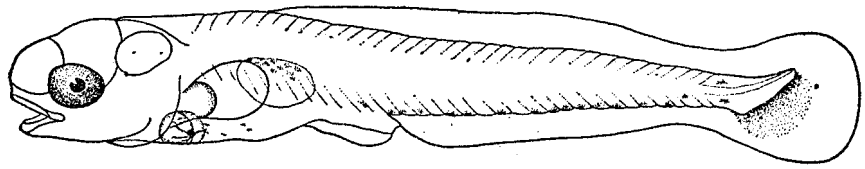

FIGURE 77.—*Percopsis omiscomaycus*, 7 millimeters

vent plus 21 behind. Total length identical with the newly hatched specimen, but yolk sac greatly reduced and body much heavier behind vent; a single-chambered air bladder evident, covered with subsurface chromatophores.

Pigmentation.—Essentially as before.

7.0-millimeter stage.—Total length, 7.0; length to vent, 3.4; greatest depth, 1.1 diameter of eye, 0.5 millimeter. Myomeres, 13 to vent plus 21 behind. Snout still somewhat decurved and mouth inferior; marginal fin unchanged; pectorals larger.

Pigmentation.—The 7-millimeter specimen is characterized by a very few large stellate chromatophores situated in the antero-ventral part of stomach region, extending up only on the right side. This unsymmetry is constant and apparently due

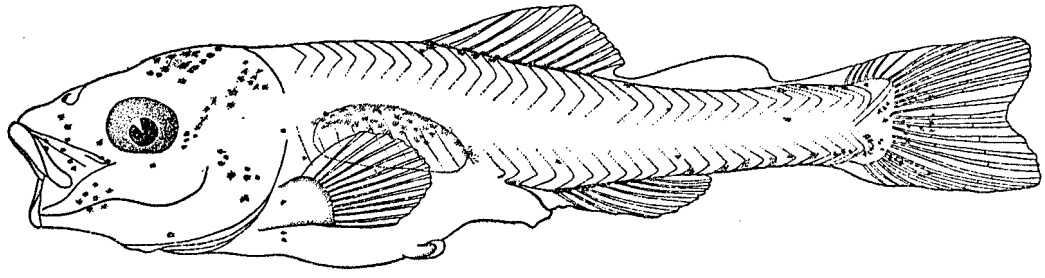

FIGURE 78.—*Percopsis omiscomaycus*, 9.5 millimeters

to uneven development of this region. A ventral line of small chromatophores extends backward from anus, and a subsurface group over the stomach constitutes the only other marking.

9.5-millimeter stage.—Total length, 9.5; standard length, 8.1; length to vent, 5.0; greatest depth, 2.0; diameter of eye, 0.8 millimeter. Myomeres, 14 to vent plus 20 behind. Characterized by long head with long, pointed snout; mouth moderate with delicate teeth in both jaws; body not compressed; air bladder large, one chambered. Eleven dorsal rays developed extending shortly beyond vent, and large portion of embryonic marginal fin fold persistent behind; anal incomplete with eight rays developed, originating below and just before end of dorsal; ventrals apparent for first time, inserted below dorsal origin; caudal forked. Eye higher than in preceding stages.

Pigmentation.—A few chromatophores occur around jaws and over top of head, a few on cheeks and below angle of jaws, very few on underside between gills, many over top of air bladder, very few on either side of dorsal fin, a double series around anal fin, and a single series of about 20 small, uneven spots from anal to end of body. A few chromatophores appear also at base of caudal and on the fin itself.

Young adult, 39.5-millimeter stage.—Dorsal II, 9 (first 2 spines very weak, represent unsegmented rays); adipose fin present; anal I, 7; ventrals 1, 8 (spine rudimentary). Total length, 35.5; standard length, 28.0; length to vent, 17.0; length of head, 9.0; greatest depth, 6.9; length to origin of dorsal, 13.5; diameter of eye, 2.5 millimeters. Myomeres, 15 to vent plus 19 behind. Body moderately elongate, somewhat compressed; caudal peduncle long and slender; head conical, pointed; mouth small, horizontal; maxillary short, narrow, no supplemental bone, not reaching eye; very small teeth in bands on premaxillaries and mandible. Dorsal short, median, and anal origin about opposite end of dorsal. Fully scaled. (Scales not shown in fig. 79.)

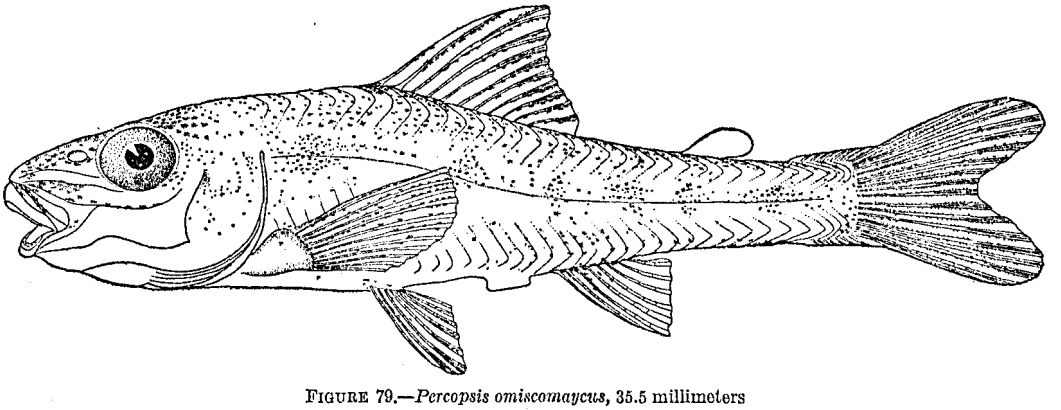

FIGURE 79.—*Percopsis omiscomaycus*, 35.5 millimeters

Pigmentation.—Many chromatophores occur over whole body, arranged laterally in about six indefinite bands. All fins except adipose are marked.

BREEDING

Adults live usually in rather deep water but spawning occurs inshore between early May and the first half of July; its height probably occurs around the middle of June.

Family SERRANIDÆ, Sea basses

37. Lepibema chrysops (Rafinesque). White bass, silver bass.

RECORD OF CAPTURE

Young white bass showing adult characters are fairly common in Lake Erie near the mouths of creeks, and larvæ from 3.7 to 13.5 millimeters were taken quite abundantly at the western end of the lake on June 29, 1929. Adults are common in the Niagara River, the lake, and at the mouths of its tributaries.

DESCRIPTION

The very large mouth, deep compressed body, and few myomeres distinguish the white bass from other Lake Erie larvæ.

5.0-millimeter stage.—Total length, 5.0; standard length, 4.8; length to vent, 2.4; length of head, 1.0; diameter of eye, 0.27; greatest depth before vent, 1.0; depth behind vent, 0.45 millimeter. Myomeres, 8 to vent plus 15 to 18 behind. Head small, mouth very large; body extremely deep and compressed. Some of yolk re-

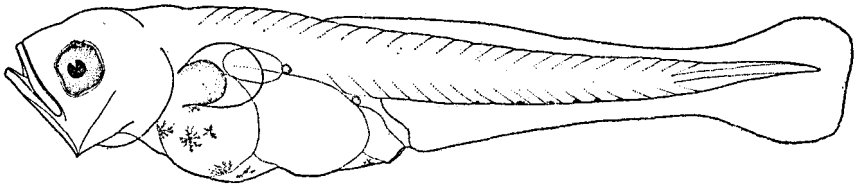

FIGURE 80.—*Lepibema chrysops*, 5 millimeters

maining, but even in this small specimen the large, short intestine already beginning to coil; oil diffused through yolk region. Marginal fin fold originating over middle of yolk region, low, continuing around tail; deeper at vent; caudal lophocercal; pectorals short and rounded.

Pigmentation.—Chromatophores are very large on ventral and lateral aspects in anterior part of stomach region, and 1 or 2 occur shortly before the vent. The

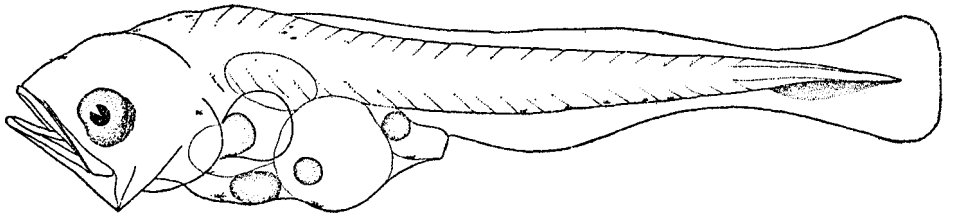

FIGURE 81.—*Lepibema chrysops*, 5.1 millimeters

only other pigmentation consists of a series of about 6 small chromatophores along ventral line of tail.

5.1-millimeter stage.—Total length, 5.1; standard length, 4.5; length to vent, 2.25; length of head, 1.1; diameter of eye, 0.3; greatest depth before vent, 1.2; depth behind vent, 0.36 millimeter. Myomeres, 8 to vent plus 15 behind. A slightly later stage than preceding, although the length is practically the same. Differs from the pre-

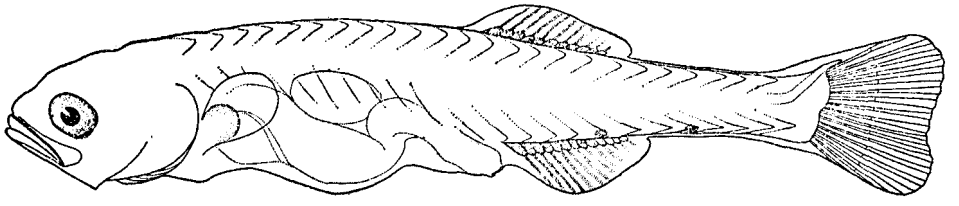

FIGURE 82.—*Lepibema chrysops*, 10.5 millimeters

ceding stage principally in the deeper body. Yolk more nearly but not completely absorbed.

Pigmentation.—Chromatophore marking is identical with preceding stage except for a very few small additional dorsal spots.

10.5-millimeter stage.—Total length, 10.5; standard length, 9.0; length to vent, 5.5; length of head, 2.0; diameter of eye, 0.6; greatest depth before vent, 2.0; depth behind vent, 1.2 millimeters. Myomeres, 8 to vent plus 15 behind. Basal elements

and incomplete rays, about 11 dorsal and 12 anal. Young fish beginning to resemble adult at this stage. Very large mouth, projecting lower jaw. No trace of ventrals or first dorsal. Air bladder present, small, adherent to dorsal wall of abdomen.

Pigmentation.—Characteristic pigment is the set of 1 or 2 very large subsurface spots near ventral margin of tail. In this specimen one is above and one just follows anal base.

12.6-millimeter stage.—Total length, 12.6; standard length, 10.5; length to vent, 6.55; length of head, 3.15; diameter of eye, 0.85; greatest depth before vent, 2.45; depth behind vent, 1.7; length to dorsal, 6.5; to anal, 6.6 millimeters. Myomeres, 12 or 13 before vent plus 13 behind. Generally as preceding stage but with arched back resembling adult. Teeth visible in lower jaw; small ventrals below and shortly behind pectorals; second dorsal I, 14; anal III, 12; slight marginal fin fold before second dorsal indicating position of first dorsal.

Pigmentation.—The marking is confined to two large subsurface chromatophores on ventral margin as before.

18.5-millimeter stage.—Total length, 18.5; standard length, 15.6; length to vent, 8.6; length of head, 5.1; snout, 1.5; diameter of eye, 1.9; greatest depth 4.4 (at vent);

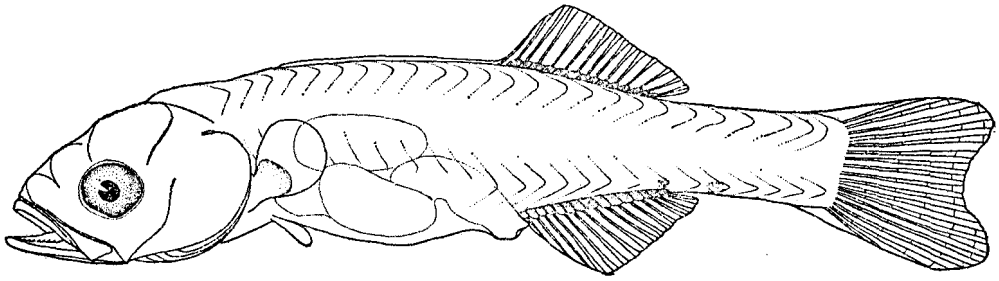

FIGURE 83.—*Lepibema chrysops*, 12.6 millimeters

length to first dorsal, 6.2; to anal, 9.0 millimeters. Body not as oblong as adult but greatly elevated and compressed; head somewhat depressed above eye; eye about equal to snout; lower jaw projecting. Dorsals IX, I, 14; anal III, 11 to 12. Vertebrae, 12 to vent plus 17 behind.

Pigmentation.—The body is colorless with sparsely distributed small black chromatophores arranged about jaws, over snout and more heavily on posterior part of head, a few on cheeks, and in a double line below second dorsal continuous to caudal (numbering about 18). A single linear series occurs along lateral line below dorsal series, and the ventral half of body has light-colored, stellate ones along the myocommata. A well-marked series on either side of anal base continues as a single series on ventral ridge to caudal. Few chromatophores are apparent on ventrals and pectorals, but the other fins are thickly covered.

BREEDING

The white bass spawns in May and June in shallow water far inshore or at the mouths of creeks.

Family PERCIDÆ, Perches

38. Perca flavescens (Mitchill). Yellow perch.

RECORD OF CAPTURE

Young of this very common Lake Erie species were taken abundantly during the middle of July, 1928, from Bertie Bay on the Canadian shore to Angola in Helgoland and meter-net towings from 0 to 4 meters below the surface, and again in the middle of July a few were captured off Silver Creek. From June 7 to August 6, 1929, great numbers of larvæ and postlarvæ were taken throughout the length of Lake Erie, usually inshore in shallow water but sometines even in the very center of the lake. So numerous were they off Rondeau in 19 meters of water on June 17, that 118 were taken in a 5-minute meter-net towing at 1 meter above the bottom. A fully developed young fish, 50 millimeters long, was taken on August 6 on the bottom at 11 meters depth.

DESCRIPTION

The rounded head, large rounded yolk sac with one large oil globule, and pigment which spreads from the ventral ridge up a short distance along the myocommata are

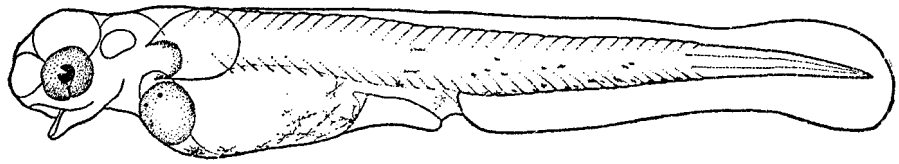

FIGURE 84.—*Perca flavescens*, 5.6 millimeters

constant early larval characters, and the serrated preopercle, lack of canine teeth, oblong compressed body with ventrals close together distinguish the later stages.

Egg.—The eggs of the yellow perch are spawned in a long tube-shaped mass, closed at the ends and folded like the bellows of an accordion. The mass contracts to a length of less than a foot through this folding, but can be stretched out 3 or 4 times as long. Such a mass was spawned in the Buffalo Musem Aquarium on May 26, 1930, but inability to procure a ripe male made embryological study impossible.

5.6-millimeter stage.—Total length, 5.6; length to vent, 2.75; length of head, 0.75; snout, 0.17; diameter of eye, 0.32; greatest depth before vent, 0.93; depth behind vent, 0.75 millimeters. Myomeres, 18 to vent plus 18 behind (incomplete). Characterized by large yolk sac with one large clear yellow oil globule, about 0.4 millimeter in diameter, placed anteriorly; embryonic marginal fin fold granular in texture, originating dorsally at base of brain and ventrally at middle of yolk sac, moderate in height without pronounced elevation; pectorals well developed.

Pigmentation.—The eye is very dark. Sparsely distributed large light-colored stellate chromatophores occur on bottom of yolk sac and usually one or more on dorsal and ventral aspects of intestine. An uneven series of very small unequal chromatophores is evident ventrally behind the vent, and the divisions of the myomeres (few or all depending on the individual) are marked by black pigment lines running from ventral edge to lateral line.

7.3-millimeter stage.—Total length, 7.3; length to vent, 3.6; greatest depth, 0.95; diameter of eye, 0.45 millimeter. Mouth terminal, slightly below mid-line; yolk much absorbed with one large, oval, yellowish oil globule occupying the anterior part;

vent ending far from body at edge of marginal fin. Pectorals considerably larger; dorsal embryonic marginal fin fold raised somewhat before the vent, dropping again about midway from vent to end of myomeres; ventral marginal similarly elevated just behind the vent; caudal lophocercal.

Pigmentation.—Chromatophores occur on underside of yolk in a very irregular double row, fewer and smaller than in the preceding stage. There is a single row of

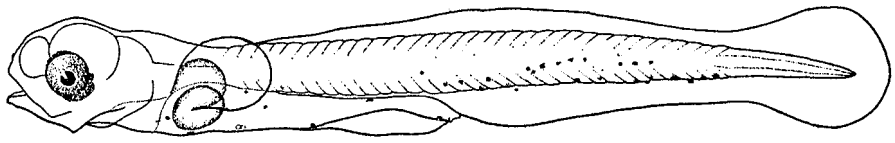

FIGURE 85.—*Perca flavescens*, 7.3 millimeters

about 15 very tiny ones on ventral aspect behind vent, and, extending upward from it a short way over the sides, are a series of from 1 to 3 small chromatophores between each myomere. Two chromatophores appear on intestine at vent.

8.25-millimeter stage.—Yolk completely absorbed, and simple intestine evident. Fins and chromatophores as before.

9.0-millimeter stage.—Total length, 9.0; length to vent, 5.0; greatest depth, 1.04; diameter of eye, 0.5 millimeter. This and successive stages changing mostly in

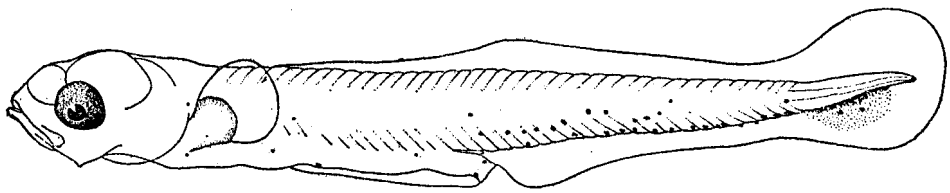

FIGURE 86.—*Perca flavescens*, 9 millimeters

development of head and heavier body. Pigmentation remains the same, consisting of a single ventral series from vent backward, and an irregular line on either side of body midway between ventral ridge and lateral line.

