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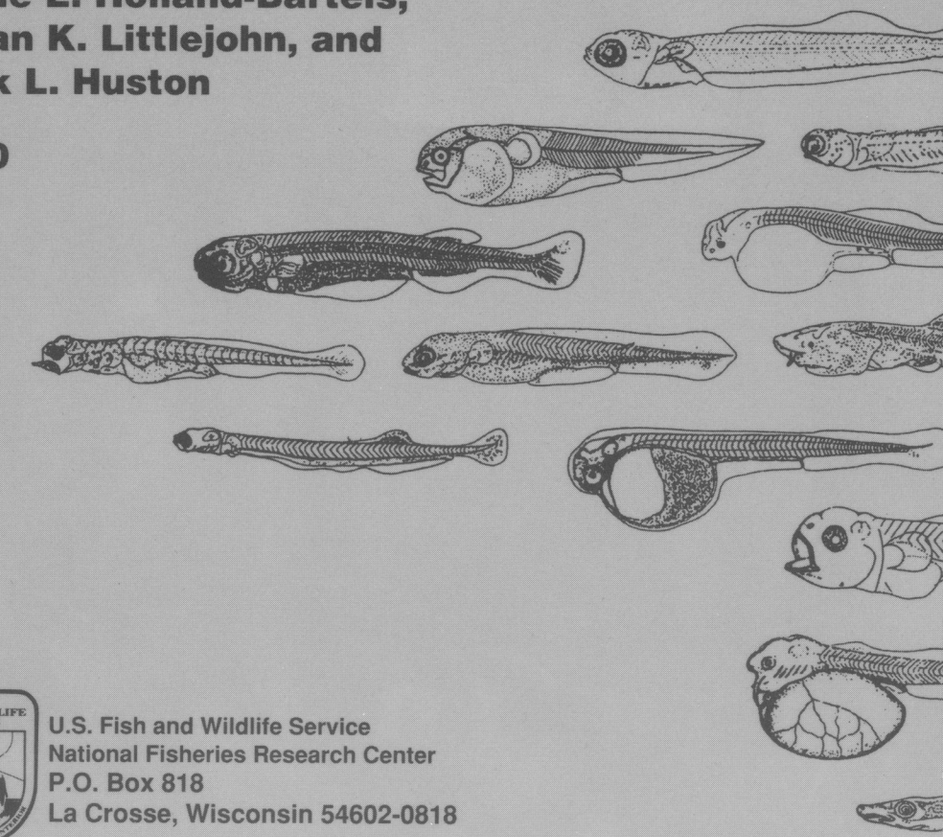
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A GUIDE TO Larval Fishes of the Upper Mississippi River

Leslie E. Holland-Bartels,
Susan K. Littlejohn, and
Mark L. Huston

1990



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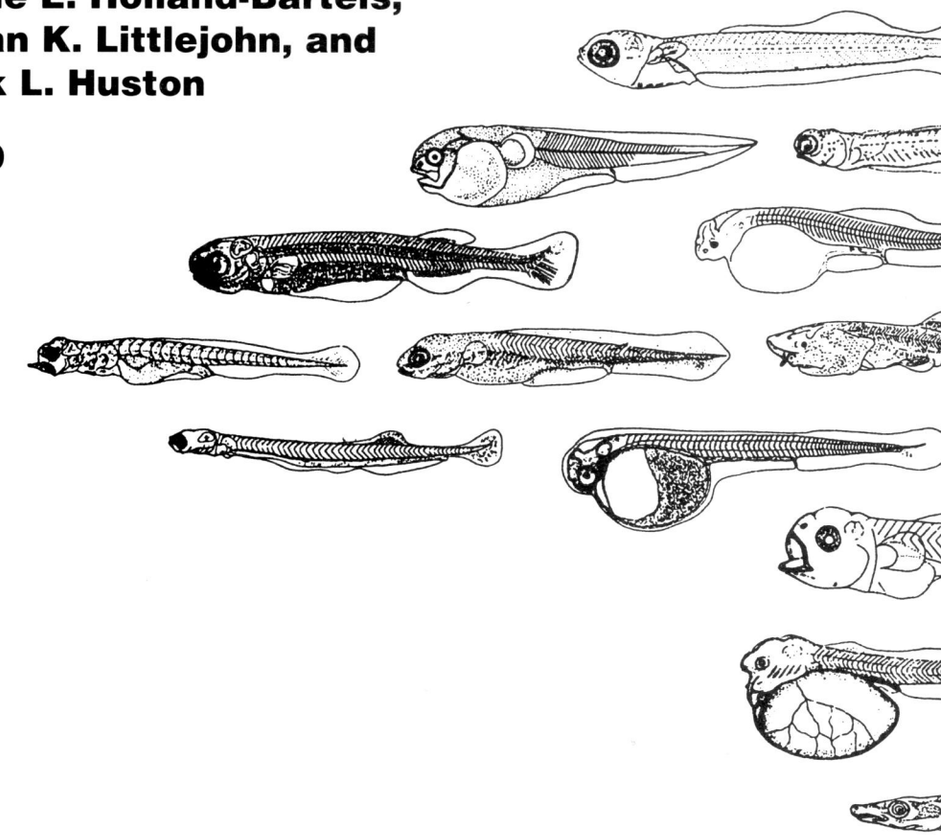
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A GUIDE TO Larval Fishes of the Upper Mississippi River

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Preface

This document was completed with funding provided by the U.S. Fish and Wildlife Service and Rock Island District of the U.S. Army Corps of Engineers as one of the studies recommended by the Great River Environmental Action Team (GREAT). River studies by GREAT were authorized under Section 117 of the Water Resources Development Act of 1976 (P.L. 94-587) and the Upper Mississippi River System Master Plan (P.L. 95-502). These studies evolved from controversy between commercial navigation and environmental interests on the Upper Mississippi River. The first studies, completed in 1976-1982, resolved some conflicts and shed light on others, but also revealed the magnitude of data gaps related to the river environment. Funds to complete studies that would fill some of the data gaps were appropriated in 1982 as part of the GREAT Implementation Program of the Rock Island Corps of Engineers District.

We thank the Fish and Wildlife Interagency Committee, which is responsible for overseeing the implementation of the GREAT II environmental program, for making recommendations to the River Resources Coordinating Team and for critically reviewing various drafts of this work. We also thank Thomas Hornung, Jerry Broughton, Thomas Kammer, and Georginia Ardinger for assisting in the completion of this project and Dr. John Van Conner for providing useful materials.