12.5-millimeter stage.—Total length, 12.5; standard length, 12.0; length to vent, 6.2; greatest depth, 2.1; diameter of eye, 0.6 millimeter. Stomach region prominent showing coiled intestine; head more pointed. Marginal fin fold intact but dorsal portion elevated and small elements of 7 rays starting immediately above vent, one

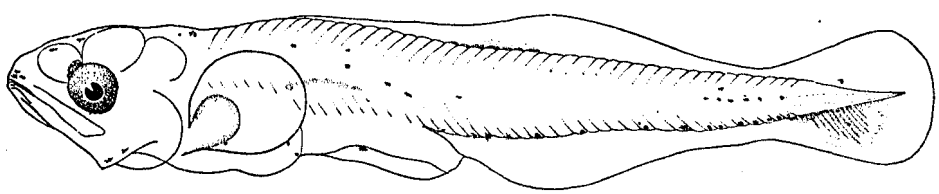

FIGURE 87.—*Perca flavescens*, 12.5 millimeters

for each myomere; in other specimens of this length, a cell concentration indicating later location of anal; few rays on ventral part of caudal but still lophocercal; pectorals moderate.

Pigmentation.—A few chromatophores are developed around both jaws and top of head, a few on preopercle, a subsurface group over stomach region, and 1 very large chromatophore on ventral aspect midway to vent. The lateral and ventral series of 17 to 25 are about as before.

14.4-millimeter stage.—Total length, 14.4; standard length, 12.9.; length to vent, 7.5; length of head, 3.45; snout, 0.9; diameter of eye, 0.8; greatest depth before vent, 2.5; depth behind vent, 2.0 millimeters. Myomeres, 22 to vent plus 18 behind. About 12 very tiny spines of first dorsal apparent, 15 elements and 13 partly formed rays of second dorsal rays; anal I, 8, incomplete; caudal rays developed, distal end of caudal emarginate; ventrals budding.

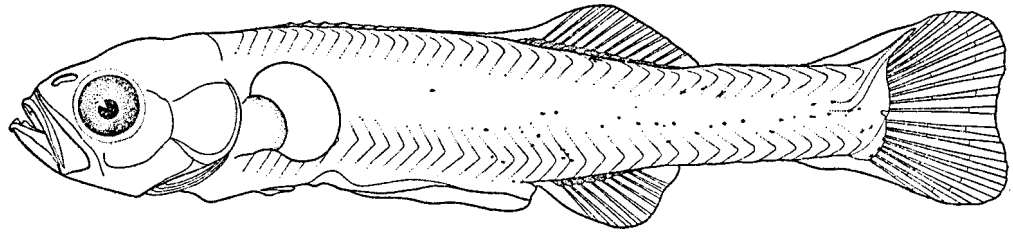

FIGURE 88.—*Perca flavescens*, 14.4 millimeters

Pigmentation.—The marking is much as in preceding stages, but the chromatophores are inclined to be lighter with the ventral series less conspicuous or entirely lacking.

20.0-millimeter stage.—Total length, 20.0; standard length, 17.0; length to vent, 10.5; length of head, 4.7; snout, 1.0; diameter of eye, 1.55; greatest depth before vent, 3.95; depth behind vent, 3.2; length to first dorsal, 6.1; to second dorsal, 10.3; to anal, 11.0 millimeters. Myomeres, 24 to vent plus 16+ behind. At this length the young fish resembles the adult with all fins formed, serrated preopercle, and large mouth. Dorsal XV, II, 13; anal II, 8.

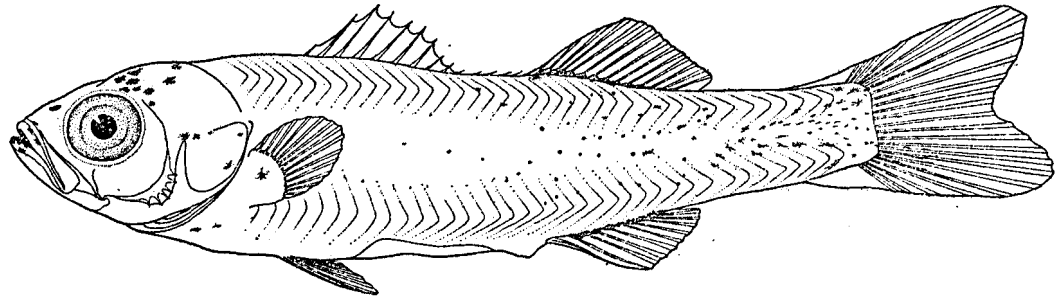

FIGURE 89.—*Perca flavescens*, 20 millimeters

Pigmentation.—This specimen is sparingly marked, with chromatophores limited to a few large stellate ones on jaws and over head, a few at dorsal and anal bases, and others distributed over sides of tail from vent backward, extending somewhat on to caudal. The anterior half of body from behind head to region of vent is almost colorless.

For comparison with the previous stage described the following heavily pigmented specimen is included. It is in a slightly older stage of development evidenced by the longer snout, larger mouth, and more advanced fins, although barely larger than the other.

Postlarva, 20.5-millimeter stage.—Dorsal III to VII–II, 9 to 12 (badly mutilated); anal II, 6 to 8; caudal shallowly forked; ventrals developed, below pectorals. Total length, 20.5; standard length, 17.25; length to vent, 10.5; length to first dorsal, 5.95; length of maxillary, 2.0; greatest depth, 3.6; diameter of eye, 1.5 millimeters. Myo-

meres about 18 before vent plus 18 behind. Body greatly compressed, more elongate than adult yellow perch but decidedly deeper than pike perch of this length; mouth large, with very small sharp teeth discernible but no canines, maxillary reaching to middle of eye; pelvic fins very close together.

Pigmentation.—Round and stellate chromatophores occur on head and a double line dorsally to end of body. Others are scattered also over sides of head and more or less evenly over sides of body. Many specimens have a dark subsurface area over stomach region. A rather indistinct ventral row of large stellate chromatophores extends to vent and an irregular double series from vent to caudal, darkest at base of anal. Dorsals, anal, and caudal are speckled. The banded coloration of the adult is not evident in these preserved specimens.

Adult.—Specimens of 40 millimeters fully developed, definitely banded.

BREEDING

Our records of young from Lake Erie show that hatching may occur as early as the first week of May and continue until after the first week of July, but the height of the season in 1928 and 1929 at both ends of the lake was between June 7 and 17.

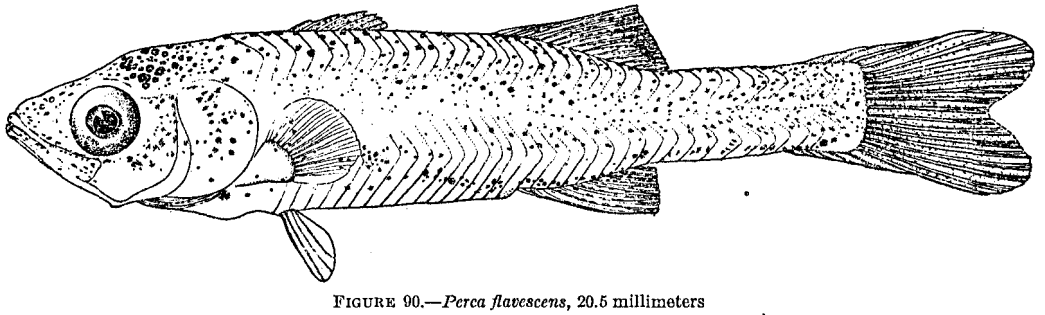

FIGURE 90.—*Perca flavescens*, 20.5 millimeters

39. Stizostedion canadense griseum (DeKay). Sauger; sand pike. [*Cynoperca canadensis* (Smith). Jordan, Evermann, Clark, p. 282.]

RECORD OF CAPTURE

Only one postlarval sauger was captured during the two seasons work of the *Shearwater*, a 14.5-millimeter specimen at 60 meters in the deep hole off Long Point Bay on July 30, 1928. Several young of about 28 to 30 millimeters were taken on June 29, 1929, in towings near the surface at the western end of the lake, and others of this size in seinings at the mouths of creeks. The adults are common in Lake Erie, seeking shallow water rather than the deeper parts.

DESCRIPTION

The earliest larva is distinguished from that of *Perca flavescens* by the larger number of myomeres, and the postlarva by its slenderer, less compressed body, larger mouth, and the characteristic fin-ray count of the adult, dorsal XII to XIII–I, 17 to 18; anal II, 12.

9.0-millimeter stage.—Total length, 9.0; standard length, 8.8; length to vent, 4.25; length of head, 1.8; diameter of eye, 0.47; greatest depth before vent, 1.45; depth behind vent, 0.65 millimeter. Myomeres, 16 to vent plus 26 behind (incomplete). Dorsal marginal fin fold originating shortly behind head, rising to highest point beyond

vent, continous around lophocercal tail (in which concentration ventrally already indicates formation of caudal rays), and corresponding to dorsal contour on the ventral side. Mouth large, maxilla to posterior margin of pupil; both jaws armed with canine teeth.

Pigmentation.—The marking is confined to one large chromatophore on ventral side about halfway from pectoral base to vent, and a few barely distinguishable on dorsal aspect of air bladder.

13.0-millimeter stage.—Total length, 13.0; standard length, 12.5; length to vent, 6.5; length of head, 2.8; diameter of eye, 0.68; greatest depth before vent, 2.5; depth

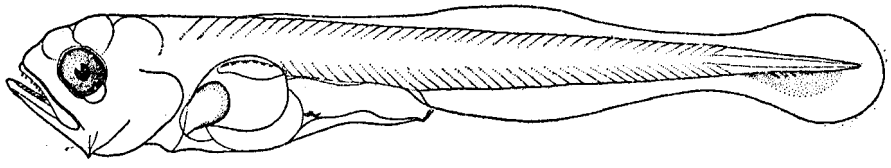

FIGURE 91.—*Stizostedion canadense griseum*, 9 millimeters

behind vent, 1.4 millimeters. Myomeres, 17 to vent plus 27 behind (incomplete). Snout lengthening and becoming pointed (differing from *Perca* in this respect) with well developed canines evident; mouth terminal. Marginal fin fold abruptly elevated immediately behind vent over the basal elements of about 15 rays; persisting ventrally with basal elements and suggestions of about 11 rays; caudal becoming heterocercal, its lower rays developed. Large simple air bladder; intestine coiled; vent open, intestine ending away from body, at edge of marginal fin.

14.6-millimeter stage.—Dorsal XIII–I, 15 (incomplete); anal II, 10 (incomplete); pectorals rather small; ventrals small, below pectorals; caudal emarginate. Total length, 14.6; standard length, 12.6; length to vent, 7.7; greatest depth, 2.0; diameter of eye, 1.0 millimeter. Myomeres, 21 to vent plus 21 behind. Body elongate, dorsal

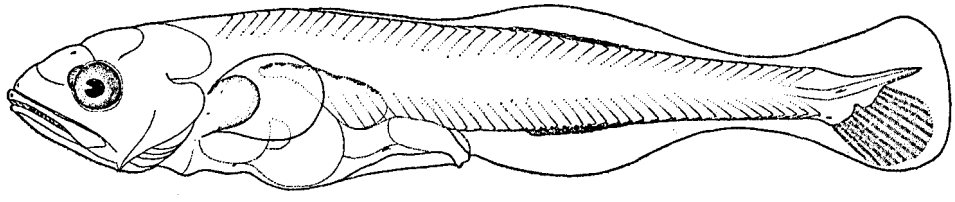

FIGURE 92.—*Stizostedion canadense griseum*, 13 millimeters

contour slightly depressed before soft dorsal and anal, and somewhat depressed just behind head; head pointed, sides quite parallel, eyes directed sideward; mouth terminal; large curved teeth in both jaws; maxillary reaching to posterior margin of pupil. First dorsal, consisting of 13 slender spines, originating just behind ventrals.

Pigmentation.—The 14.6-millimeter specimen is mostly opaque white. One large chromatophore is apparent on dorsal side of intestine at vent, and a double ventral series of about 25 small, uneven, inconspicuous pigment spots (12 of them around anal) extends from vent to end of body. A few occur in the thoracic region and near the posterior limit of lateral line.

27.0-millimeter stage.—Total length, 27.0; standard length, 22.0; length to vent, 13.8; length of head, 7.7; snout, 2.0; diameter of eye, 2.0; greatest depth before vent,

4.1; depth behind vent, 3.15; length to dorsal, 8.0; to anal, 14.1 millimeters. Myomeres, about 22 to vent plus 19 behind (incomplete). Snout greatly produced and pointed, jaws equal; maxilla to hind margin of pupil; canines large; body elongate and terete. Dorsal XII–I, 18; anal II, 12; ventrals well developed, inserted before vertical from first dorsal spine; dorsals well separated; caudal deeply forked.

Pigmentation.—Chromatophores are massed over tip of both jaws, top of head especially behind eye, and on operculum. A double series occurs on dorsal aspect

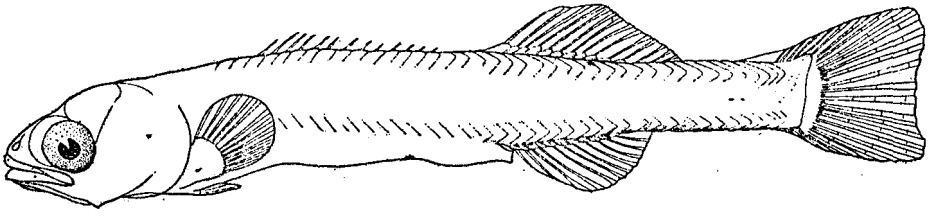

FIGURE 93.—*Stizostedion canadense griseum*, 14.6 millimeters

of body, heaviest about bases of fins, and a double series around anal base followed by a single series behind to caudal. There are a few tiny chromatophores on the sides of the caudal peduncle and along the lateral line in this region. All fins are unmarked except for a few chromatophores outlining the caudal base.

39.0-millimeter stage.—Total length, 39.0; standard length, 33.0; length to vent, 20.05; length of head, 10.5; snout, 4.5; diameter of eye, 2.9; greatest depth before vent, 6.1; depth behind vent, 5.0; length to first dorsal, 12.0; to anal, 11.2 millimeters. Body rather slender, not much compressed, subterete; head pointed with maxilla

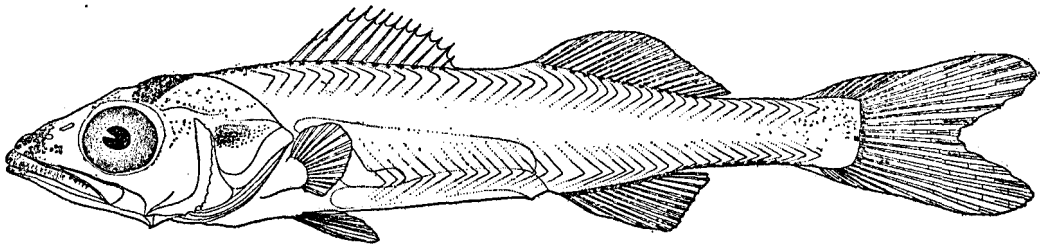

FIGURE 94.—*Stizostedion canadense griseum*, 27 millimeters

reaching to hind margin of pupil only; dorsals well separated. Dorsal XIII–I, 17; anal II, 12.

Pigmentation.—The 39-millimeter fish is white with numerous black chromatophores covering all of body, most numerous on both jaws and over top of head. A slightly larger single series occurs at base of each marginal fin and along the lateral line posterior to the dorsals. The belly is white. The caudal is the only fin with many chromatophores.

BREEDING

The sauger spawns in early spring on shallow gravelly or sandy bars, often running up rivers. With the beginning of warm weather it is reported to work its way downstream again and off into deep water. Whether the postlarval stages are common also in deep water, or whether this specimen was an exception, can not be determined from our scanty evidence.

40. Stizostedion vitreum (Mitchell). Yellow pike, pike-perch, wall-eyed pike.

RECORD OF CAPTURE

Larval *Stizostedion*, probably of this species, were taken in towings in the western part of the lake from the middle of May until the middle of June. It is a very common fish of Lake Erie and the Niagara River and the young may be seined in abundance alongshore in sheltered places.

DESCRIPTION

The larval yellow pike resembles the yellow perch but has a myomere count of 15 plus 26 instead of 18 plus 18. Postlarvæ and young stages may be distinguished

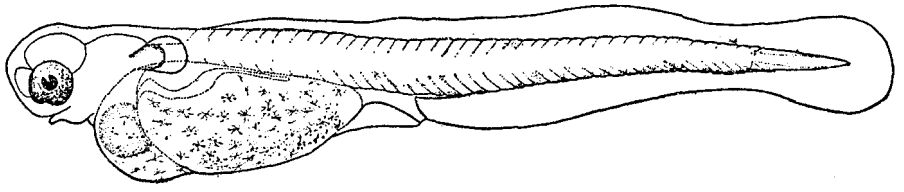

FIGURE 95.—*Stizostedion vitreum*, 7.75 millimeters

from the yellow perch by their slenderer, more rounded bodies, and the possession of canine teeth, and from the young of the more closely related sauger by a soft dorsal count of 19 to 22 rather than 17 to 19.

Newly hatched larva (Thurlow hatchery specimen identified and loaned by John Hart).—Total length, 7.75; length to vent, 3.7; greatest depth, 1.5; diameter of eye, 0.5 millimeter. Myomeres, 15 to vent plus 26 behind (incomplete). Inferior mouth and vent open; yolk very large, bright yellow in color and covered completely by large, light-colored, very stellate chromatophores, which extend over the heart and the large

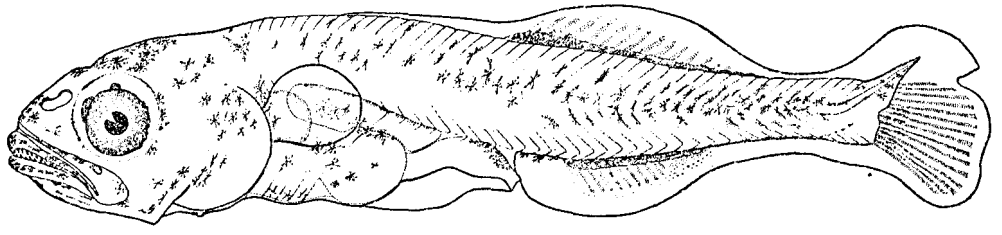

FIGURE 96.—*Stizostedion vitreum*, 12.5 millimeters

clear yellow oil globule. Eye large, blue-black in color. Embryonic marginal fin fold complete; small pectorals developed.