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1 Introduction

Many of the people responsible for studying and managing fishery resources on the Upper Mississippi River (UMR) are unfamiliar with larval fish identification and ecology. These people need training to increase their knowledge and skills in order to fulfill their roles as stewards of our fishery resources. Such training can be time consuming and labor intensive, especially if each group responsible for early life history projects undertakes its own literature review and training. A major obstacle to proper training has been the lack of a comprehensive information source on identification of early life history stages of UMR fishes. Local sources of expertise are available in the region, but comprehensive compilation of available data has been critically needed so that Master Plan recommendations could be successfully implemented. In *Larval Fishes of the Upper Mississippi River* we have attempted to combine data from the literature with our own data to provide such a compilation.

We hope that this publication will significantly reduce the training and literature search time and promote the study of the early life history of fishes in the Upper Mississippi River and perhaps other similar river systems.

The Mississippi River has a drainage basin of nearly 4 million km^2 and is one of the largest and most productive aquatic systems in the world. The river above the confluence of the Ohio River is commonly called the UMR System (fig. 1). Nearly 500,000 km^2 of watershed are included in this section of the river. The system is characterized by extensive development for industry, navigation, and flood control.

The UMR System contains more than 2,000 km of waterways that have been developed and are being maintained for commercial navigation. In the main stem of the UMR, a series of terraced pools formed by a system of locks and dams facilitates the passage of commercial vessels. Habitats in a "typical" pool include a braided channel, a lotic area at the head of the pool, and a lentic environment above the impounding lock and dam (Van Vooren 1983). The pools often include quiet backwaters and sloughs, as well as fast current main channel habitats. Despite alterations of the former natural system, or perhaps because of them, the UMR maintains a diversity of fish fauna. Nearly 150 species of fish have been collected in the river and adjoining waters. Of these, about half occur with some regularity in collections of adult fish and may be collected in the ichthyoplankton.

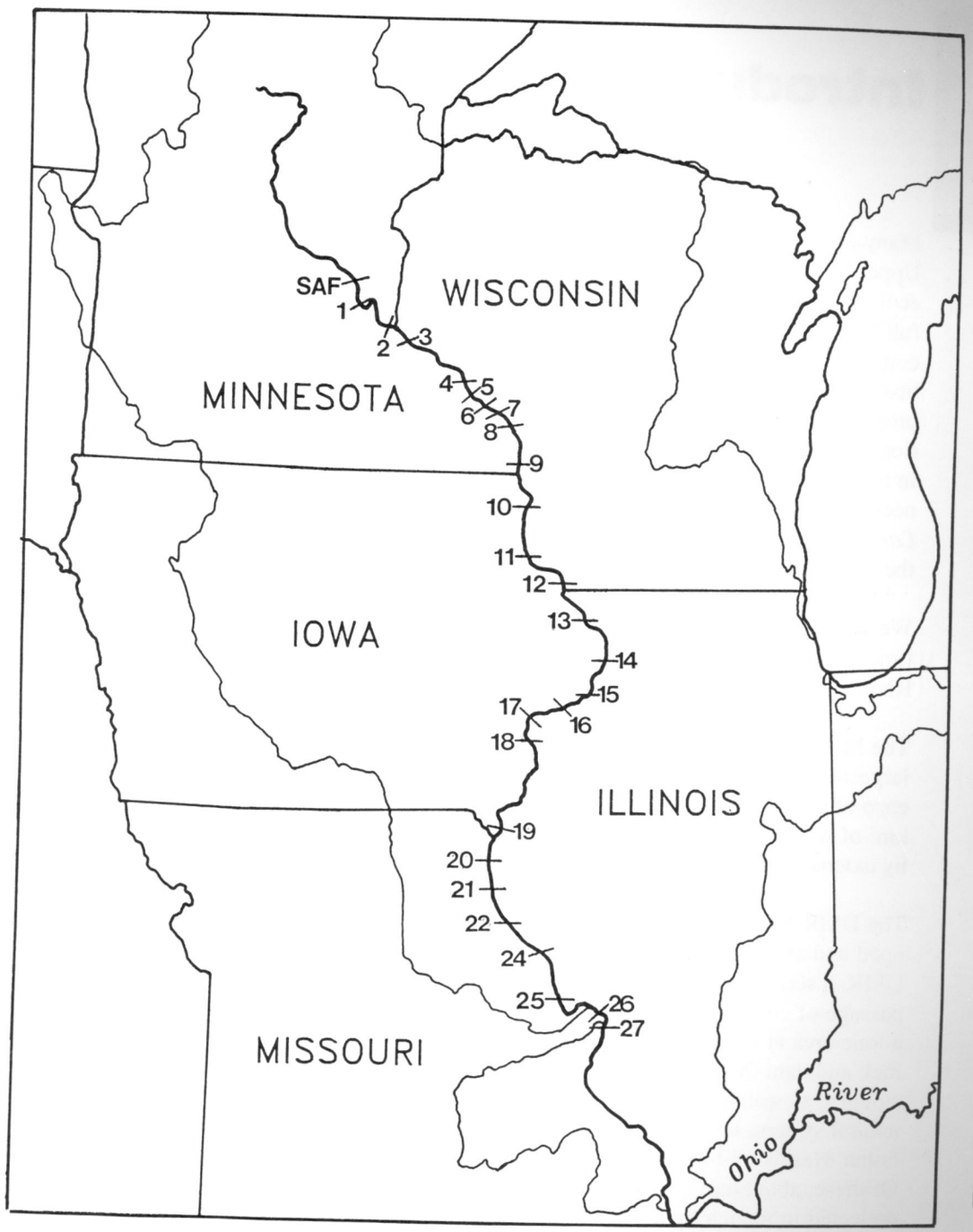


Figure 1. The Upper Mississippi River System, showing the locations of pools, extending from Pool 26 to Pool 1; St. Anthony Falls locks (SAF).

2 Identification of Larval Fishes of the Upper Mississippi River

The developmental process in fishes is a continuum of changes, unlike the distinct stages of many invertebrates. It is necessary, however, to divide the early life of fishes into stages in order to make comparisons of species at certain points in their development. The terminology of Snyder (1976) has been adapted for use in the present work and is included in the definitions provided below.

Egg: Although this term is sometimes applied to gametes in the ovaries, in this document it refers to an embryo unless otherwise indicated.

Larva: This is the stage of obvious fin morphogenesis; it extends from hatching to development of the adult complement of fin rays. Certain families, such as the Ictaluridae, have no true post-yolk-sac larval stage. As the yolk sac is absorbed, the young catfish develops a full complement of principal rays and is then considered to be in the early juvenile or alevin stage.

Yolk-sac larva: This stage extends from hatching to complete absorption of the yolk sac.

Protolarva: This stage is characterized by an absence of distinct spines or rays in the median fins. It often includes the yolk-sac stage.

Mesolarva: A stage that begins when at least one fin ray or spine is present in future median fins.

Metalarva: The stage characterized by a full adult complement of principal rays in median fins, but may not have fully developed paired fins.

Juvenile: The stage when a full complement of spines and rays, including secondary rays, is present in all fins. Segmentation is evident in a few of the rays in each fin (in species in which fins of adults are segmented). Finfolds and atrophying fins must be absorbed. Fish in this stage are not sexually mature.

Adult: The stage when a fish is sexually mature.

The successful identification and study of larval fishes is a process of elimination. Knowledge of the typical spawning temperatures, locations, and substrates used by a species (table 1) is the first step in determining if a species might be present in a collection. An ecological classification of fishes based on reproductive strategies, such as that developed by Balon (1975) is useful in the elimination process and in the design of taxonomic studies.

Table 1. Spawning characteristics reported for selected fishes of the Upper Mississippi River. See individual species descriptions (Part 4) for references.

Species	Spawning temperature (°C)	Spawning Habitat
Acipenseridae		
Scaphirhynchus platorynchus	19-21	Open channel, over gravel, strong current, eggs attached
Polyodontidae		
Polyodon spathula	15-16	Sand-gravel bars, swift water
Lepisosteidae		
Lepisosteus osseus	19-21	Backwaters, over vegetation
L. platostomus	19-24	Backwaters, over vegetation
Amiidae		
Amia calva	16-19	Nests, shallow weedy sites
Clupeidae		
Dorosoma cepedianum	17-23	Protected bays, inlets, shallow water
Hiodontidae		
Hiodon alosoides	10-13	Pools or backwaters of turbid rivers
H. tergisus	12-15	Clear streams
Esocidae		
Esox lucius	4-11	Marshes, shallow marginal areas with vegetation
Cyprinidae		
Cyprinus carpio	15-25; optimum 18-23	Quiet backwaters
Notemigonus crysoleucas	20-27	Vegetation
Hybopsis aestivalis	>21	Swift current deep water
H. storeriana	19; peak 23	In pelagic zone of streams
Notropis atherinoides	22	Sand or firm mud, shallow water
N. blennius	—	Over gravel and sand bottoms
N. dorsalis	—	In creeks, small rivers; occasionally, large rivers, over sand and gravel
N. hudsonius	15-20	Sand shoals or gravel riffles
N. lutrensis	25; 16-29	Clean gravel riffles or submerged objects
N. spilopterus	21-24	Crevices on undersides of submerged objects
N. stramineus	21-27	Shallows, in protection of submerged vegetation, over sand and gravel
N. volucellus	—	Fairly deep water in weedy littoral areas
Pimephales notatus	21-26	Sand gravel bottoms, on submerged objects, nests under flat objects

Table 1 continued

Species	Spawning temperature (°C)	Spawning Habitat
P. promelas	16-18	Underside of hard surfaces, over substrate of sand, marl, or gravel
P. vigilax	>26	Ponds, shallow pools, nest under submerged objects
Catostomidae		
Carpiodes carpio	18-24	Scattered over bottom, flooded marshes or low-lying meadows
C. cyprinus	19-28	Over sand, gravel, or mud, in overflow areas
C. velifer	19-28	Shallow areas, overflow ponds of streams
Catostomus commersoni	7; 10	Streams
Ictiobus bubalus	16-18	Quiet waters, flooded areas
I. cyprinellus	16-18	Rock riprap, quiet water, shallow
Minytrema melanops	15-18	Riffles over large pools
Moxostoma anisurum	14	Shallow riffles, main channel waters over rocks, gravel, and rubble
M. erythrurum	17-22	Low ends of pools, riffles, over loose gravel
M. macrolepidotum	8-16	Tributaries, shallow riffles
Ictaluridae		
Ictalurus melas	21	Shallow water, ponds, streams, nest beneath vegetation
I. natalis	—	Shallow water, nest protected by stumps or stones
I. nebulosus	21-25	Nest, sand, or gravel, near submerged objects
I. punctatus	21-29	Nests in need or under ledges, protected or weedy areas
Pylodictis olivaris	24-25	Nests near submerged objects
Aphredoderidae		
Aphredoderus sayanus	—	Nest or gill cavity brooders
Percopsidae		
Percopsis omiscomaycus	16-20	Shallows, lakes, or streams, over sand or gravel
Gadidae		
Lota lota	1-2	Backwaters, over sand or gravel
Cyprinodontidae		
Fundulus notatus	—	Vegetation

Table 1 continued

Species	Spawning temperature (°C)	Spawning Habitat
Atherinidae		
Labidesthes sicculus	>20	Gravel shoals or vegetation beds
Percichthyidae		
Morone chrysops	13-26	Shallow water, tributaries, or gravel areas
M. mississippiensis	16-20	Tributaries, gravel areas, demersal eggs
Centrarchidae		
Ambloplites rupestris	16-21	Nests near vegetation, sand, gravel, or marl bottom
Lepomis cyanellus	16-28	In shelter of logs, rocks, or vegetation
L. gibbosus	20-28	Low current, ponds, lakes, or creeks, nests
L. humilis	18-32	Low to intermittent flow, more turbid areas, nests or no nests
L. macrochirus	17-31	Shallow backwaters, next in sand or gravel
Micropterus dolomieui	12-21	Sheltered areas, current over gravel or sand
M. salmoides	17-18	Shallow backwaters, nest in sand, gravel, or vegetation
Pomoxis annularis	14-23	Nests in deeper water over many substrate types
P. nigromaculatus	18-20	Nest in vegetation or undercut banks
Percidae		
Ammocrypta clara	—	—
Etheostoma nigrum	12-21	Underside of rocks or other objects
Perca flavescens	7-11	Littoral zones over sand or gravel, usually by macrophytes
Percina caprodes	10-15	Gravel or sand riffle areas
P. shumardi	9-12	Shallow side chutes or riffles, over rock, sand, or gravel
Stizostedion canadense	4-6	Shallow shoals, over rock or gravel
S. vitreum	3-10	Over rocky areas below dams, gravelly shoals, outer bends of river channel, emergent vegetation in flooded river borders
Sciaenidae		
Aplodinotus grunniens	19-22	Open water near surface