Pigmentation.—There are about two large chromatophores on dorsal aspect of tail, and a well-defined line of dark brown spreading chromatophores, almost interlocking, from vent to caudal.

Older specimens in the same collection have the yolk absorbed. In these the large stellate yolk chromatophores persist on the yellow stomach region, and the last quarter of dorsal aspect has about 6 others arranged alternately on the two sides.

12.5-millimeter stage.—Total length, 12.5; standard length, 11.75; length to vent, 6.5; length of head, 3.35; snout, 0.9; diameter of eye, 0.8; greatest depth before vent,

2.5; depth behind vent, 2.75 millimeters. Myomeres, 21 to vent plus 25+ behind. Embryonic marginal fin fold starting dorsally shortly before vent, becoming abruptly high immediately behind over the elements and slight suggestions of about 17 rays, ventrally persisting before vent and behind over elements and suggestions of about 11 anal rays; no ventrals; pectorals moderate; rays forming in heterocercal caudal. Body rather slender, not as compressed as yellow perch of similar length. Small canines in both jaws; maxillary to hind margin of pupil. Large simple air bladder. Vent situated at distance from body, at edge of marginal fin fold.

Pigmentation.—Rather large stellate chromatophores are distributed on tips of both jaws, over top and sides of head, and in a single series on dorsal ridge, becoming double around fin. An irregular series extends along lateral line with myomere interspaces above and below marked with irregular black lines. Chromatophores have become scattered over sides of stomach and are more numerous below the surface over air bladder and intestine to vent. They occur also along ventral line, especially at base of anal, and extend on to caudal. The eye is very black.

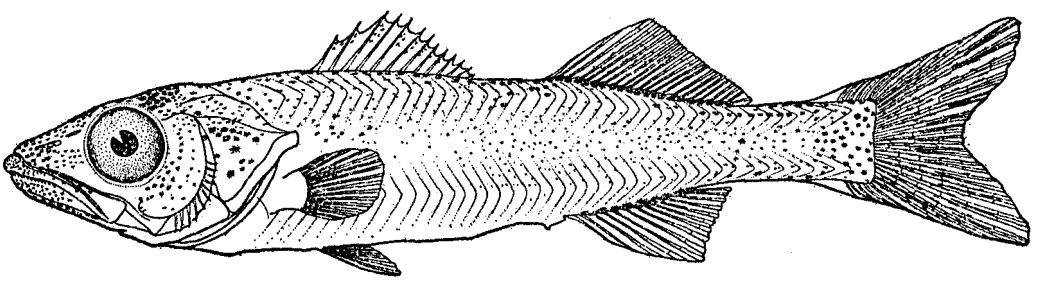

FIGURE 97.—*Stizostedion vitreum*, 32 millimeters

32.0-millimeter stage.—Total length, 32.0; standard length, 26.0; length to vent, 17.0; length of head, 9.1; snout, 2.0; diameter of eye, 1.8; maxilla, 4.0; greatest depth before vent, 5.6; depth behind vent, 4.0; length to first dorsal, 10.0; to second dorsal, 17.0; to anal, 18.0 millimeters; dorsal XIII–I, 21 (well separated); anal II, 13. Myomeres, 22 to vent plus 20 behind. Body long, of moderate depth; mouth large, maxilla to beyond pupil; preopercle serrate; canines strong.

Pigmentation.—Chromatophores are heavy over top of head and usually in about seven patches or bars crossing dorsal ridge. These patches extend only a short distance down each side of body, then are broken, and other oblique bands, starting in the interspaces, cross the lateral line and extend midway to ventral ridge. There is much individual variation in pattern, as seen in the specimen figured, which does not exhibit these bands markedly. The ventral surface is colorless except from origin of anal backward to caudal, where a double series of small, closely placed chromatophores occurs. Both dorsals and caudal are pigmented, but other fins remain colorless except for a few chromatophores at base of pectorals.

BREEDING

The yellow pike spawns in spring, running upstream as soon as the ice breaks up. It prefers sandy bars in shallow water.

41. Hadropterus maculatus (Girard). Black-sided darter. [*Alvordius maculatus* Girard. Jordan, Evermann, Clark, p. 283.]

RECORD OF CAPTURE

This rather uncommon darter is found in many of the warmer tributary streams. The single specimen represented in our collections was seined in Ellicott Creek on August 1, 1928.

DESCRIPTION

Two anal spines and nonprotractile premaxillaries are characters which the black-sided darter has in common with the log perch, separating them from other darters, but the absence of a conical projection of the snout which typifies the log perch, and vertebral count of 42 or less, distinguishes the present species.

41.0-millimeter stage.—Total length, 41.0; standard length, 35.0; length to vent, 21.5; length of head, 9.0; greatest depth, 6.4; diameter of eye, 2.6 millimeters. Myomeres, 20 to vent plus 22 behind. Dorsal XII, 13; anal II, 10; caudal only slightly emarginate; ventrals just behind pectoral base. Body elongate, fusiform; head long and pointed; mouth rather wide, subinferior, lower jaw included.

Pigmentation.—A black streak occurs on upper jaw, and a wide longitudinal stripe from tip of snout through eye to back of head. The top of head and interorbital space are heavily pigmented from occiput to dorsal fin, and the whole dorsal aspect is covered with small chromatophores gradually becoming a pattern outlining the scale arrangement. On lateral line, 5 large and 2 small patches are evident where the scales are outlined and crowded with chromatophores (lateral line practically straight, curving downward only slightly to region of vent). The dorso-lateral region is patterned like python skin, that is, the scales are outlined to make an irregular pattern of lighter and darker patches. Chromatophores occur at margin of anal and a single series a short distance behind. The ventrals are the only fins unmarked.

BREEDING

The black-sided darter spawns in spring in shallow water over a stony bottom.

42. Percina caprodes zebra (Agassiz). Log perch. [*Percina zebra* (Agassiz). Jordan, Evermann, Clark, p. 283.]

RECORD OF CAPTURE

Adults were taken in Petersen and Helgoland trawls and seines near shore during July and August, 1928. Larvæ and postlarvæ from 6 to 24 millimeters were taken in western Lake Erie from June 29 to July 3, and a single specimen 6.5 millimeters long was taken on August 20 in a bottom towing in 13 meters off Point Pelee, also in the far western section.

Although the longer intestine and other characters eliminate *Perca*, the head resembles this genus so much that *Percina*, in which the head is similar to *Perca*, is immediately suggested. In the larva the moderate subinferior mouth, sharp pointed teeth, rudimentary air bladder, and large pectorals and in later stages the subtruncate snout, which begins to be evident soon after a length of 12 millimeters is attained, are characteristic.

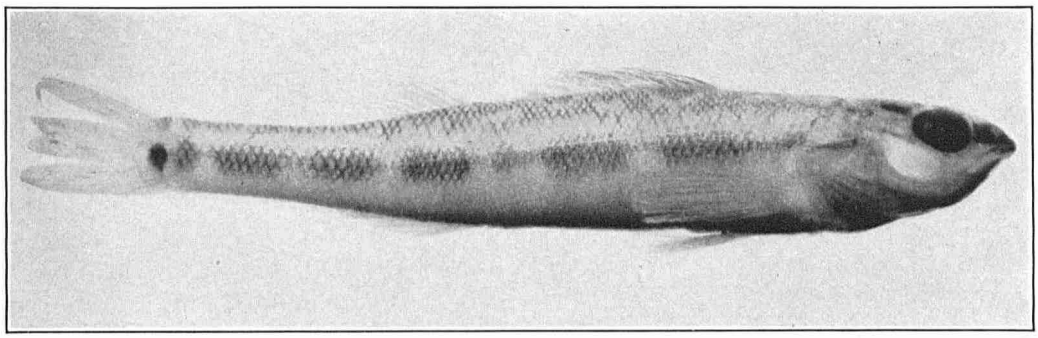

FIGURE 98.—*Hadropterus maculatus*, 41 millimeters

DESCRIPTION

6.6-millimeter stage.—Total length, 6.6; length to vent, 4.1; length of head, 1.1; snout, 0.2; diameter of eye, 0.3; greatest depth before vent, 0.83; depth behind vent, 0.87 millimeters. Myomeres, 22 to vent plus 16+ behind. Embryonic marginal fin fold originating dorsally over stomach region, rising to its highest point behind

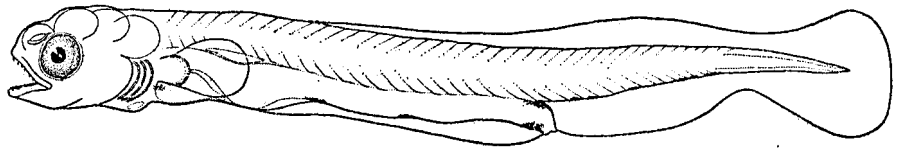

FIGURE 99.—*Percina caprodes zebra*, 6.6 millimeters

vent, continuing around lophocercal tail, and similar in contour ventrally. Body elongate, rather compressed; mouth reaching past front of pupil, armed with sharp pointed teeth in both jaws; mouth subinferior with very slight projection of snout; rudimentary air bladder; large pectorals.

Pigmentation.—One large chromatophore occurs below base of each pectoral, three along ventral margin with the last at vent, one above this on dorsal surface of intestine, and a broken inconspicuous single series on ventral ridge to caudal.

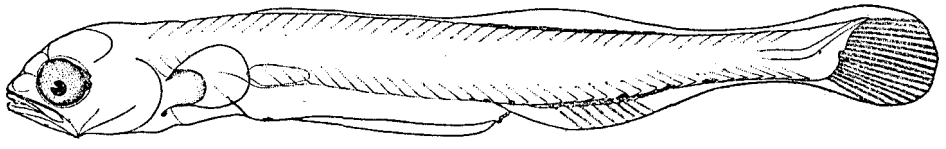

FIGURE 100.—*Percina caprodes zebra*, 12.15 millimeters

12.15-millimeter stage.—Total length, 12.15; standard length, 11.2; length to vent, 6.6; length of head, 2.06; diameter of eye, 0.6; greatest depth before vent, 1.4; depth behind vent, 0.98 millimeter. Myomeres, 20 to vent plus 20+ behind. Elements of 14 dorsal rays in marginal fin fold, and about 9 elements and 8 incomplete rays of anal directly below; tail becoming heterocercal and caudal rays forming.

Pigmentation.—The marking is as in the preceding stage with 1 subsurface chromatophore below pectoral base, 1 or more along ventral margin of intestine,

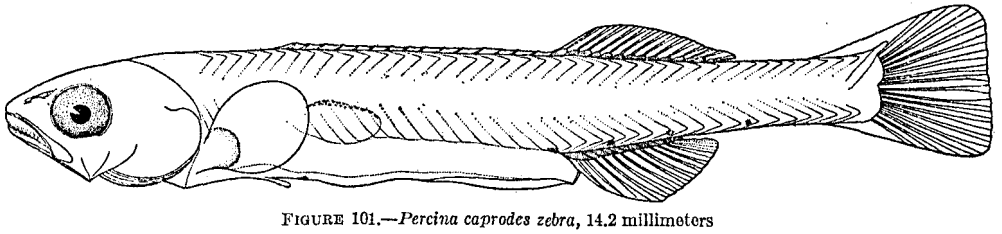

FIGURE 101.—*Percina caprodes zebra*, 14.2 millimeters

and about 4 or more large subsurface spots on ventral ridge of tail, the first of which is at vent.

14.2-millimeter stage.—Total length, 14.2; standard length, 12.6; length to vent, 8.25; length of head, 3.0; snout, 0.67; diameter of eye, 1.0; greatest depth before vent, 2.03; depth behind vent, 1.4 millimeters. Myomeres, 20 to vent plus 20+ behind. Snout pointed, definitely projecting; body elongate, slightly compressed. All spines and rays of marginal fins apparent but not completely developed, spines of first

dorsal very small; caudal barely emarginate; pectorals large but unrayed, ventrals just appearing.

Pigmentation.—The marking is unchanged from the preceding stage except for the addition of a few chromatophores over small air bladder.

20.5-millimeter stage.—Total length, 20.5; standard length, 17.0; length to vent, 10.8; length of head, 4.65; snout, 1.0; diameter of eye, 1.35; greatest depth before vent, 3.15; depth behind vent, 2.53; length to dorsal, 6.1; to anal, 11.4 millimeter. Myomeres, 22 to vent plus 20+behind. Tapering; piglike snout characteristic; mouth inferior, not as small comparatively as in adult. Fins long and low; dorsal XV, 15; anal II, 10 (last divided); ventrals well separated; pectorals rounded.

Pigmentation.—Tip of snout and both jaws have many small chromatophores. Others are scattered sparingly over eye and over head on its distal margin. There are short patches along dorsal ridge, first between the dorsals, second below middle of second dorsal, third at end of fin and fourth nearly to end of body. Two patches occur along lateral line directly below the first and fourth dorsal patches, with 1 or more chromatophores between. A double series appears along ventral ridge from vent to caudal, heavier around anal base and a few large ones at proximal end of

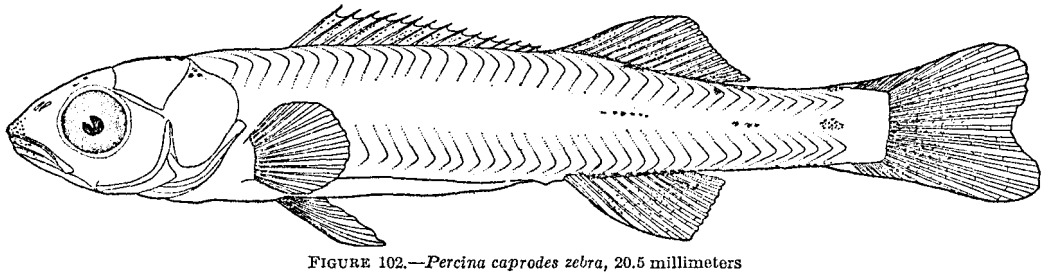

FIGURE 102.—*Percina caprodes zebra*, 20.5 millimeters

caudal rays indicate the future black spot. All vertical fins are dotted with small chromatophores, but the paired fins are colorless.

25.5-millimeter stage.—Dorsal XV, 14, well separated; anal II, 10; ventrals long, more than halfway to vent, well separated; pectorals rather large, equal to ventrals. Total length, 25.5; standard length, 21.0; length to vent, 13.5; length of head, 6.0; greatest depth, 4.0; diameter of eye, 2.0 millimeters. Myomeres, about 20 to vent plus 20 behind (slightly incomplete). Body elongate, slightly compressed; head depressed, rather pointed; horizontal mouth small and inferior, overlapped by subtruncate, piglike snout; very small, pointed teeth on vomer and palatines.

Pigmentation.—The marking is in bars, 8 crossing dorsal aspect, not connected but opposite the lateral bars, of which there are about 10. Chromatophores are scattered over jaws, top, and sides of head. A line of small black ones extends from vent to end of body, double around anal fin. Many occur on dorsals and anal in a more or less longitudinally barred pattern. The caudal is dusky with a black spot at its base.

BREEDING

This very common lake fish spawns upstream during late spring. The capture of late larval and postlarval stages off some of the creeks in late June indicates that the season extends well into that month and that some spawning probably occurs only a short distance from the creek mouths, the young being carried out into the lake soon after hatching.

43. Rheocrypta copelandi Jordan. Copeland's darter. [*Cottogaster copelandi*, (Jordan). Jordan, Evermann, Clark, p. 285.]

RECORD OF CAPTURE

Although this is a common species in Lake Erie and the larger tributaries, only one larva taken by the survey can be assigned even tentatively to it. This was a 7-millimeter specimen taken on June 7, 1929, in 12 meters near Point Abino on the Ontario shore. The fact that many adults seek streams in which to spawn probably accounts in this species, as in many others, for the scanty number of young found in the lake towings. The older specimen described below was captured at the mouth of Cattaraugus Creek in late August.

DESCRIPTION

Concerning the older stages the color pattern of many darters is so similar that it fails to be useful as a field character. However, there are certain definite differences which careful examination will disclose. In the first place, the premaxillaries of this species are protractile, distinguishing it from *Hadropterus* and *Percina*, and the mid-line of belly has a single series of enlarged, spinous scales which are lacking in *Imostoma* and *Ammocrypta* and others. The color pattern and general characters resemble *Boleosoma* closely, but the latter has only 1 instead of 2 anal spines, its belly is covered with normal scales, and the anal fin is shorter than the second dorsal.

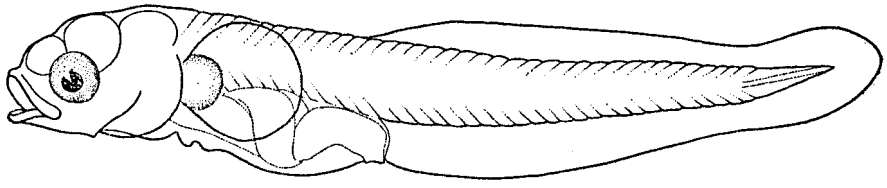

FIGURE 103.—*Rheocrypta copelandi*, 6.1 millimeters

6.1-millimeter stage.—Total length, 6.1; length to vent, 2.6; length of head, 1.2; snout, 0.25; diameter of eye, 0.26; greatest depth before vent, 1.0; depth behind vent, 1.1 millimeters. Myomeres, 14 to vent plus 24 behind. Moderate marginal fin fold, alike above and below, originating in vent region; pectorals large, not reaching quite halfway to vent. Vent located away from body, at ventral margin of fin fold. Although traces of the yolk still are present, the intestine is large and coiled. It differs from *Lota* of like size taken simultaneously in the less deep head, smaller eye, absence of air bladder, and especially in the fewer number of myomeres in tail. *Cottus* is suggested in general shape and myomere count but it is much smaller than a sculpin of like development. The body is sturdier than in the comparatively elongate *Perca flavescens*, which species, too, is recognized by its pigment series.

Pigmentation.—The 6.1-millimeter larva is entirely colorless except for its dark eye.