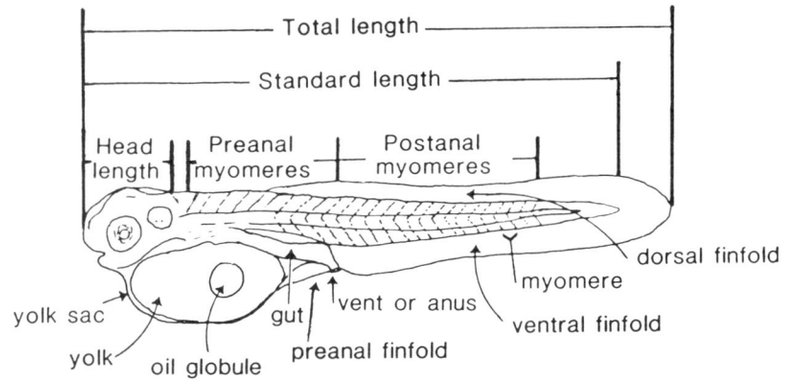


Figure 2. Meristic and morphometric characteristics commonly used to identify larval fishes.

After ecological requirements have been considered, several primary morphometric and meristic characteristics are used in the identification of larval fishes (fig. 2). These include muscle segments, fin ray or spine counts, fin development, body measurements, and pigmentation. Some of the more useful characteristics are defined and summarized below (Snyder 1981):

Myomeres: These muscle segments are clearly evident in larval fishes when viewed with a dissecting microscope. The use of a pair of polarizers, one above and one below the specimen, greatly increases the visibility of myomeres. (Note: myomeres in larvae that have been stained to facilitate sorting are difficult to count under polarized light.) Myomeres are relatively consistent in number and position and are most useful in the identification of protolarvae and mesolarvae. Myomeres have nearly a one-to-one relationship with vertebrae. (Vertebrae cannot be counted unless the larvae have been cleared and stained.) Typical myomere counts used include total, preanal, and postanal numbers.

Partial counts are used to describe the locations of pigmentation and structures other than the vent.

Postanal and preanal myomeres: Postanal myomeres represent all complete myomeres posterior to a line drawn through the body at the posterior end of the anus. All other myomeres in front of or bisected by the line are considered to be preanal. Myomere counts are presented as preanal + postanal throughout this work (e.g., shovelnose sturgeon 33-34 + 20).

Fins and Finfolds: Fin ray counts and fin positions of the adults can sometimes be used to identify larvae, especially late mesolarvae and metalarvae. The sequence and timing of development, as well as the lengths of the fins, are useful.

Median finfold: Most obvious in protolarvae and early mesolarvae.

Preanal finfold: A secondary median finfold that may be absent.

Caudal fin: The first fin to become differentiated in most fishes.

Dorsal and anal fins, pelvic fins, pectoral fins: The position and number of rays in these fins are useful in identification.

Other Countable Structures: Branchiostegal rays, gill rakers, pharyngeal teeth, and scales are often useful in the identifying of adults. Branchiostegal rays develop early, are usually constant within major taxonomic groups, and may be helpful in identifying larvae. The other characteristics are of little use in identifying early developmental stages.

Morphology: The shapes of larvae and of anatomical structures provide obvious characteristics, particularly at the family and subfamily levels. Examples: lengths—total (TL), standard (SL), snout-to-vent, preanal, predorsal, prepelvic, head, eye, snout, and fin—and body depth and width.

Pigmentation: This characteristic should be used with caution because preservation may alter pigmentation. Natural variations can be considerable.

Preanal length, as a percent of total length (tables 2, 3), is one of the physical characteristics most often used to separate larvae to family level. Extremes in preanal lengths are found in the Clupeidae (preanal length more than 75% of total length) and the Atherinidae (27 and 30%). Myomere and vertebral counts and total lengths of larvae during specific developmental stages can often be used to bring the identification to species (table 3).

Table 2. Summary of preanal length as a percentage of total length for certain larval fishes of the Upper Mississippi River System.

Larval stage and percent of total length	Species
Protolarva	
≥75	*Alosa, Dorosoma*
68-75	Most *Esox;* some common carp (up to 69%); all catostomids; few hatchling *Notropis* (up to 69%); very young *Notemigonus* (up to 69%)
57-67	Common carp and most cyprinids, very young *Morone*
46-56	Many *Morone* after the yolk has been absorbed; percids; a few hatchling Micropterus; very few young drum (up to 46%); most cyprinids; Percopsis
40-45	Most Micropterus; most Lepomis; most Aplodinotus
30-39	Pomoxis; Lota lota
20-30	Labidesthes; Fundulus
Mesolarva	
≥75	Alosa; Dorosoma
67-75	Common carp; catostomids
57-67	Hiodon; cyprinids except common carp; all known darters
50-56	Morone; Stizostedion
48-50	Few Aplodinotus
42-47	Micropterus; Lepomis; Aplodinotus
36-41	Pomoxis
28-30	Labidesthes; Fundulus

Table 3. Ranges of total length (TL), preanal length as a percentage of total length, typical myomere counts (extremes in parentheses), and vertebra count in larvae of selected Upper Mississippi River fishes (modified from J. V. Conner, Gulf States Utilities Company, St. Francisville, Louisiana, personal communication, with additions from original research and data from studies referenced in Part 4)[a].

Species	Total length (mm) and (in parentheses) preanal length as percent of total length[a]			Myomere count[b]		Vertebra count[b]
	Protolarva	Mesolarva	Metalarva	Preanal	Total	
Polyodon spathula	7.5-12.0 (53)	— (51.5)	— (—)	31-35	51-59	—
Amia calva	— (—)	— (—)	— (—)	—	60	80-90
Lepisosteus osseus	— (—)	— (64.5)	— (57)	—	—	—
Alosa chrysochloris	5.2- 6.5 (76-79)	6.5-15.0 (76)	15.0-21.0 (63-65)	—	—	—
Dorosoma cepedianum	3.3-12.0 (80-89)	10.5-14.8 (84)	14.5-24.0 (64-75)	—	(32) 45-50	48-51
D. petenense	3.4-11.0 (82-84)	10.8-15.0 (86)	14.7-21.0 (63-82)	—	—	40-45
Hiodon alosoides	— (62)	— (57-59)	— (56-58)	29-35	Postanal ≥24	—
H. tergisus	7.3-11.5 (62)	11.5-20.0 (57-59)	20.0-35.0 (56-58)	29-35	Postanal ≤24	—
Esox lucius	9.0 (—)	— (—)	— (—)	31	46+	—
Cyprinus carpio	3.0-9.0 (58-71)	9.0-11.5 (61-70)	11.5-17.0 (60-67)	24-27	32-30	32-40
Hybognathus nuchalis	5.5-6.0 (58)	6.0-12.0 (62-66)	12.0-16.0 (57-60)	21-23 (26)	34-41	36-39
Hybopsis aestivalis	— (—)	— (—)	— (—)	22-23	34-39	37-38
H. storeriana	4.5-6.5 (59)	6.5- 9.5 (58-60)	9.5-14.0 (60)	22-24	36-39	38-41
Notemigonus crysoleucas	2.7-5.7 (60-69)	6.5- 9.5 (59-60)	10.0-20.0 (53-58)	(22) 23-25 (26)	35-40	35-40
Notropis atherinoides	4.5-8.8 (63-66)	8.8-11.0 (63-64)	11.0-14.0 (58)	(23) 25-26 (26)	35-41	38-43
N. cornutus	— (64-65)	— (63-64)	— (58-61)	—	—	—
N. dorsalis	— (59-63)	— (59-62)	— (56-59)	—	—	34-37
N. emiliae	— (—)	— (—)	— (—)	—	—	37-39
N. hudsonius	— (—)	— (—)	— (—)	—	36-40	35-40
N. lutrensis	3.3-6.0 (59-62)	6.0 (58-63)	9.5 (56-58)	—	32-37	34-36
N. spilopterus	— (—)	— (—)	— (—)	—	35-40	37-39
N. stramineus	— (59-64)	— (62-65)	— (56-63)	—	33-37	33-36
N. volucellus	— (—)	— (—)	— (—)	—	32-35	34-37
Pimephales notatus	4.9-6.4 (58-65)	6.9-12.0 (62-64)	12.0-15.9 (60-61)	23-25	34-39	37-40
P. promelas	— (57-64)	— (53-63)	— (59-62)	22-24	34-37	—
Carpiodes carpio	5.0-9.5 (68-73)	9.3-15.0 (67-79)	15.0-16.5 (57-66)	25-30	33-37	35-36
C. cyprinus	5.0-9.5 (68-73)	9.3-15.0 (67-79)	— (57-66)	(26) 27-31(32)	37-40	37-41
C. velifer	— (—)	— (—)	— (—)	(25) 26-27 (29)	32-38	34-37
Ictiobus bubalus	5.0-9.5 (70-75)	9.6-23.1 (62-68)	22.2-23.6 (60-62)	28-31	(28) 35-39	35-39
I. cyprinellus	5.0-9.4 (71-75)	9.4-21.3 (59-71)	21.1-22.4 (59-60)	30	37	36-37
I. niger	5.3-8.7 (72-78)	8.8-17.9 (72-75)	21.9-24.88 (61-69)	—	—	37
Catostomus commersoni	8.7-14.4 (75-82)	14.4-17.9 (73)	17.9-28.5 (67)	(33) 36-39 (42)	(41) 44-47 (52)	44-48
Moxostoma macrolepidotum	— (75-78)	— (66-99)	— (—)	(30) 32-37 (39)	38-41	41-44
Minytrema melanops	— (86)	— (67)	— (—)	31	35-42	43-44
Percopsis omiscomaycus	5.5-<7 (—)	<7-<9.5 (—)	<9.5 (—)	13-14	32-34	—
Labidesthes sicculus	— (27-29)	— (20)	— (30-39)	6-7; 15-16	36-38; 39-41	—
Morone chrysops	2.4-8.5 (45-66)	8.9-13.0 (53-55)	13.020.0 (49)	8	23-26	24
Lepomis cyanellus	— (—)	— (45-47)	— (—)	(10) 10-12 (13)	27-28 (30)	28-29
L. gibbosus	2.6 (37-45)	— (42-43)	— (43-49)	10-13	27-34	28-29
L. humilis	— (—)	— (42-48)	— (—)	13-15	27-31	28-30
L. macrochirus	2.2-7.5 (41-55)	5.0-10.5 (43)	10.5-12.5 (44-45)	11-14	28-31; 33-35	28-29
Micropterus salmoides	3.4-7.0 (41-48)	7.2-9.0 (42-45)	9.0-12.5 (44-45)	11	34-36	30-32
M. dolomieui	6.0-8.0 (45)	— (45-54)	— (—)	10-11	19-21	31-32
Pomoxis annularis	3.0-8.0 (35-39)	8.0-12 (36-41)	12.5-14.0 (40)	11-13	29-33	30-32
P. nigromaculatus	— (—)	>9 (41)	— (30)	10-13	29-32	31-33
Perca flavescens	5.5-7.5 (48-52)	5.6-13.0 (45-56)	— (54-56)	18-22	34-42	38-41
Percina caprodes	4.8-10.0 (62)	— (54-59)	— (50-58)	18-20	37-41	40-42
Stizostedion canadense	— (47-51)	— (51)	— (50-51)	19-21	40-46	43-45
S. vitreum	6.0-9.0 (49)	11.0-15.0 (52)	15.0 (—)	18-22	38-51	44-48
Aplodinotus grunniens	3.2-7.5 (43-46)	7.8-10.5 (44-47)	10.5-15.0 (44-47)	10-14	19-25	24

[a] Dashes indicate no known data. No data are shown for 10 species: *Scaphirhynchus platorynchus, Lepisosteus platostomus, Notropis blennius, Fundulus notatus, Morone mississippiensis, Ambloplites rupestris, Ammocrypta clara, Etheostoma asprigene, E. nigrum,* and *Percina shumardi.*

[b] Myomere and vertebral counts in parentheses have been reported in the literature, but are outside the usual range.

3 Illustrations of Larval Fishes of Certain Families Common in the Upper Mississippi River

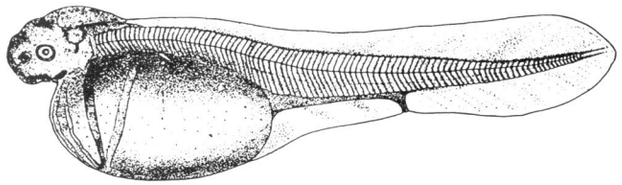
Acipenseridae — Sturgeons • Polyodontidae — Paddlefishes
Lepisosteidae — Gars • Amiidae — Bowfins
Clupeidae — Herrings • Hiodontidae — Mooneyes
Esocidae — Pikes • Ictaluridae — Catfishes
Cyprinidae — Minnows and Carps • Catostomidae — Suckers
Aphredoderidae — Pirate Perches • Percopsidae — Trout-Perches
Cyprinodontidae — Killifishes • Atherinidae — Silversides
Percichthyidae — Temperate Basses • Centrarchidae — Sunfishes
Percidae — Perches • Sciaenidae — Drums
Gadidae — Codfishes

The following illustrations and brief descriptions distinguish the larvae of 15 of the families of fishes found in the Upper Mississippi River. Families that are often confused because they have similar characteristics are shown on the same page to facilitate comparison.