43.0 millimeter stage.—Total length, 43.0; standard length, 35.8; length to vent, 22.2; length of head, 8.5; snout, 2.5; diameter of eye, 2.6; greatest depth, 6.0; length to first dorsal, 11.5; to anal, 22.4 millimeters. Vertebrae, 18 plus 20. Dorsal XI, 12; anal II, 9. Body rather slender, elongate; head large and long, resembling *Boleosoma*, with small, subinferior, horizontal mouth and protractile premaxillaries. Mid-line of belly with single series of enlarged, spinous, thickened scales.

Pigmentation.—The back is tessellated similar to *Boleosoma* and *Hadropterus* with small zebralike markings, but the brown patches along lateral line are more linear and form a lateral band, somewhat interrupted. Along dorsal ridge the brown spots are large and obvious, and a black streak extends forward from eye to snout. Very few chromatophores occur on fins, except for a small inklike spot at base of caudal, and a black spot on anterior rays of spinous dorsal.

BREEDING

Greeley (1929) took ripe males on June 11 in the riffles about a quarter of a mile from the mouth of Eighteen Mile Creek.

44. Boleosoma nigrum nigrum (Rafinesque). Johnny darter. [*Boleosoma nigrum* (Rafinesque). Jordan, Evermann, Clark, p. 287.]

RECORD OF CAPTURE

On June 11, 1928, a small mass of eggs assigned to this species was found attached to an empty clam shell caught in a torn gill net floating near Sturgeon Point.

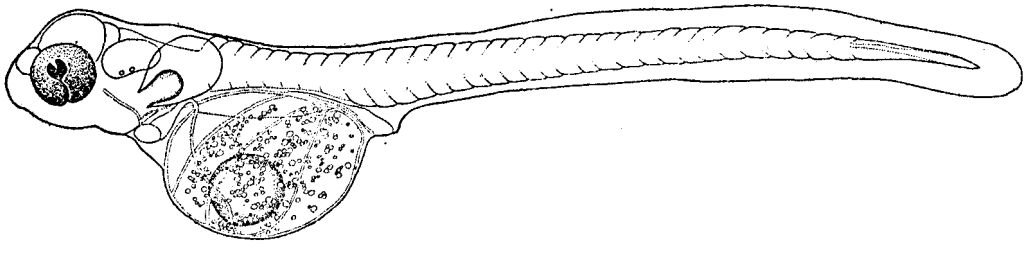

FIGURE 104.—*Boleosoma nigrum nigrum*, immediately after hatching, 5 millimeters. (Drawn from live specimen)

Between June 12 and August 8, specimens ranging from 5.5 to 35 millimeters were taken near shore between Buffalo and Dunkirk in Helgoland trawls towed at 7 to 25 meters. (Figures 105–109.) No young were taken in 1929 in the eastern part of Lake Erie but a few eggs and numerous young shortly after hatching were taken on June 29 in shallow water at the western end. Adults are commonly found in weedy places alongshore.

DESCRIPTION

The inferior mouth with characteristic protruding snout, large eye, and myomere count of 15 plus 19 to 22, distinguish the earlier stages. The protractile premaxillaries and single anal spine mark the later ones further.

Egg.—Diameter of living egg 1.4 to 1.5 millimeters, with an oil globule lying ventral to embryo in yolk; not perfectly round but flattened by adhesion to others; all with late embryos, opaque white except for black eyes.

Newly-hatched larva.—Total length, 5.0; length to vent, 2.25; diameter of eye, 0.4 millimeter. Myomeres, 11 to vent plus 22 behind (very incomplete). Large yellowish oil globule lying at ventral margin of large yolk sac; short intestine terminating just behind yolk, at margin of fin and free from body; embryonic marginal fin fold originating directly behind head, low and even around lophocercal tail; pectorals developed; colorless except for black and silvery eye.

1-day-old larva.—Length still 5.0 millimeters but yolk sac appreciably reduced.

5.6-*millimeter stage.*—Total length, 5.6; length to vent, 3.0; greatest depth, 0.8; diameter of eye, 0.4 millimeter. Myomeres, 15 to vent plus 19 behind (incomplete). Characterized by very large pectorals extending past middle of yolk region; large well-imbedded eyes; prominent snout; comparatively short intestine; moderate mouth,

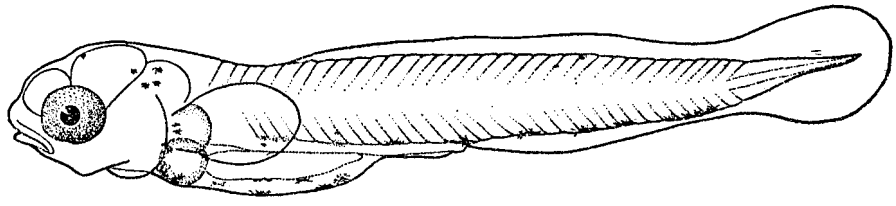

FIGURE 105.—*Boleosoma nigrum nigrum*, 5.6 millimeters

inferior, upper law projecting; dorsal contour very sloping to behind eye; yellow yolk sac much reduced with large yellow oil globule in anterior position.

Pigmentation.—The eye is very dark. About 4 lines of large stellate chromatophores occur on ventral surface of yolk sac, 4 very large subsurface spots over yolk region, the last of them immediately before vent, 4 groups (either of a single chromatophore or several) from vent to caudal and a very few on side of head.

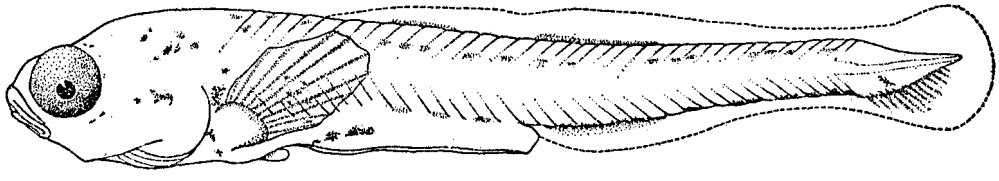

FIGURE 106.—*Boleosoma nigrum nigrum*, 7.1 millimeters

7.1-millimeter stage.—Total length, 7.1; length to vent, 4.0; greatest depth, 1.1; diameter of eye, 0.5 millimeter. Myomeres, 15 to vent plus 21 behind. General characters as preceding stage, but eye definitely higher, almost at dorsal margin with head much depressed above. Embryonic marginal fin low, intact, but slight depression above vent and concentration indicating later position of two dorsals and anal; ventrals appearing; pectorals very large; caudal lophocercal.

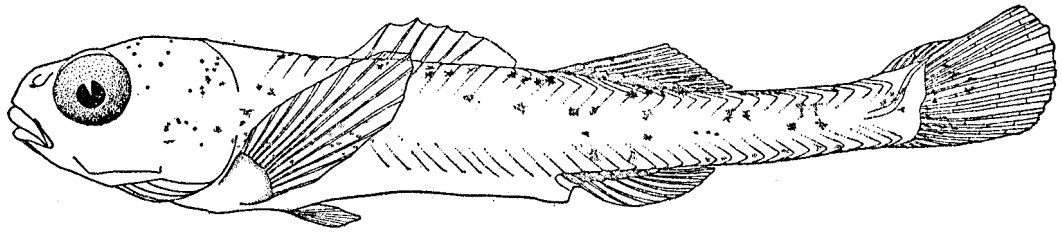

FIGURE 107.—*Boleosoma nigrum nigrum*, 9.6 millimeters

Pigmentation.—Ventral chromatophores of yolk sac are reduced to a few large masses on bottom and sides of stomach region. Four large ones occur on dorsal aspect of intestine and six on ventral edge behind vent. Others (subsurface) in this stage are evident above each ventral one, and, on the myomeres above the notochord, the whole pattern suggests that of a 15-millimeter specimen taken simultaneously.

9.6-millimeter stage.—Dorsal VI, 10 (broken and incomplete); anal I, 7. Total length, 9.6; standard length, 8.1; length to vent, 5.1; greatest depth, 1.54; diameter of eye, 0.9 millimeter. Myomeres, 15 to vent plus 22 behind. Changed from preceding principally in partial development of spines and rays; further development of ventrals and pectorals, completion of caudal, and the addition of a few scattered chromatophores over head, dorsal aspect of body, and lateral line.

15.0-millimeter stage.—Dorsal VIII, 11; anal I, 8. Total length, 15.0; standard length, 12.6; length to vent, 8.0; greatest depth, 2.45; diameter of eye, 1.1 millimeters. Myomeres, 15 to vent plus 22 behind. Adult characters apparent with completion of fins, and addition of more chromatophores on snout, head, and sides of body, giving typically blotched appearance; fins still colorless except for a few chromatophores near base of caudal.

35.0-millimeter stage.—Small adult female with ripe eggs.

BREEDING

The eggs of the Johnny darter are attached to objects usually about a foot or so below the surface of the water. The flat undersides of stones are a favorite nest, over which the parent fish guards assiduously. The breeding season is in May and June, at which time the anterior part of the male becomes very black.

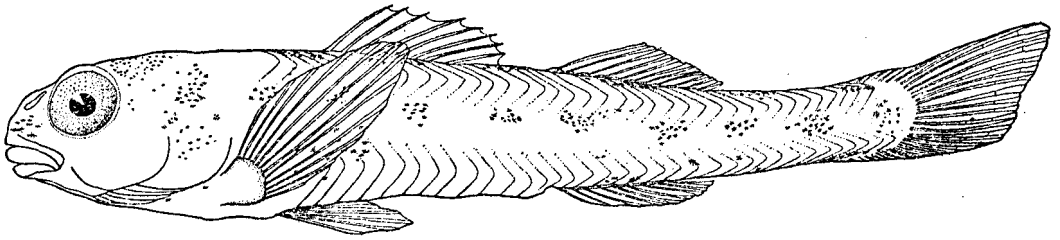

FIGURE 108.—*Boleosoma nigrum nigrum*, 15 millimeters

45. Poecilichthys coeruleus coeruleus (Storer). Rainbow darter; soldier darter; blue darter. [*Oligocephalus coeruleus* (Storer). Jordan, Evermann, Clark, p. 291.]

RECORD OF CAPTURE

The rainbow darter is never found in Lake Erie, but frequents the shallow creeks of the region, where it is common.

DESCRIPTION

Its incomplete lateral line, moderately decurved snout, and anal rays numbering 12 to 14 differentiate the rainbow from other darters of this genus.

22.6-millimeter stage.—Total length, 22.6; standard length, 19.1; length to vent, 11.6; length of head, 5.6; diameter of eye, 1.6; greatest depth, 4.0 millimeters. Dorsal X, 12; anal II, 7; ventrals large, inserted close together. Myomeres, about 15 to vent plus 21 behind. Body rather stout; head large; lower jaw slightly included; premaxillaries not protractile.

Pigmentation.—Chromatophores are thickly distributed over head with a black band extending from tip of snout through eye to back of head. On dorsal aspect they are arranged in about 10 blocks crossing ridge and extending down the sides somewhat. The chromatophores in these blocks are arranged around outlines of scales. On lateral aspect occur about 13 crossbars, narrower than the dorsal blocks, neither opposite nor connecting with them. The last bar is darker than the others, situated at base of caudal, and it has a dark round spot above and below on dorsal

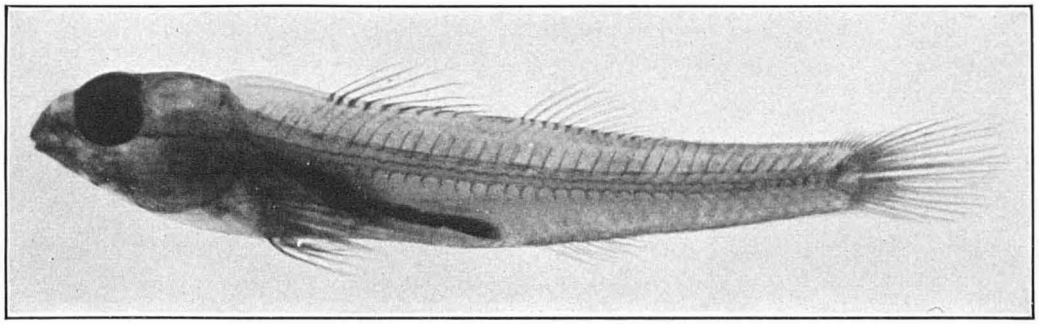

FIGURE 109.—Young *Boleosoma nigrum nigrum*, stained and cleared

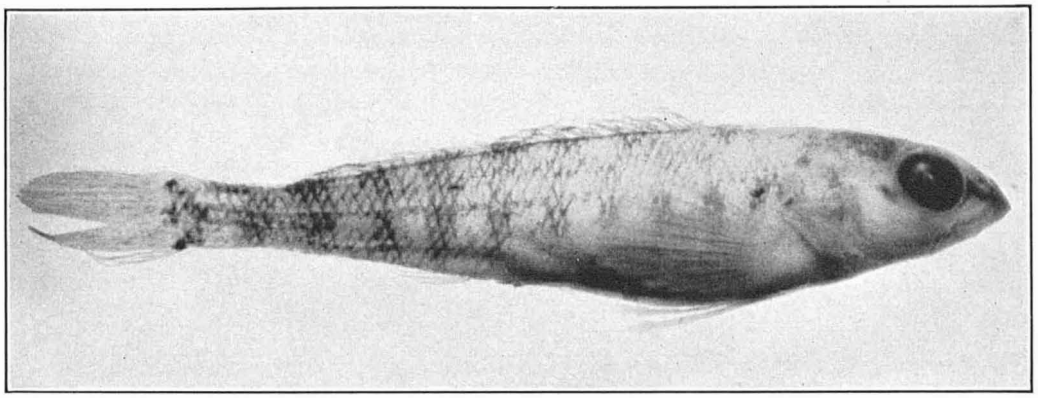

FIGURE 110.—*Poecilichthys coeruleus coeruleus*, 22.6 millimeters

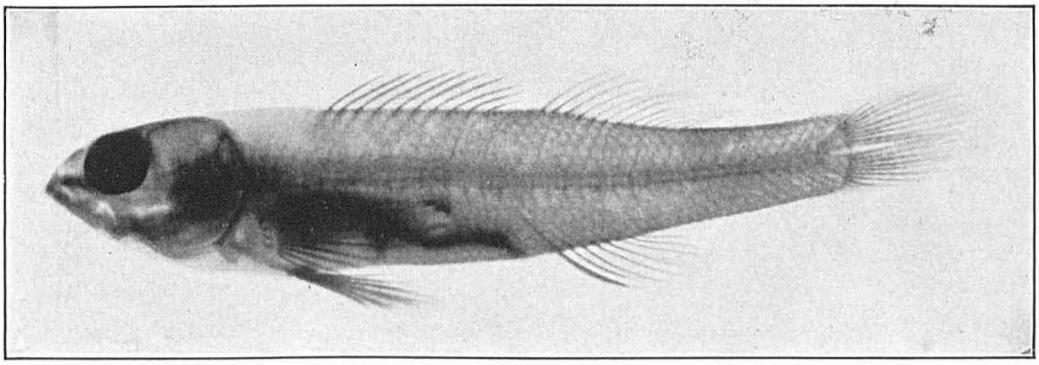

FIGURE 111.—*Poecilichthys coeruleus coeruleus*, 22 millimeters, stained specimen

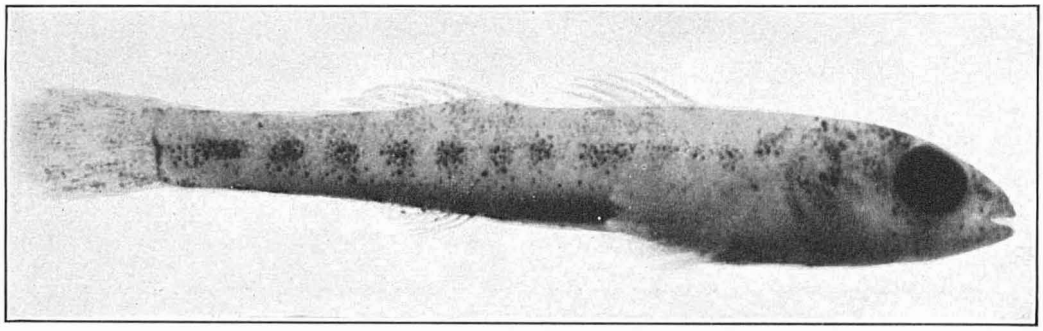

FIGURE 112.—*Poecilichthys exilis*, 19.5 millimeters

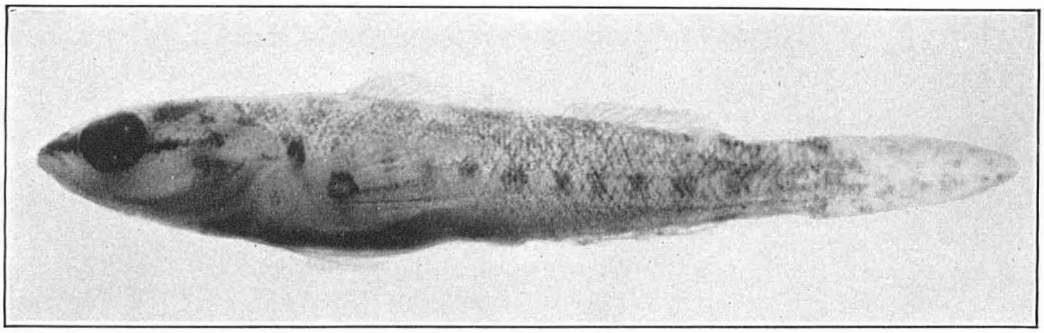

FIGURE 113.—*Catonotus flabellaris*, 22.6 millimeters

and ventral extremities of body. Almost no chromatophores appear on ventral aspect. The peritoneum is dark. All fins except ventrals have many chromatophores, those of the dorsal giving a checked appearance. The brilliant indigo-blue, orange, and crimson of the male are not indicated in these young specimens.

46. Poecilichthys exilis (Girard). Iowa darter. [*Boleichthys exilis* Girard Jordan, Evermann, Clark, p. 294.]

RECORD OF CAPTURE

The Iowa darter is restricted in its distribution to certain sheltered bays along the Lake shore and several of the larger tributaries.

DESCRIPTION

This darter is distinguished from the rainbow darter by fewer rays in the soft dorsal, more slender body, and the bars confined to middle of sides.