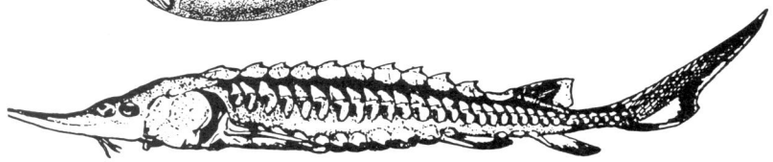
Two illustrations generally are presented for each family to show an early and later developmental phase of the larval stage. However, in four cases, there is only one illustration per family. In these cases, one illustration sufficiently delineates larval characteristics because either no true larval stage exists after yolk absorption (e.g., Ictaluridae) or characteristics necessary to distinguish all developmental stages of larvae are sufficiently illustrated in the one stage presented (e.g., Cyprinodontidae, Atherinidae, Gadidae). References for the presented illustrations are given after each family description.

■ Acipenseridae—Sturgeons *(p. 26)*

A.



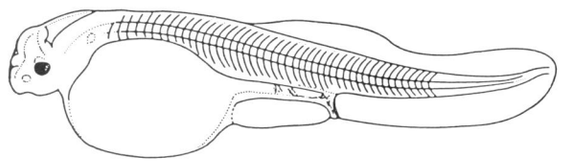
B.



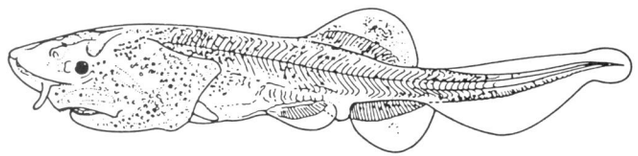
Larvae large (10-11 MM TL at hatching); yolk sac large, oval and vascular; darkly pigmented; late protolarvae with 4 barbels; dorsal fin origin posterior to vent; posterior margin of the operculum not extending past base of pectoral fin; in early mesolarva stage, difficult to separate from polydon. In early mesolarvae preanal length 65% TL becomes 60% at 11 MM; distance from snout to origin of dorsal finfold is 25% TL; dorsal finfold rises immediately to a moderate height; very high myomere count (54) in older mesolarvae and metalarvae as in adults (A, Ryder 1890; B, Dean 1895).

■ Polyodontidae—Paddlefishes *(p. 27)*

A.



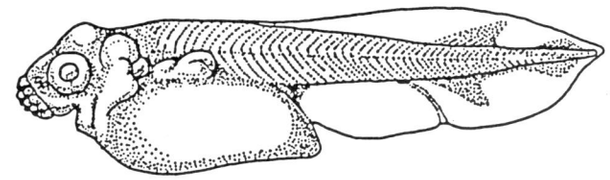
B.



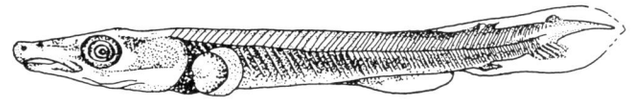
In early protolarval stage, larvae are difficult to separate from acipenseridae that are also in early protolarvae stage; preanal length is 60% TL (50% at 11 MM TL); distance from snout to origin of dorsal findold, 35%; dorsal finfold rises at posterior margin of the yolk sac; older larvae with 2 barbels; dorsal fin origin posterior to vent (A, B, Yeager and Wallus 1982).

■ Lepisosteidae—Gars *(p. 28)*

A.



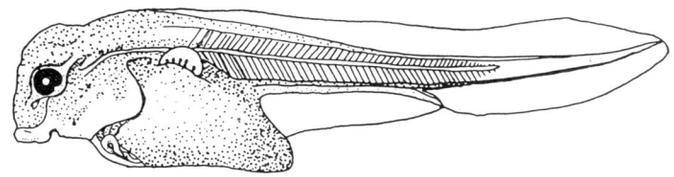
B.



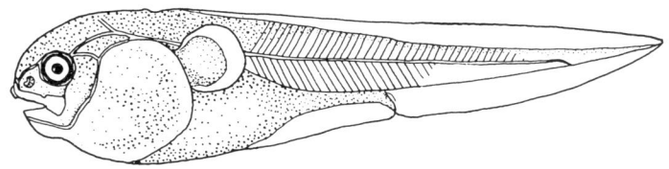
Larvae with high myomere counts; large, mound-like (papillate) adhesive organ on snout; older larvae "gar-like"; tail heterocercal; dorsal and anal fins posterior (A, Balfour and Parker 1882; B, Wilder 1877).

■ Amiidae—Bowfins *(p. 30)*

A.



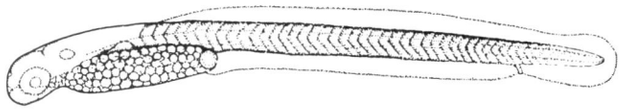
B.



Early protolarvae with dark yolk sac; yolk with vitelline vessels; high myomere count (60); ring-like adhesive organ; body "tadpole-like"; mesolarvae with robust head, round gular plate developing; long dorsal plate developing; long dorsal fin with origin above pectorals (A, B, Dean 1896).

■ Clupeidae—Herrings *(p. 31)*

A.



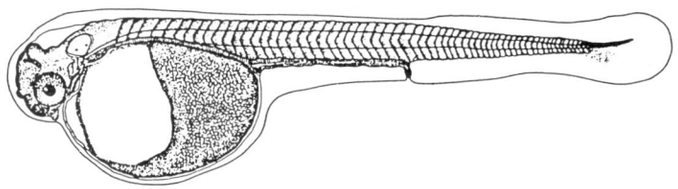
B.



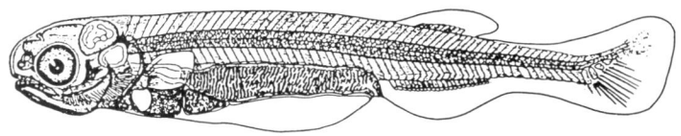
Protolarvae elongate, slender, extremely fragile; preanal length greater than about 75% TL; origin of dorsal finfold at nape; dorsal fin anterior to anal fin origin; gas bladder distinct; gut striated (A, Warner 1940; B, Lippson and Moran 1974).