19.5-millimeter stage.—Total length, 19.5; standard length, 16.25; length to vent, 10.0; length of head, 5.0; diameter of eye, 1.5; greatest depth, 2.75 millimeters. Myomeres, 21 to vent plus 19 behind. Dorsal IX, 11; anal II, 7; ventrals close together; caudal squarish. Lateral line incomplete; snout only moderately decurved.

Pigmentation.—Chromatophores are thickly distributed over both jaws, back of head, in 3 to 5 longitudinal rows on dorsal surface to tip of tail (with slight breaks in 5 places), on opercles and preopercles, in 12 clusters along lateral line from head to caudal, speckling whole body, especially dorsally, in single line from vent to tail, in heavy subsurface patches over stomach region and on all fins.

47. Catonotus flabellaris (Rafinesque). Fan-tailed darter.

RECORD OF CAPTURE

This darter is common in the Lake Erie region but is limited to the streams, frequenting the headwaters and never venturing into the open lake.

DESCRIPTION

The fan-tailed darter is similar to *Poecilichthys*, but differs primarily in its projecting lower jaw and scaleless head.

22.6-millimeter stage.—Total length, 22.6; standard length, 19.5; length to vent, 11.5; length of head, 6.0; diameter of eye, 1.5; greatest depth, 3.75 millimeters. Dorsal VIII, 12 (very low); anal II, 8; caudal large and rounded; ventrals close together. Body slender and compressed; head long; very oblique, lower jaw definitely protruding; premaxillaries not protractile.

Pigmentation.—Chromatophores are sparsely distributed on both jaws and front of head, and more heavily on brain region. A very pronounced longitudinal band extends from tip of snout through eye to back of head. Over the dorsal aspect about 10 darker patches are apparent. Chromatophores occur also on surface and below surface in opercular region, in about 10 patches on lateral line forming short horizontal bars and over all lateral surface, sometimes irregular, or in criss-cross pattern. Ventral aspect is clear to vent, thence chromatophores border anal fin and those of lateral pattern on either side meet behind. All fins except ventrals are pigmented.

BREEDING

The fan-tailed darter spawns during the latter part of June and the first of July. Greeley (1927) found egg masses of this species in several places attached to the underside of flat stones in shallow water of moderate to swift current. There were about 400 eggs in a round mass, each one measuring individually about three-thirty-seconds inch in diameter. The young were one-fourth inch at hatching, with rather small yolk sac, and dark spots on the body. A male, probably the parent, was always found under the stone. The water temperature varied from 66° to 76° F.

Family CENTRARCHIDÆ, Sunfishes

48. Micropterus dolomieu Lacépède. Smallmouth bass, black bass.

RECORD OF CAPTURE

Six larvæ, 9.5 to 10 millimeters long, were taken on July 11 in a Helgoland trawl at 6 meters depth near Dunkirk, and others in a young-fish stage at the mouth of Eighteen Mile Creek on July 18, 1928. None was captured in 1929. Larvæ and postlarvæ were obtained for comparison and study from the Caledonia hatchery.

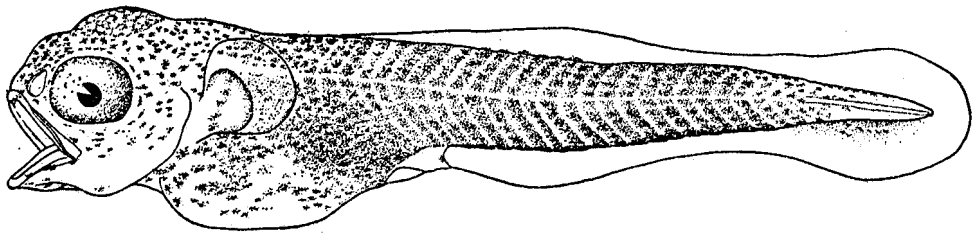

FIGURE 114.—*Micropterus dolomieu*, 8.8 millimeters. (Drawn from hatchery specimen)

The smallmouth bass is very abundant along the shores of Lake Erie, spawning in shallow places in spring and through the first week of July.

DESCRIPTION

This heavily pigmented, robust little fish with its bulbous head and large mouth, extending to the middle of pupil, will not be confused with other forms taken.

Eggs.—Unfertilized eggs taken from the ovary of a 30-centimeter fish on June 29 measured 1.2 to 2.52 millimeters in diameter, mostly 2.2. They were round, semi-transparent, light amber in color, with from six to many comparatively large, clear, dark amber oil globules (largest 0.9 millimeter). The eggs were not adherent, and only loosely joined together.

8.8-millimeter stage.—Total length, 8.8; length to vent, 4.0; greatest depth, 1.8; diameter of eye, 0.85 millimeters. Myomeres, 10 before vent plus 19 behind (very incomplete). Embryonic marginal fin fold originating over end of yolk region, rising to slight elevation at position of later soft dorsal, similar on ventral side; caudal lophocercal; pectorals rounded. Head and yolk region robust, body compressed behind vent; eye large; mouth large, oblique, with maxillary extending to middle of pupil; intestine ending at edge of marginal fin.

Pigmentation.—The whole larva is darkly spotted. Many large stellate chromatophores are massed over bulbous head, with fewer on sides of head and around jaws.

The yolk region is well covered, except on ventral aspect. The myomeres have lines of large, very spreading chromatophores (about 2 wide on each myomere before vent, 1 wide behind), giving an almost even appearance of brown color in the preserved specimens. Chromatophores extend on to base of pectorals, and slightly into caudal. Otherwise, the fins are colorless. The eye is dark.

9.5-millimeter stage.—Total length, 9.5; standard length, 8.5; length to vent, 5.1; greatest depth, 2.1; diameter of eye, 1.0 millimeters. Myomeres about 11 to vent

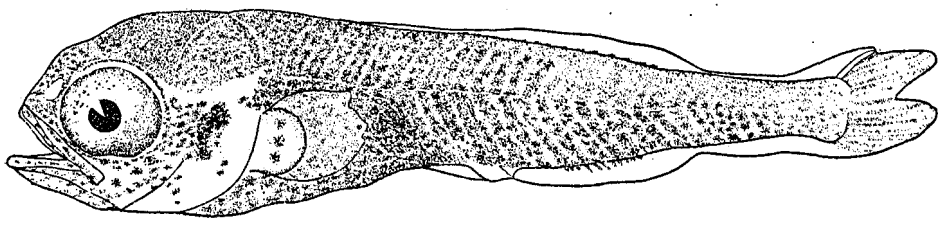

FIGURE 115.—*Micropterus dolomieu*, 9.5 millimeters. (Drawn from hatchery specimen)

plus 22 behind (incomplete). In this stage the head is the deepest part of the fish, rest of body tapering gradually to caudal; stomach much flatter than following stage, intestine probably little coiled. Very slight elements of 13 dorsal and 11 anal rays evident. Greater development of caudal than in following stage probably indicates an older specimen, although of shorter length.

10.0-millimeter stage.—Total length, 10.0; length to vent, 5.25; greatest depth, 2.17; diameter of eye, 1.0 millimeter. Myomeres, 10 before vent plus 19–20 behind (incomplete). Proportions and general appearance as hatchery stock, but differing mostly in light color, resulting from contracted chromatophores which in other

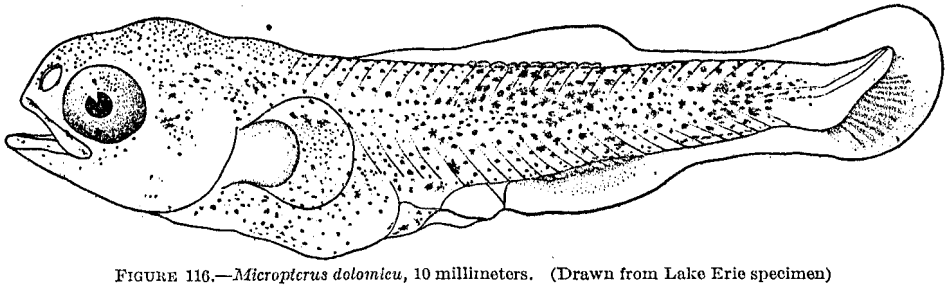

FIGURE 116.—*Micropterus dolomieu*, 10 millimeters. (Drawn from Lake Erie specimen)

specimens were much expanded (contraction constant for lake specimens); however, number and arrangement of chromatophores identical in the two stocks. Apparently, also, the larva in its natural environment develops fin-rays and other adult characters at a slightly greater length than that at which a hatchery specimen—with its normal growth retarded by captivity—will show them, evident from this and the following figure. (See p. 346 for discussion of the effects of artificial rearing on another species.)

9.5-millimeter stage.—Total length, 9.5; standard length, 8.75; length to vent, 5.0; length of head, 2.6; greatest depth, 2.6; diameter of eye, 1.0 millimeter. Stomach region now deeper than head due to large convolutions of intestine; vent still at distance from body. Embryonic marginal fin fold widened above dorsal and anal locations, and fin ray elements much larger than in Figure 116 but in the same numbers. Profile of head higher and more sloping.

19.0-millimeter stage.—Dorsal X, 14; anal III, 12; ventrals and pectorals well developed; caudal forked. Total length, 19.0; standard length, 15.0; length to vent,

9.6; length of head, 5.4; greatest depth, 4.3; diameter of eye, 1.5 millimeters. Mouth very large, oblique, lower jaw projecting, maxillary ending about middle of pupil.

Pigmentation.—Marking is essentially as in younger stages, the sides of body being closely covered with stellate and round chromatophores of varying sizes. Three longitudinal rows occur on either side of dorsal ridge, and a single line on

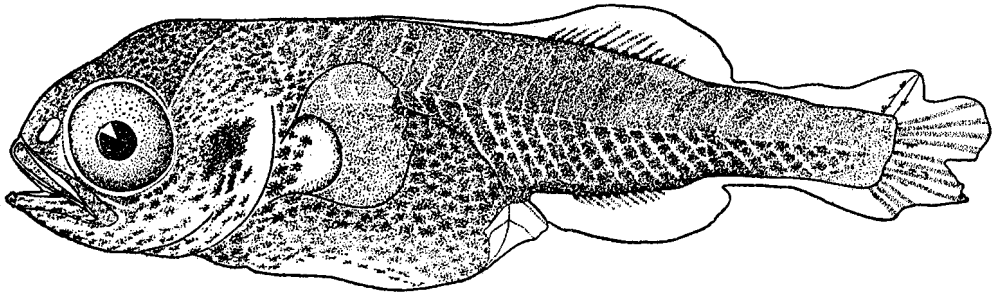

FIGURE 117.—*Micropterus dolomieu*, 9.5 millimeters. (Drawn from hatchery specimen)

either side of ventral ridge behind vent. The peritoneum is black. The head is less pigmented than body, and underside of stomach is much lighter than the rest of body. The fins are colorless.

BREEDING

The black bass spawns from May until early July, incubation taking from 5 to 15 days depending upon the water temperature. Shallow nests are scooped out in the sand for the eggs, and the parent fish guard them carefully until hatched. Reighard (1906) has described in detail the breeding and development of this species.

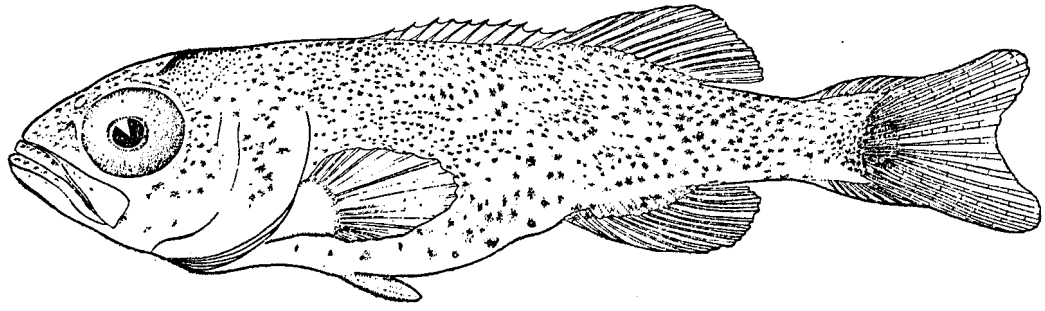

FIGURE 118.—*Micropterus dolomieu*, 19 millimeters. (Drawn from Lake Erie specimen)

49. Aplites salmoides (Lacépède). Largemouth bass. [*Huro floridana* (LeSueur). Jordan, Evermann, Clark, p. 297.]

RECORD OF CAPTURE

The largemouth bass is not as common as its smallmouth relative but is restricted to weedy places along the lake shore, some of the quieter tributaries, and ponds near by. Forty-five young fish, each measuring about 7 centimeters in length, were taken in a seine haul at Long Point Bay on August 23, 1928.

DESCRIPTION

The upper jaw extending to hind margin of eye, and a prominent dark lateral streak serves to distinguish this species from *Micropterus* in which the mouth extends only to middle of pupil and the sides have many short vertical bars.

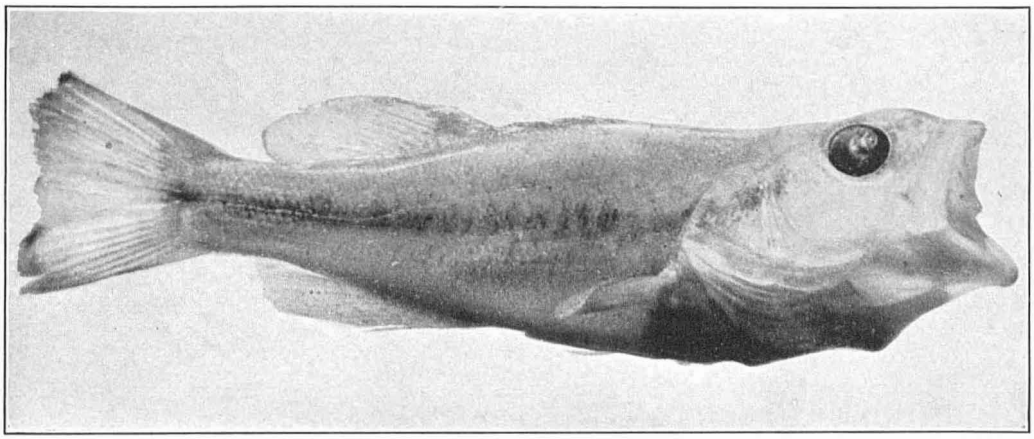

FIGURE 119.—*Aplites salmoides*, 75 millimeters

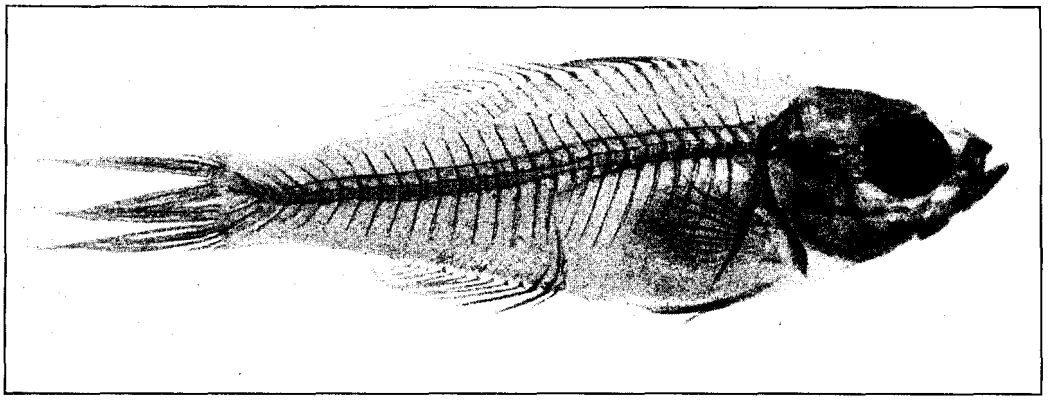

FIGURE 121.—Young *Eupomotis gibbosus*, stained and cleared

75.0-millimeter stage.—Total length, 75.0; standard length, 70.0; length of head, 28.0; greatest depth, 19.5; diameter of eye, 4.8 millimeters. Body elongate; mouth very large, oblique, maxilla to back of eye; lower jaw projecting; deep notch between dorsals. Dorsal X, 13; anal III, 11.

Pigmentation.—The 75-millimeter fish is slightly greenish above and silvery below. A broad, very dark lateral band extends in mid-line of body from behind head to caudal. Three oblique stripes are apparent across cheek and opercles behind eye. Very small black chromatophores are abundant on top and sides of body, darker and more numerous above lateral band, and arranged more heavily on outline of scales. The belly is white. All fins except ventrals are sprinkled with chromatophores.

BREEDING

The largemouth bass spawns during the period from early April to July. The nesting habits are similar to those of *Micropterus*, and the adhesive eggs are attached to stones. Incubation takes from one to two weeks, depending upon temperature, and the larvæ remain in the nest after hatching for upward of two weeks. At that age they are about 15 to 19 millimeters long.

50. Eupomotis gibbosus (Linnaeus). Common sunfish; pumpkinseed.

RECORD OF CAPTURE

The sunfish is found always in weedy places, whether it be along the lake shore or in the streams and ponds adjoining. It is one of the commoner species of the region.

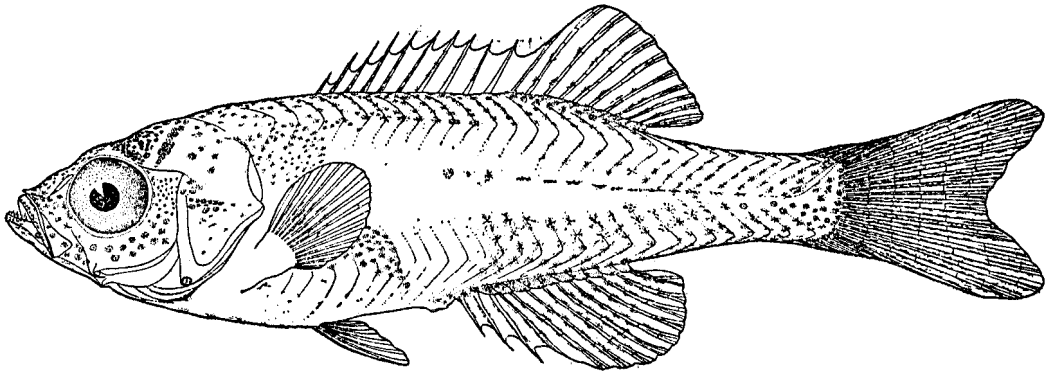

FIGURE 120.—*Eupomotis gibbosus*, 18.5 millimeters

DESCRIPTION

The chubby shape easily identifies these young fishes as sunfish, and the small mouth, scarcely produced operculum, caudal vertebræ numbering 18, and anal spines only 3, distinguish the common sunfish or pumpkinseed from others.

Egg.—The eggs are about 1 millimeter in diameter, demersal, adhering to vegetation or rocks on the bottom.

18.5-millimeter stage.—Total length, 18.5; standard length, 14.5; length to vent, 7.6; length of head, 4.52; snout, 1.1; diameter of eye, 1.5; greatest depth before vent, 4.4; depth behind vent, 3.7; length to dorsal, 5.8; to anal, 8.0 millimeters. Myomeres, 10 to vent plus 18 behind. Dorsal X, 12; anal III, 10. Body ovate, very compressed;

snout short and depressed over eye, interorbital space flat; mouth small, oblique, with maxilla just reaching forward margin of eye.

Pigmentation.—The body is evenly covered with small black chromatophores which follow margins of myomeres. The marking is heavier around jaws, top of head, and cheeks. Single linear spots occur along lateral line from above origin of anal to caudal, and around bases of dorsal and anal. Only the belly is colorless. All fins have chromatophores, fewer on ventrals and pectorals.

BREEDING

The common sunfish is a nest builder, using its fins to hollow out a depression in the mud or sand. The male carefully guards the nest and fearlessly drives off intruders. During the breeding season his colors become much more brilliant, and the ear flaps are conspicuous.

51. Ambloplites rupestris (Rafinesque). Rock bass; goggle-eyed bass.

RECORD OF CAPTURE

The rock bass is found very generally about weedy places on the lake shore and in most of its tributaries. Many young were taken by seines in the Niagara River and alongshore, but none was taken in the surface towings farther out in the lake.

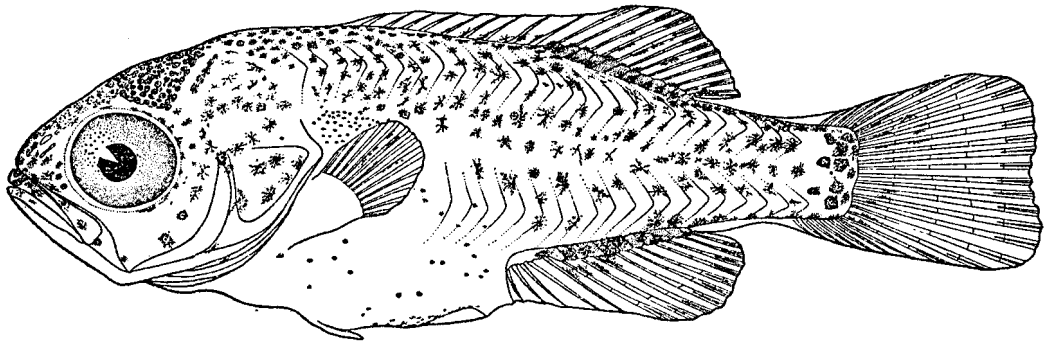

FIGURE 122.—*Ambloplites rupestris*, 10.5 millimeters

DESCRIPTION

The robust, compressed shape of the rock bass resembles other sunfishes, but the large mouth, 5 or 6 anal spines, and 10 to 12 dorsal and anal soft rays distinguish it immediately from others.

10.5-millimeter stage.—Total length, 10.5; standard length 8.9; length, to vent, 5.0; length of head, 3.1; snout, 0.35; diameter of eye, 1.1; greatest depth before vent, 3.18; depth behind vent, 2.3 millimeters. Myomeres, 13 to vent plus 18 behind (only 14 well developed). Body oblong, much compressed; caudal peduncle stout; eye large; large mouth terminal, oblique, maxilla past vertical from anterior margin of pupil; lower jaw barely projecting.

Pigmentation.—The fish is covered by large stellate black chromatophores, especially on tip of both jaws, massed over snout and top of head, and in heavy dorsal and ventral series along margins of body and around fins. The chromatophores are more openly arranged on dorsal half and posterior half behind the vent. The

belly is lighter, with small round chromatophores more sparingly distributed, most numerous along ventral margin. Chromatophores are few on dorsal, caudal, anal, and pectorals, usually situated near their bases. Small subsurface spots are massed over dorsal aspect of air bladder.

BREEDING

Like the common sunfish, the rock bass is a nest builder, scooping out a shallow nest to contain the eggs, over which the male watches with the greatest of patience and care, encouraging the circulation of water over the eggs by fanning with the fins. The breeding season is in May and June.

Family ATHERINIDÆ, Silversides

52. Labidesthes sicculus (Cope). Brook silverside; skipjack.

RECORD OF CAPTURE

The only young specimens were taken along the lake shore in shallow water, at the mouths of Eighteen Mile and Silver Creeks, and in Long Point Bay. It is not of common occurrence in the region.

DESCRIPTION

The very slender body of the silverside, with the shining lateral band from which its name is derived, the short, depressed beak, and two dorsals are characters which readily distinguish the species from any other encountered.

27.0-millimeter stage.—Total length, 27.0; standard length, 23.2; length to vent, 11.4; length of head, 5.6; diameter of eye, 1.8; greatest depth, 3.1 millimeters. Myomeres, 16–17 to vent plus about 25 behind. Dorsal IV–I, 11; anal I, 23; ventrals small, abdominal; pectorals inserted high; caudal forked. Mouth very elongate, terminal and very oblique, with lower jaw slightly projecting; jaws prolonged into a short pointed beak, flattened above and rounded on underside; snout about equal to diameter of eye.

Pigmentation.—The species is characterized by a silvery lateral band from behind head to caudal, edged above in lead color. The cheeks are silvery, and the top of head is rather greenish-yellow at this stage. Chromatophores are distributed on both jaws and on top of head, in interorbital region below the surface and in a heavy main series down dorsal aspect with irregular series on either side to end of second dorsal. They are massed on lateral band, although the individual pigment spots are very small. A double ventral series extends from vent backward. The belly is white. All fins but ventrals are pigmented.

Family SCIAENIDÆ, Drumfishes

53. Aplodinotus grunniens Rafinesque. Sheepshead; freshwater drum; gray bass.

RECORD OF CAPTURE

One young fish, 13.3 millimeters long, was taken on the bottom in 17 meters of water on August 16, 1928, near Port Maitland, Ontario. Adults are common in the lake.

DESCRIPTION

The complete vertical fins at this stage make identification easy. The back is much less elevated but otherwise most of the characters of the adult are evident.

13.3-millimeter stage.—Dorsal VIII–I, 30; anal II, 7; pectorals well developed; ventrals closely behind pectorals; caudal doubly truncate. Total length, 13.3; standard length, 11.0; length to vent, 7.0; length of head, 3.5; diameter of eye, 0.8 millimeter. Myomeres, 12 to vent plus 12 behind. Body rather deep before vent and somewhat compressed; back much less elevated than adult; mouth low, lower jaw included; maxillary to posterior margin of pupil; eye small, placed high; snout wider than eye; teeth in villiform bands, outer enlarged above; preopercle somewhat serrate.

Pigmentation.—Chromatophores are rather large and sparsely distributed over top of head, around jaws, outlining preopercle and at base of pectorals. A subsurface group occurs over the large air bladder and in the jugular region. None is apparent on dorsal or lateral aspects. Ventrally there are about 5 very large, delicate,

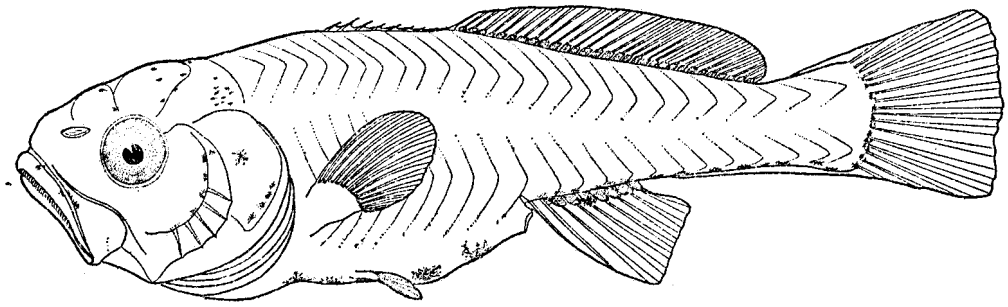

FIGURE 124.—*Aplodinotus grunniens*, 13.3 millimeters

stellate chromatophores from beginning of stomach region to vent. Behind vent about 5 subsurface ones join a double series of about 5 on the surface around base of anal, and the group is continued behind as a single series of 6 to 8 on ventral ridge. The base of caudal is outlined with chromatophores situated on the fin itself.

15.6-millimeter stage.—Total length, 15.6; standard length, 12.5; length to vent, 8.0; length of head, 4.2; diameter of eye, 1.2; greatest depth, 4.0 millimeters. Myomeres, 12 to vent plus 13 behind. Dorsal VIII–I, 30; anal II, 7. The present specimen is slightly older than preceding, but differs only in the increased number of chromatophores. Here, too, the first dorsal has one less spine than given in the description of the adult, but it may be incomplete at this young stage.

Pigmentation.—The pigmentation is very scanty as in the preceding stage, but a few additional chromatophores have appeared at base of dorsal, and in a group on lateral aspect posterior to origin of dorsal, followed by about 20 chromatophores in an irregular broken series. Below the surface others occur on sides and under head, and they are sparingly distributed on all fins.

BREEDING

It is probable that the sheepshead spawns in early summer in Lake Erie.

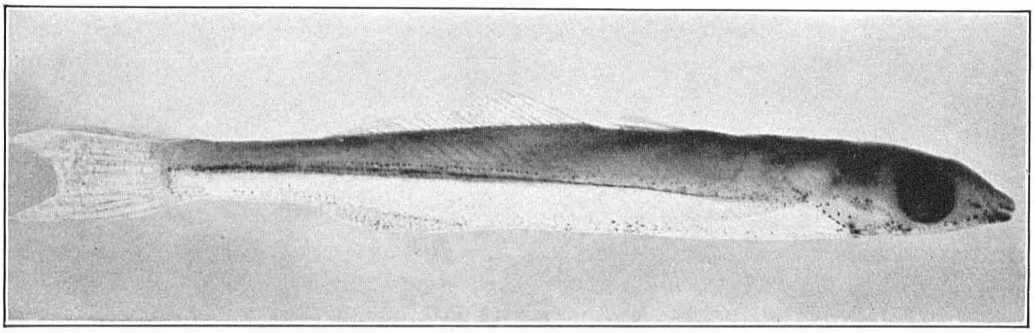

FIGURE 123.—*Labidesthes sicculus*, 27 millimeters

Family COTTIDÆ, Sculpins

54. Triglopsis thompsoni Girard. Deep-water sculpin; cockatush.

RECORD OF CAPTURE

Young specimens of this interesting cottid were taken in 1928 from the end of July until the middle of August in the deeper regions, the first time the species has ever been recorded in Lake Erie although adults had been found previously in all of the other Great Lakes (M. P. Fish, 1929 (1)). During 1929 none was taken. The species is interesting in that it is a relic of a former marine arctic fauna, a close relative of the present circumpolar genus *Oncocottus*, and degraded through fresh-water life from a species stranded here in glacial times.

DESCRIPTION

The slender body, elongate cavernous head, gill-membranes free from the isthmus, widely separated dorsal fins, and series of bony processes along either side of dorsal aspect and along ventral ridge behind the anus, and in larger specimens on

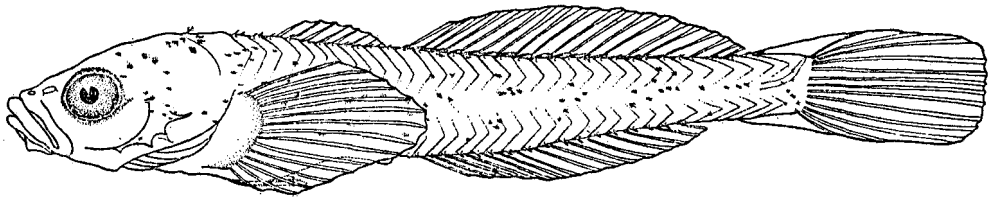

FIGURE 125.—*Triglopsis thompsoni*, 12.5 millimeters

dorso-lateral aspect halfway to lateral line from above vent to a point more than halfway to caudal, distinguish these specimens from all other sculpins taken.

12.5-millimeter stage.—Total length, 12.5; standard length, 10.25; length to vent, 5.0; length of head, 3.25; length of pectoral, 3.0; greatest depth, 1.8; diameter of eye, 0.6 millimeter. Myomeres, 10 to vent plus 23 behind. Dorsal VIII, 19; anal 15; pectorals 15; ventrals I, 4 on one side (in other specimens both sides I, 3), inserted directly below pectorals; caudal exceedingly long. Body very elongate and slender; elongate head, rather cavernous, with elliptical eyes smaller and interorbital space wider than in adult specimens (adult eye 4 in head, much wider than interorbital space and nearly as long as snout, while in these young it is 5.4 in head, slightly less than interorbital space and nearly as long as snout); low dorsal profile gently rising from terminal mouth to back of head, depressed between eyes; snout long and pointed in profile, rather spatulate from above. Rather long, slender, little curved preopercular spine, directed backward and upward, with 3 smaller spines below, the second directed backward, and the others downward; otherwise head unarmed. Body armature consisting of a double series of long, very sharp bony spines directed backward on either side of dorsal aspect from behind head to end of myomeres, and a similar ventral series from behind vent to end of anal fin (about 34 dorsal and 18 ventral). Gill membranes almost free from isthmus, forming only a broad fold across it; branchiostegals 6; dorsals rather widely separated; lateral line conspicuous.

Pigmentation.—A few small round chromatophores occur on top of head, smaller stellate ones between the eyes, and a few on sides of head and around base of pectorals.

A few are evident also on dorsal aspect of stomach region, very large and stellate in shape. Small round ones are arranged in 6 to 7 bands on sides of body extending obliquely from mid-dorsal line forward to a point midway between lateral and mid-ventral lines. These bands are not heavily marked but are made up of 6 to 12 small chromatophores. A few appear on lateral line near base of caudal. On mid-ventral line, there are about 6 widely separated ones to vent, and in more transparent specimens 9 subsurface chromatophores occur from vent to caudal in a single series just above the mid-ventral line.

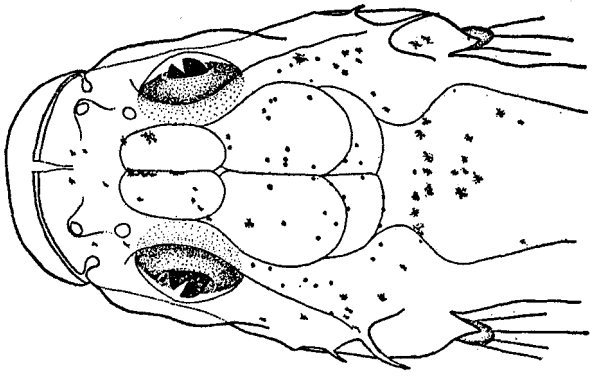

FIGURE 126.—*Triglopsis thompsoni*, 12.5 millimeters. Dorsal view of head

Figure 126 shows the dorsal aspect at this stage with interorbital space much wider than most fresh-water cottids, long spatulate snout, pointed in profile, tubular anterior nares; and long preopercular spine directed obliquely upward. The depressed cavernous nature of the head is not brought out in the drawing.

16.2-millimeter stage.—Dorsal VIII, 18; anal 15, pectorals 15; ventrals I, 4; caudal very long, rounded posteriorly. Total length, 16.2; standard length, 13.0; length to vent, 6.5; length of head, 4.2; length of snout, 1.0; diameter of eye, 0.8; greatest depth, 2.65; interorbital width, 0.9 millimeter. Myomeres, 10 to vent plus 23 behind. Changed from earlier stage principally in deepening of region behind head; heavier pigmentation; the partial covering by skin of preopercular spines, and addition of another series of spiny processes between the dorsal series and the lateral line extending from over vent to a point more than halfway to caudal.

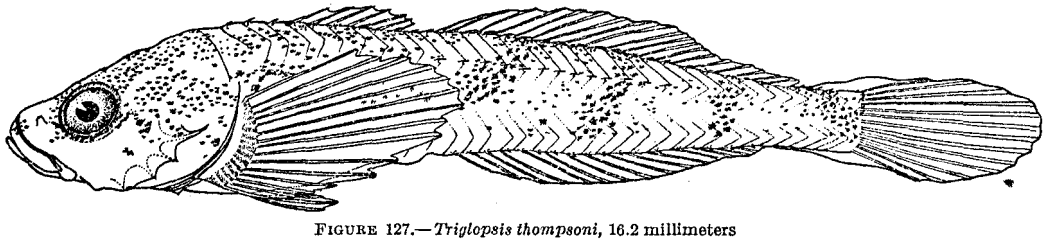

FIGURE 127.—*Triglopsis thompsoni*, 16.2 millimeters

Pigmentation.—The marking is intensified. A few chromatophores occur on upper jaw and many over top and sides of head. They are more or less concentrated over the back and extend downward to lateral line region from behind head to vent. Four broad, well-marked oblique bands behind vent, the last at base of caudal, originate on dorsal aspect and extend obliquely forward nearly to ventral aspect. The ventral aspect and all fins are colorless. The eye is very black.

There are certain characters which differ from the adult descriptions of *Triglopsis thompsoni*, but this species varies widely and our specimens are so small that it seems wisest to identify them thus, considering that these differences may be due to their immature condition.

55. Cottus bairdii kumlieni (Hoy). Lake sculpin, miller's thumb. [*Cottus franklini* Agassiz. Jordan, Evermann, Clark, p. 385.]

RECORD OF CAPTURE

The subspecies *kumlieni* is found in both shallow and deep waters of Lake Erie and the Niagara River. Although only one specimen was captured in 1928 (on June 11 over Seneca Shoal in a bottom Helgoland trawl at 10.5 meters), larvæ and post-larvæ were taken quite generally from June 7 to July 11, 1929, especially along the

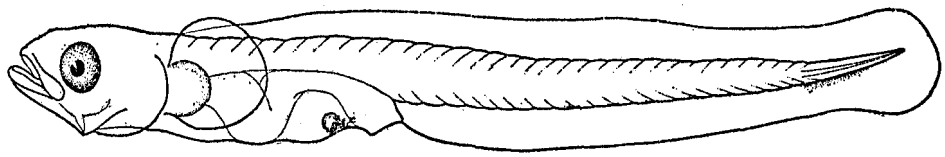

FIGURE 128.—*Cottus bairdii kumlieni*, 6.6 millimeters

Canadian shore from Long Point toward the far western portion of the lake. The subspecies found toward the headwaters of the tributary streams was *C. bairdii bairdii*.