■ Hiodontidae—Mooneyes *(p. 32)*

A.



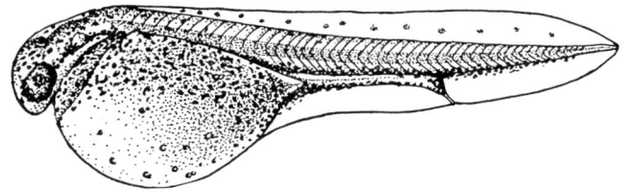
B.



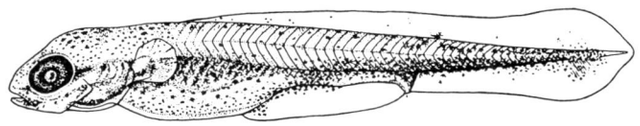
Larvae large, robust; anterior large oil globule in yolk sac; preanal length about 60% TL; origin of dorsal finfold posterior; dorsal and anal fin insertions in line; anal fin long; mouth inferior; snout bulbous and bluntly squared (Battle and Sprules 1960).

■ Esocidae—Pike *(p. 34)*

A.



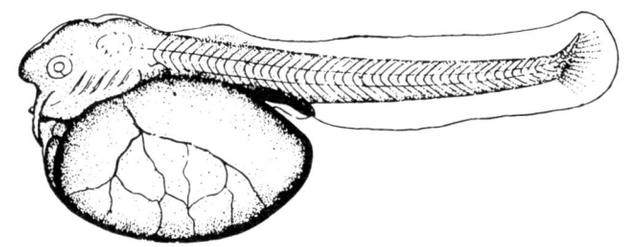
B.



Oval yolk; long preanal finfold; preanal length about 60% TL; in older larvae, snout extended and depressed; dorsal and anal fins posterior (A, B, Mansueti and Hardy 1967).

■ Ictaluridae—Catfishes *(p. 56)*

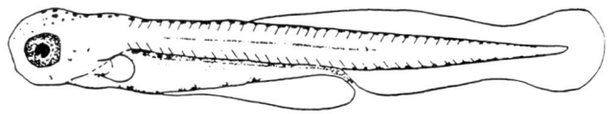
A.



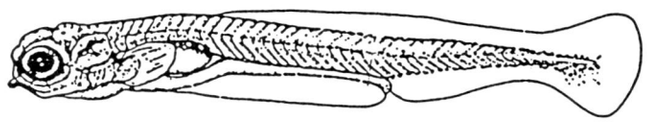
Young resemble adults; yolk large with vitelline vessels; barbels present at hatching; no true larval stage (A, Ryder 1887).

■ Cyprinidae—Minnows and Carps *(p. 36)*

A.



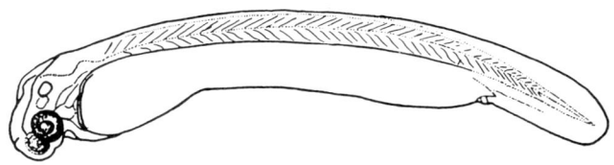
B.



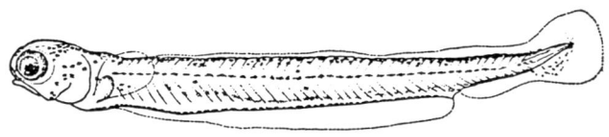
Yolk sac long, bilobed with thick anterior portion and thin and tubular posterior section; preanal 57-67% TL; pigmentation often in rows; anal fin origin below or slightly behind dorsal fin base (A, Raney 1939; B, Lippson and Moran 1974).

■ Catostomidae—Suckers *(p. 47)*

A.



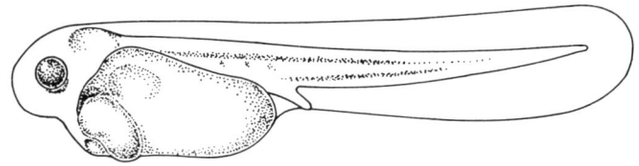
B.



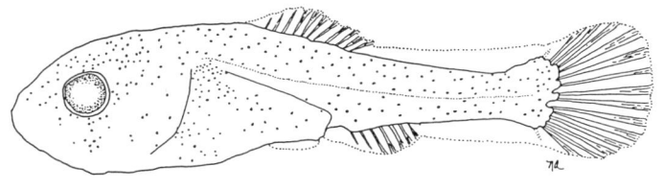
Yolk long and cylindrical; preanal length 67-75% TL; anal fin insertion posterior to dorsal fin base; inferior mouth in older larvae (A, Stewart 1926; B, Fish 1932).

■ Aphredoderidae—Pirate Perches *(p. 60)*

A.



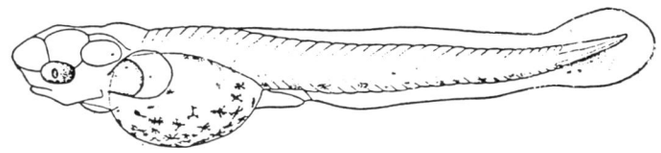
B.



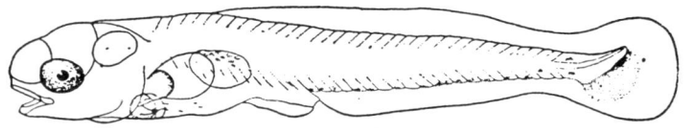
Protolarvae and mesolarvae with vent in normal preanal fin position (50% TL); 12-15 preanal and 13-16 postanal myomeres; body robust; anus begins to migrate to adult position at about 13 mm TL (preanal length about 50% TL after migration); large stellate melanophores over body. (A, Hardy 1978; B, Hogue et al. 1976. Delineated by Auer in Auer [1982])

■ Percopsidae—Trout-Perches *(p. 61)*

A.



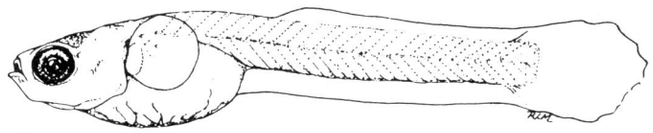
B.



Preanal length 44-49% TL; total myomeres 32-34 (14 + 18-20); large head; large single oil globule in yolk sac; snout pointed by 9 mm TL; teeth also developed on both jaws (A, B, Fish 1932).

■ Cyprinodontidae—Killifishes *(p. 63)*

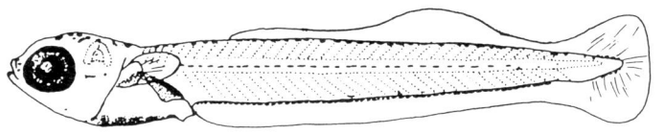
A.