DESCRIPTION

In the youngest stages it is quickly recognized by the single large chromatophore at vent, myomere count of 10 plus 23, and the maxillary reaching only to front of pupil, and later by its stouter body and lack of the even series of spines on the body characteristic of *Triglopsis*. The marginal fin-ray counts of all of our specimens range slightly higher than the usual number given in descriptions of adults, being consistently dorsal VI to VIII, 16 to 17; anal 12 to 15, but the variability of the sculpins is great and the increased number may be constant for this subspecies.

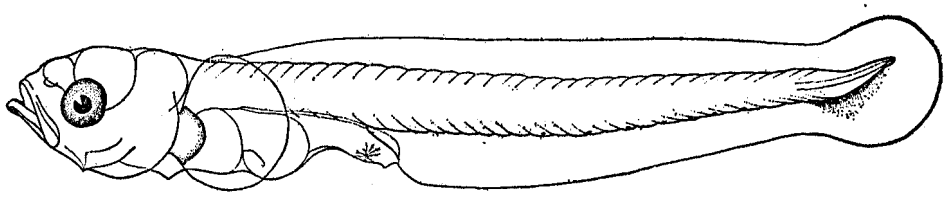

FIGURE 129.—*Cottus bairdii kumlieni*, 7.2 millimeters

6.6-millimeter stage.—Total length, 6.6; length to vent, 2.6; length of head, 1.15; snout, 0.3; diameter of eye, 0.31; greatest depth before vent, 0.9; depth behind vent, 1.1 millimeters. Myomeres, 10 to vent plus 23 behind. Distinguished by very long marginal fin-fold originating at nape, short intestine, very large unrayed pectorals reaching halfway to vent, very broad head with dorsal profile rounded above; lophocercal tail. Although the intestine already is coiled once, some yolk material remains, containing one moderate oil globule near vent.

Pigmentation.—The body is almost colorless except for a single very large, stellate chromatophore on underside shortly before vent, and 4 very small, hardly perceptible, linear-shaped ones on ventral margin of tail.

7.2-millimeter stage.—Total length, 7.2; length to vent, 3.1; length of head, 1.3; snout, 0.35; diameter of eye, 0.35; greatest depth before vent, 1.03; depth behind vent, 1.2 millimeters. Myomeres, 10 to vent plus 24 behind. Much like preceding

but whole body heavier. Stomach region deeper, intestine more convoluted, all trace of yolk material gone. Marginal fin fold as in preceding stage, but notochord turned slightly upward and concentration marking beginning of caudal ray development evident below.

Pigmentation.—Black eyes, a large single vent spot, and six tiny chromatophores along ventral ridge of tail characterize this larval stage.

10.0-millimeter stage.—Total length, 10.0; length to vent, 4.5; greatest depth, 1.5; diameter of eye, 0.5 millimeter. Myomeres, 11 to vent plus 23 behind. Dorsal

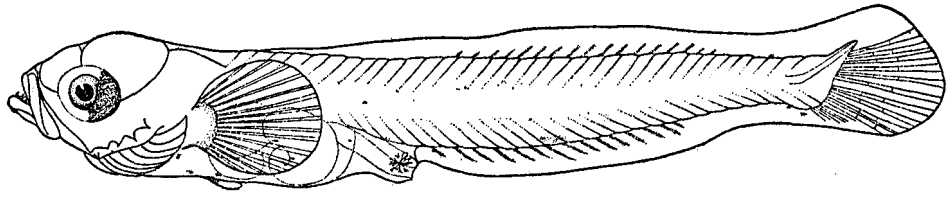

FIGURE 130.—*Cottus bairdii kumlieni*, 10 millimeters

marginal fin fold originating just behind head, rising evenly and slowly to the highest point about halfway between vent and peduncle; anal similar to dorsal; starting behind vent, 16 elements of dorsal fin rays, widely separated, and 13 anal below; ventrals I, 4, inserted just behind pectorals; pectorals 14, fully rayed, large, round; caudal rayed. Head and body stout to anus, compressed behind; interorbital space wider than in adult; eye rather small and bulging; mouth terminal, oblique, lower jaw projecting; preopercle with a short, straightish spine directed backward and upward, and two smaller spines below; subopercle with a stout spine directed downward.

Pigmentation.—Four surface chromatophores occur on ventral aspect at beginning of stomach region, 1 (subsurface) at base of left pectoral, 1 of very large size on

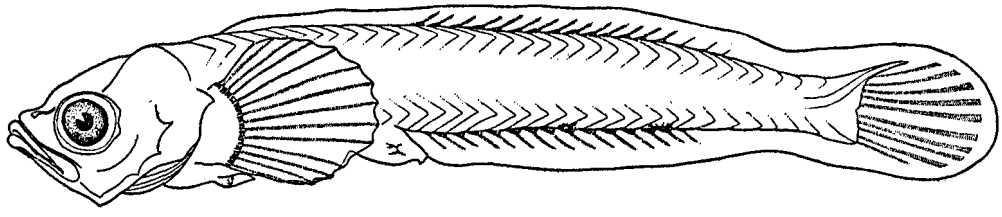

FIGURE 131.—*Cottus bairdii kumlieni*, later 10 millimeters

left side of intestine almost at vent, and 1 on ventral aspect slightly less than halfway from vent to end of body.

Later 10.0-millimeter stage.—Total length, 10.0; standard length, 9.0; length to vent, 4.16; length of head, 2.12; snout, 0.55; diameter of eye, 0.45; greatest depth before vent, 1.7; depth behind vent, 1.6 millimeters. Myomeres, 10 to vent plus 24 behind. Slightly older specimen of same length as preceding but with head further developed, and elements of dorsal and anal fins quite completely formed. Pectorals longer, reaching three-quarters of distance from base to vent.

Pigmentation.—Unchanged from preceding.

11.0-millimeter stage.—Total length, 11.0; standard length, 9.5; length to vent, 4.45; length of head, 2.6; snout, 0.75; diameter of eye, 0.6; greatest depth before vent, 2.1; depth behind vent, 1.3 millimeters. Myomeres, 12 to vent plus 22 behind.

Dorsal VII, 17; anal 14; pectorals reaching practically to vent; caudal well formed; ventrals I, 4. Resembling later stages in general characters, but body slightly more slender, fins lower, and heavy adult pigment lacking.

Pigmentation.—Chromatophores are limited to 2 on either side of head above eye, 1 at ventral extremity of each pectoral base, and 1 which forms the characteristic vent spot of earlier stages.

19.0-millimeter stage.—Total length, 19.0; standard length, 15.1; length to vent, 8.25; length of head, 5.0; diameter of eye, 1.75; greatest depth, 3.5 millimeters. Myomeres, about 12 to vent plus 23 behind. Dorsal VIII, 16; anal 12; ventrals I, 4. Body rather robust but more slender than *C. bairdii bairdii;* head very broad; preopercle with short, sharp, straightish spine turned upward and backward, with two smaller spines below; bones of head not cavernous; mouth terminal, oblique, maxilla to pupil; gill membranes attached to wide isthmus.

Pigmentation.—Small brownish chromatophores evenly cover dorso-lateral aspect of head and body and occur on and below the surface in brain region. Two wide bands obliquely cross dorsal ridge beginning at dorsal; another wider band extends down either side beyond the lateral line; and a fourth long bar appears at end of dorsal, followed by two or three small bars on caudal peduncle. Below the lateral line, pigmentation is in blotches with clear spaces between where skin is very white.

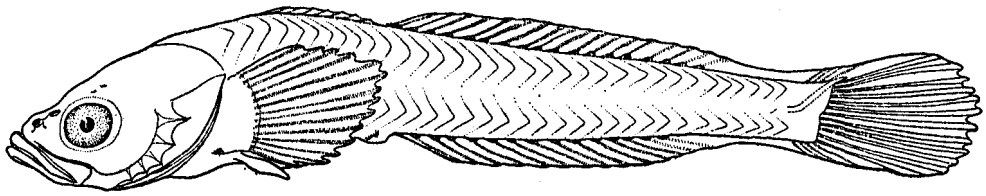

FIGURE 132.—*Cottus bairdii kumlieni,* 11 millimeters

Ventrally about 15 very small chromatophores occur in gill region, a series of about 9 on either side of anal, and a small group behind this fin. All fins but ventrals are spotted or barred with chromatophores.

56. Cottus bairdii bairdii Girard. Sculpin, miller's thumb. [*Cottus ictalops* (Rafinesque). Jordan, Evermann, Clark, p. 385.]

RECORD OF CAPTURE

A single larva 6 millimeters long taken in the far northwestern portion of the lake on July 2, 1929, differs from specimens of *C. bairdii kumlieni* found to the eastward. Its capture immediately off the Detroit River suggests the subspecies *C. bairdii bairdii,* which is common in the tributaries and which might under certain circumstances be carried into the lake itself. Sculpins vary so considerably that this may be identical with *kumlieni,* but the differences are sufficient to warrant a tentative separation.

DESCRIPTION

The present larva resembles *C. bairdii kumlieni* in myomere count (10 plus 22 or 23), but differs in its very large mouth, maxilla reaching to middle of eye whereas in the latter it reaches barely to front of pupil, a wider interorbital space, and a more conspicuous chromatophore series on ventral aspect of tail.

6.0-millimeter stage.—Total length, 6.0; standard length, 5.6; length to vent, 2.5; length of head, 1.2; diameter of eye, 0.35; greatest depth before vent, 0.9; depth behind vent, 0.35 millimeter. Myomeres, 10 to vent plus 22 (23) behind. Embryonic marginal fin fold originating over fifth myomere behind head (in *kumlieni* over first), with considerable concentration indicating formation of caudal rays in the still lophocercal tail (much more development than in *kumlieni* of 7.2 millimeters); large unrayed pectorals reaching halfway to vent; very broad head with longer and more pointed snout than in *kumlieni.*

Pigmentation.—Several chromatophores occur on ventral surface shortly before vent (but not as large nor stellate as in *kumleini*), and a conspicuous series of rather

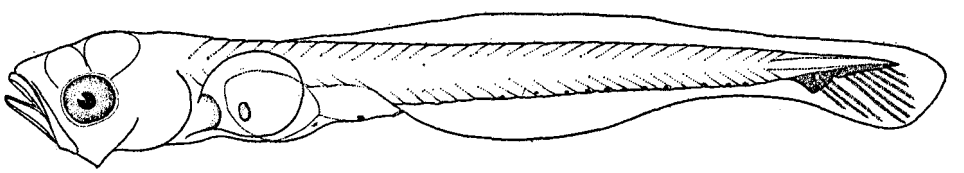

FIGURE 133.—*Cottus bairdii bairdii,* 6 millimeters

large rounded spots is evident along ventral surface of tail to caudal (very few, if any, small chromatophores in *kumlieni* of like size). The body is otherwise colorless.

57. Cottus cognatus Richardson. Muddler; miller's thumb; northern sculpin.

RECORD OF CAPTURE

During August, 1928, from the New York State line around the eastern end of the lake to Tecumseh Shoals on the Canadian side, specimens of this northern stream species were taken in small numbers but rather generally in Petersen and Helgoland

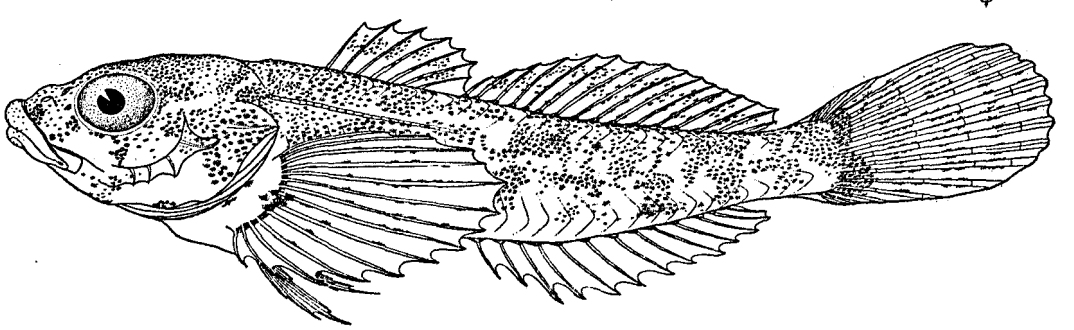

FIGURE 134.—*Cottus cognatus,* 18 millimeters

trawls from 16 to 23 meters. *C. cognatus* had not been recorded previously in Lake Erie.

DESCRIPTION

The young of this species closely resemble *C. bairdii kumlieni* in their rather short bodies, with gill membranes attached to the isthmus, but differ in having pelvic fin ray count I, 3.

18.0-millimeter stage.—Total length, 18.0; standard length, 14.0; length to vent, 8.0; length of head, 5.0; snout, 1.2; diameter of eye, 1.33; greatest depth before vent, 3.3; depth behind vent, 2.4; length to dorsal, 5.6; to anal, 8.5 millimeters. Myomeres, 10 to vent plus 19 behind. Dorsal VII, 17; anal 12. Body short and stout; snout not

very obtuse; maxillary to pupil; eye almost 4 in head; eyes rather close together; preopercular spine very long, hooklike, pointed upward and backward; dorsals contiguous; anal inserted under fourth ray of soft dorsal; lateral line incomplete; vent nearer caudal than tip of snout.

Pigmentation.—The whitish body is marbled with black chromatophores in a pattern similar to *Cottus baridii kumlieni* of like size, though more broken up.

21.5-millimeter stage.—Total length, 21.5; standard length, 17.8; length to vent, 9.2; length of head, 5.3; greatest depth, 4.3; diameter of eye, 2.0 millimeters. Myomeres, 10 to vent plus 19 behind (incomplete). Dorsal VIII, 17; anal 11; ventrals I, 3; pectorals not quite to vent.

Pigmentation.—The body is mottled with black as in the preceding stage. The definite greenish and reddish colors of adult specimens are not evident in these younger stages, except for a slight greenish tinge over the head.

58. Cottus ricei (Nelson). Rice sculpin.

RECORD OF CAPTURE

This species was taken on August 25, 1928, in a Helgoland trawl at 22 meters below the surface on Tecumseh Shoals, the first record of its occurrence in Lake Erie

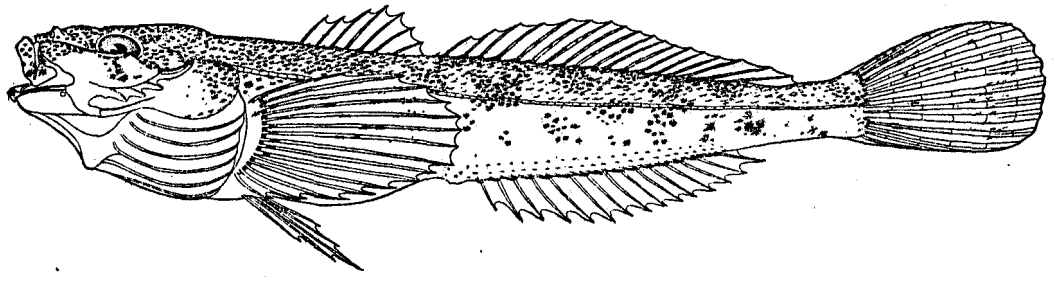

FIGURE 135.—*Cottus ricei*, 27.5 millimeters

(M. P. Fish, 1929). Other larger specimens were obtained by C. W. Greene from the stomach of a ling, which also was captured near Dunkirk in the same year.

DESCRIPTION

This one small sculpin differed from all others in its very long preopercular spine hooked backward and upward, complete lateral line, with numerous small prickles covering the body above, extending over top of head and between eyes, and with similar ones on ventro-lateral aspect of the tail.

27.5-millimeter stage.—Total length, 27.5; standard length, 23.0; length to vent, 12.0; snout, 2.0; length of head, 6.0; breadth of head, 6.4; greatest depth, 4.1; interorbital width, 1.4; diameter of eye, 1.5 millimeters. Dorsal VII, 18; anal 15; ventrals I, 4; pectorals 15, reaching to anal origin. Head very much depressed, broad and flat so that its breadth is greater than its length; outline rather tadpolelike; eyes closer together than in *Triglopsis* specimens; preopercular spine very long, hooked backward and upward, with a "buffalolike appearance"; other 3 spines hooked downward and the lowest concealed. Above lateral line space covered with stiff prickles, hooked backward, largest on either side of dorsal ridge, extending over top of head and between eyes. Lateral line complete.

Pigmentation.—The marking consists of irregular mottling of brown, especially over head and dorsal aspect, becoming scarcer over sides. Ventral aspect and ventrals are colorless. The other fins are mottled.

Family GASTEROSTEIDÆ, Sticklebacks

59. Eucalia inconstans (Kirtland). Brook stickleback.

RECORD OF CAPTURE

The brook stickleback, true to its name, was found in the many creeks tributary to Lake Erie and weed beds of the Niagara River, but never in the lake itself.

DESCRIPTION

The absence of lateral plates, only 5 or 6 dorsal spines, unkeeled tail, and rounded caudal are field characters which brand this stickleback immediately.

19.6-millimeter stage.—Total length, 19.6; standard length, 17.1; length to vent, 9.9; length of head, 5.4; greatest depth, 4.9; diameter of eye, 2.0 millimeters. Myomeres, 11 to vent plus 18 behind. Dorsal IV–I, 10 (spines short, even in length); anal I, 10; caudal rounded. Elongate body, but rather stout; caudal peduncle without a keel; smooth skin without any lateral plates; ventral spines small.

Pigmentation.—Chromatophores occur on both jaws, and thickly over top of head, so that the unpigmented pores are prominent on forepart of head. The chromatophores extend evenly and thickly down dorsal ridge and up over dorsal rays, evenly also on lateral aspect where they outline the myomeres. Some white patches of clear skin appear at intervals but not in a pattern. Ventral surface of head and stomach region is pale.

BREEDING

The brook stickleback is a nest-builder and defends its young with the utmost courage. During the breeding season the males become jet black, tinged everywhere with vivid copper color.

60. Gasterosteus aculeatus Linnaeus. Two-spined stickleback.

RECORD OF CAPTURE

A few young of this species were taken in weed beds of the Niagara River. They are of rare occurrence in the region.

DESCRIPTION

The two-spined stickleback is easily recognized by the single pair of large spines forming the first dorsal, implied by its name, the appearance of lateral plates, keeled caudal peduncle, and lunate caudal.

16.5-millimeter stage.—Total length, 16.5; standard length, 14.5; length to vent, 9.7; length of head, 5.0; snout, 1.6; diameter of eye, 1.65; greatest depth, 3.8 millimeters. Myomeres, 15 to vent plus 16+ behind. Dorsal II–I, 11; anal I, 9. Body fusiform; caudal peduncle short but very slender, distinctly keeled; bony plates on sides not yet evident in these young specimens.

Pigmentation.—The body is greenish in tinge but not as deeply colored as older stages. Chromatophores are arranged thickly over top of head and in about 10 short

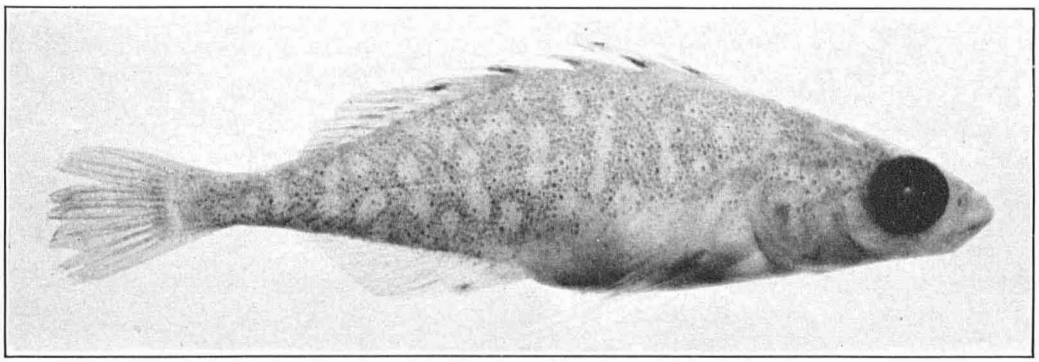

FIGURE 136.—*Eucalia inconstans*, 19.6 millimeters

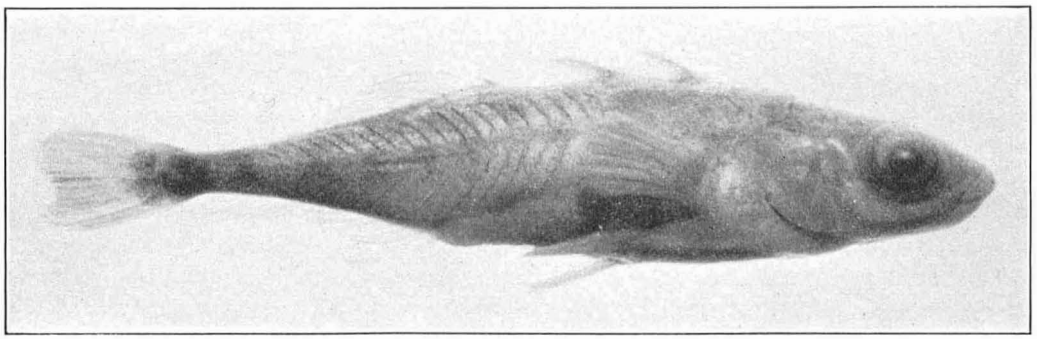

FIGURE 137.—*Gasterosteus aculeatus*, 16.5 millimeters

patches along dorsal ridge. There are five patches on lateral line which connect more or less with some of the dorsal groups by oblique bars, those of the tail region extending completely to ventral margin of body. Few chromatophores occur on fins except about the two dorsal spines and near the proximal extremity of caudal.

BREEDING

An elaborate nest is made by the two-spined stickleback from bits of grass and twigs on the sandy bottom of a stream. The male watches over the nest with great patience, fanning it with his fins to increase the circulation of water, and leaving only to search for food or drive off invaders. He is brilliant at this time, blue and green above and red below. It is reported that the male often kills his mate after spawning.

Family GADIDÆ, Codfishes

61. Lota maculosa (LeSueur). Ling; eel-pout; lawyer; gudgeon; burbot.

RECORD OF CAPTURE

Larval and postlarval stages, 3 to 15 millimeters, were quite common in meter-net hauls from 5 to 60 meters from the middle of June to the middle of August, 1928,

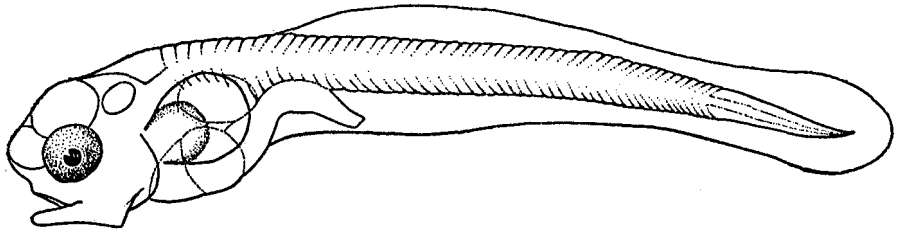

FIGURE 138.—*Lota maculosa*, 3.5 millimeters

especially in the deep hole off Long Point, and from the first week of June until the middle of July, 1929.

DESCRIPTION

The typical rounded gadoid head and very numerous myomeres render the earliest stages readily identifiable, and the elongate marginal fins, chin barbel, and isocercal tail mark the older specimens as essentially different from any other lake species.

3.5-millimeter stage.—Total length, 3.5; standard length, 3.25; length to vent, 1.5; greatest depth, 0.7; diameter of eye, 0.25 millimeters. Myomeres fairly well developed, about 14 to vent plus about 38 behind. Embryonic marginal fin fold originating over the fifth myomere behind head, rising to its highest point just behind vent, tapering gradually to caudal region, and continuing thence forward along ventral side of stomach region, identical with the dorsal. Intestine ending blindly at a distance from the body, but not quite at edge of marginal fin, as in cod, haddock, and pollock. Bulbous forehead making mouth inferior, lower jaw slightly protruding; eye about median in head. Larva characterized chiefly by the very transparent, colorless, slender body with many myomeres, relatively short intestine, lophocercal tail, well-developed rounded pectorals, and pigment confined to the dark eyes.

4.5-millimeter stage.—Total length, 4.5; standard length, 4.35; length to vent, 1.75; greatest depth, 0.95; diameter of eye, 0.4 millimeters. Myomeres, 14 to vent

plus 36+behind. Forehead starting to recede although still much rounded and projecting no farther than tip of upper jaw.

Pigmentation.—One black chromatophore is evident on each side over posterior part of air bladder.

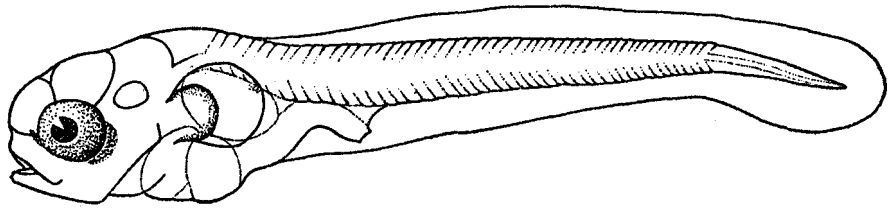

FIGURE 139.—*Lota maculosa*, 4.5 millimeters

6-millimeter stage.—Total length, 6.0; standard length, 5.7; length to vent, 2.5; greatest depth, 1.1; diameter of eye, 0.4 millimeters. Dorsal contour of head more sloping than before, mouth terminal, and lower jaw slightly projecting.

Pigmentation.—The body retains the transparent colorless condition of preceding stages, relieved only by the addition of a double line of five large stellate subsurface chromatophores over dorsal aspect of air bladder (scarcely evident in fig. 140).

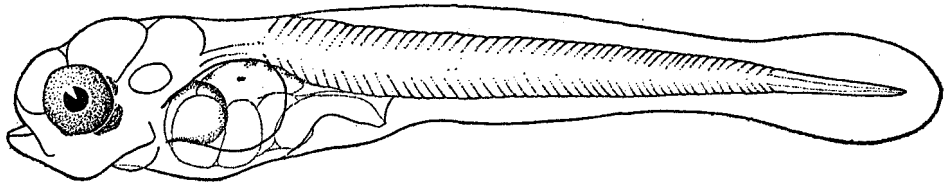

FIGURE 140.—*Lota maculosa*, 6 millimeters

6.8-millimeter stage.—Total length, 6.8; standard length, 6.6; length to vent, 3.0; greatest depth, 1.5; diameter of eye, 0.5 millimeters. Myomeres, 15 to vent plus 40 behind. Following the stage shown in Figure 140, larva apparently grows in depth and breadth more rapidly than in length, for in Figure 141, although the specimen drawn is only eight-tenths of a millimeter longer than in the preceding, the body is

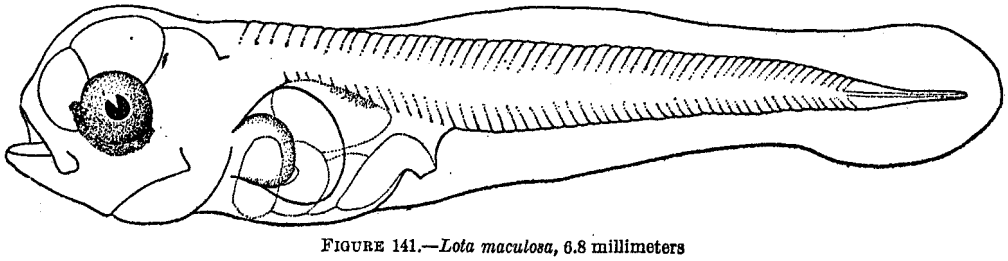

FIGURE 141.—*Lota maculosa*, 6.8 millimeters

much heavier so that the depth is contained 4.53 in total length, as compared with a proportion of 5.4 in the smaller specimen. Fins unchanged.

Pigmentation.—The only color difference consists in the addition of a few more chromatophores over stomach region.

10.9-millimeter stage.—Total length, 10.9; standard length, 9.6; length to vent, 5.0; greatest depth, 2.1; diameter of eye, 0.8 millimeters. Myomeres, 20 to vent plus 32 behind. Second dorsal about 67 rays; anal about 64 rays (incomplete). Many of

the later characters of the adult evident especially in contour of head and mouth; barbel represented by a large fleshy protuberance; intestine open at margin of body; ventrals apparent below pectorals; deep notching of marginal fin fold marking out position of the two dorsals, and most of dorsal, anal, and caudal rays indicated. Body ending in a straight point forming an isocercal tail.

Pigmentation.—Chromatophores are confined to the subsurface patch above stomach region and about 25 rather large roundish black spots distributed over

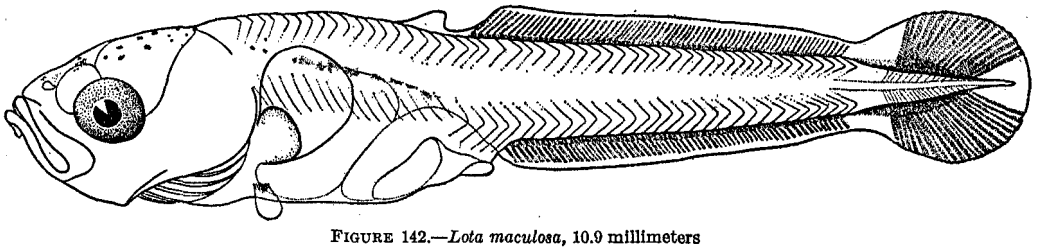

FIGURE 142.—*Lota maculosa*, 10.9 millimeters

top of head, followed by subsurface chromatophores hardly discernible over anterior part of notochord (possibly continuing for its entire length).

14.0-millimeter stage.—Total length, 14.0; standard length, 13.2; length to vent, 7.0; greatest depth, 2.75; diameter of eye, 1.0 millimeters. This stage differs from the adult in slightly shorter upper jaw. Marginal rays entirely formed at this stage, and sections of embryonic fin persist to connect caudal with dorsal and anal fins; ventrals larger and completely rayed.

Pigmentation.—A few stellate chromatophores occur on both jaws, followed by very distinct preorbital, postorbital, and opercular patches which give the impression

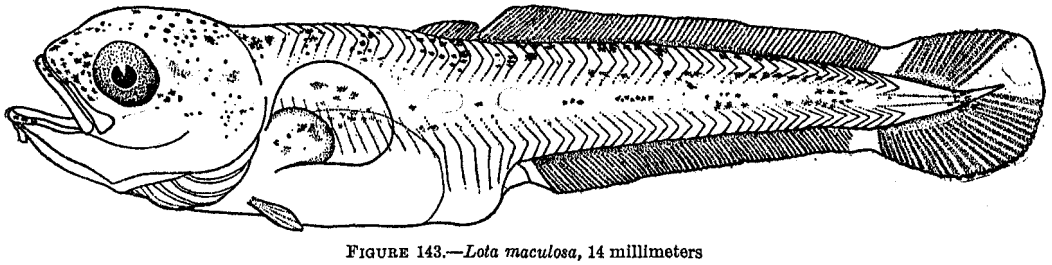

FIGURE 143.—*Lota maculosa*, 14 millimeters

of a lateral pigment band on either side of head. Many large chromatophores are massed over top of head. Lateral line is marked by a single broken series of large chromatophores extending to the extreme caudal region, becoming wider with more numerous and smaller subsurface spots toward the end. Dorsal aspect has numerous pigment spots arranged irregularly in 10 to 12 groups, each one consisting of a double row of large, close-set chromatophores outlining dorsal fins and others more sparsely distributed extending halfway to lateral line. Although the breaks in dorsal and lateral series do not necessarily coincide, a somewhat banded impression is given, emphasized in older specimens.

19.0-millimeter stage.—Total length, 19.0; standard length, 17.0; length to vent, 9.5; greatest depth, 3.15; diameter of eye, 1.2 millimeters. Characters essentially same as in preceding stage, except for completely formed fins and barbel, and intensified pigmentation. The identification of these postlarval and young-fish

stages is rendered easy by the very long marginal fins, and the persistent isocercal tail which no other local species exhibits.

30.5-millimeter stage.—Total length, 30.5; length to vent, 15.5; greatest depth, 5.0; diameter of eye, 1.8 millimeters. Dorsal 11 to 13, 66–67; anal 60–67; ventrals 7. Myomeres, 21 to vent plus 38 behind.

Pigmentation.—Top and sides of head down to posterior margin of eye are thickly pigmented, most heavily in a band through eye from tip of snout to opercle. Only an occasional chromatophore is evident below eye, and a few outline the lower jaw. Dorsal and lateral aspects are patterned with irregular groups of chromatophores, giving a checkered or marbled effect. Ventral side is unmarked except for a double series of about 20 chromatophores along base of anal fin. A few chromatophores occur on all fins except anal.

A young burbot, 178 millimeters in total length, representing probably a 1-year-old fish, was seined at the mouth of Silver Creek on September 4, 1928, by J. R. Greeley, who states in a letter to the author, "I have known of *Lota* about this size

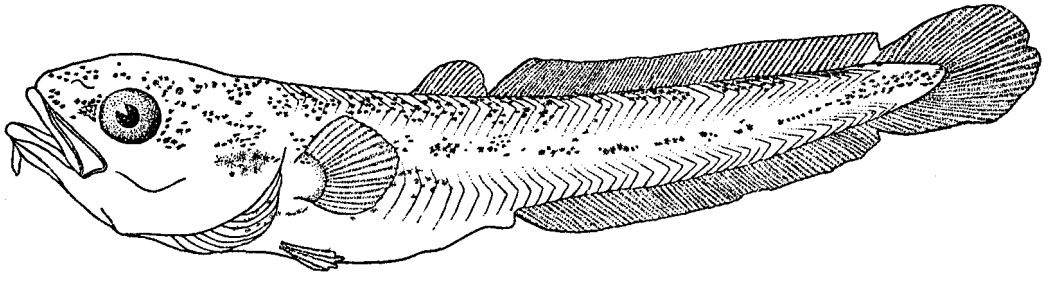

FIGURE 144.—*Lota maculosa*, 19 millimeters

being taken in creeks, and call to mind one collection of several specimens that came from Canandaigua Lake inlet, collected by Doctor Eaton of Hobart College."

BREEDING

Little is known of the breeding habits of the ling, but adults are reported full of spawn from November until March. Our records of early larvæ would indicate that hatching occurs in early summer, up until the last week of June.

62. Species A.

RECORD OF CAPTURE

Eighteen larvæ ranging from 5.3 to 6.8 millimeters long were taken on July 1 and 2, 1929, along the far western shore of Lake Erie in comparatively shallow water.

DESCRIPTION

The present specimens differ considerably from all others taken by the survey. They are characterized by a short intestine as in the cottids and centrarchids, but the compressed head eliminates the former possibility, and the slender elongate body is unlike that of the larval *Micropterus*, the only member of the sunfish family whose young are known. In the absence of further stages, no attempt at identification is made.

5.1-millimeter stage.—Total length, 5.1; standard length, 5.0; length to vent, 2.1; length of head, 0.9; diameter of eye, 0.37; greatest depth before vent, 0.66; depth

behind vent, 0.34 millimeter. Myomeres, 10 to vent plus 18 behind. Characterized by the long slender body, short intestine, very large air bladder, rounded dorsal contour of head, and large, low, oblique mouth.

Pigmentation.—Chromatophores are scattered sparsely over top of head, nape, and on body above pectorals. Others are massed over dorsal aspect of air bladder. A double or irregular single series occurs in jugular region to below front of air bladder. One large stellate spot is apparent on top of intestine immediately before vent, and a double series along ventral aspect of body from vent to caudal. There are four or more linear chromatophores along lateral line behind vent.

6.5-millimeter stage.—Total length, 6.5; standard length, 6.2; length to vent, 2.8; length of head, 1.2; diameter of eye, 0.46; greatest depth before vent, 0.9; depth behind vent, 0.5 millimeter. Myomeres, 10 to vent plus 18 or 19 behind. Generally as before but pigment intensified. Dorsal marginal fin fold originating about seventh myomere behind head; tail lophocercal but beginning of caudal rays evident below.

Pigmentation.—Chromatophores are numerous over top of head, eye, lower jaw, and sides of head. The jugular, lateral, and ventral series have many more chromatophores than in preceding stage. Dorsal chromatophores occur from head to origin of fin fold, and near tip of tail.

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