Larvae stubby and robust; well pigmented; mouth small and superior; caudal peduncle stocky; fin rays developed in caudal and pectoral fins at or near hatching (A, Foster 1967).

■ Atherinidae—Silversides *(p. 64)*

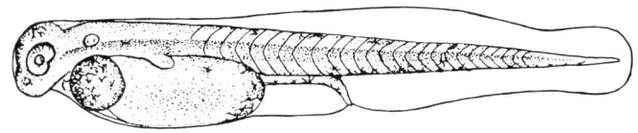
A.



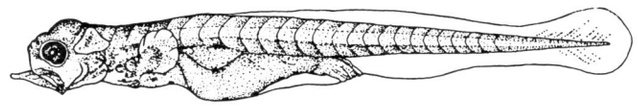
Larvae elongate; preanal length about 20-30% TL; mouth small and terminal; 2 dorsal fins (the first small); both dorsal fins positioned over a long anal fin (A, Wang 1974).

■ Percichthyidae—Temperate Basses *(p. 66)*

A.



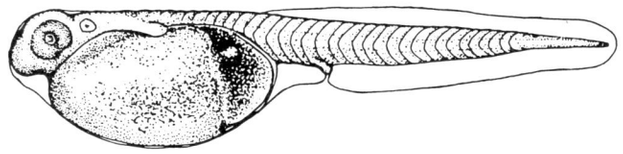
B.



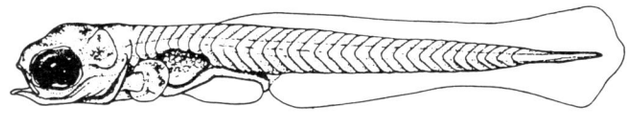
Teeth develop early; larvae with an anterior oil globule in yolk sac; myomere counts 23-26 (25); gut thick and s-shaped; spines on preopercular bones in mesolarvae (A, B, Mansueti 1964).

■ Centrarchidae—Sunfishes *(p. 68)*

A.



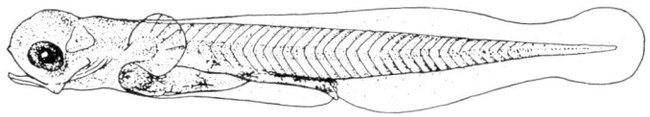
B.



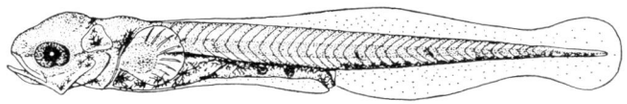
At hatching, larvae very small; mouth not developed; generally slender; gut thin, coils with growth. Larvae with posterior oil globule in yolk sac (A, B, Anjard 1974).

■ Percidae—Perches *(p. 76)*

A.



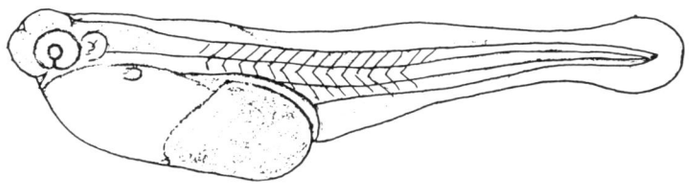
B.



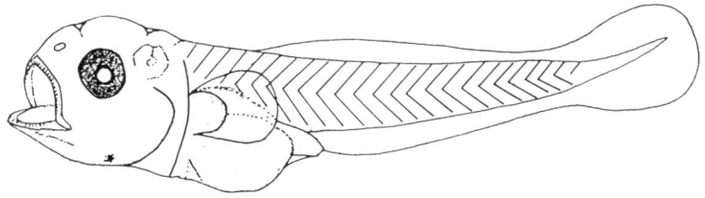
Larvae with anterior oil globule; myomere counts 30-42 or higher; pectorals usually large; large yolk sac (A, B, Mansueti 1964).

■ Sciaenidae—Drums *(p. 82)*

A.



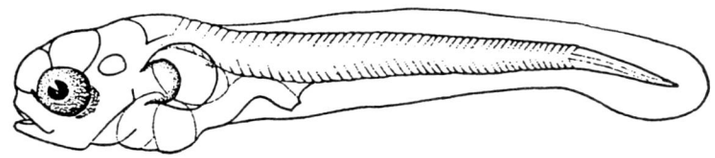
B.



Larvae very small, with large posterior oil globule; preopercular spines present; dorsal fins continuous; older larvae robust, with large heads (A, B, Taber 1969).

■ Gadidae—Codfishes *(p. 62)*

A.



Preanal length 33-40% TL; gut becomes coiled; anal opening is at the side of the finfold; in older larvae — 2 dorsal fins; second dorsal fin and anal fins elongate; pelvic fins beneath pectoral fins; single barbel develops on lower jaw (A, Fish 1932).

4 Descriptions of Selected Larval Fishes of the Upper Mississippi River

This section provides information on representatives of the most common families and species of fishes found in the UMR. These data were compiled from published research and from data collected during six years of sampling. Each family is briefly described. Data on individual species includes information on preferred habitats and distribution, spawning, characteristics of eggs and larvae, and meristic counts for juveniles or adults.

Acipenseridae — Sturgeons
Polyodontidae — Paddlefishes
Lepisosteidae — Gars
Amiidae — Bowfins
Clupeidae — Herrings
Hiodontidae — Mooneyes
Esocidae — Pikes
Cyprinidae — Minnows and Carps
Catostomidae — Suckers
Ictaluridae — Catfishes
Aphredoderidae — Pirate Perches
Percopsidae — Trout-Perches
Gadidae — Codfishes
Cyprinodontidae — Killifishes
Atherinidae — Silversides
Percichthyidae — Temperate Basses
Centrarchidae — Sunfishes
Percidae — Perches
Sciaenidae — Drums

■ Acipenseridae — Sturgeons

Three species of sturgeon—lake sturgeon *(Acipenser fulvescens),* pallid sturgeon *(Scaphirhynchus albus),* and shovelnose sturgeon *(S. platorynchus)*—are indigenous to parts of the Mississippi River (Pflieger 1975). However, only the shovelnose sturgeon is common in the UMR.

Sturgeon were of considerable commercial value during the early 1900s. Overfishing, pollution, and the construction of dams have greatly reduced populations (Pflieger 1975).

All species have heterocercal tails in which the backbone extends far into the upper lobe. The mouth is ventrally located and the body is covered with lengthwise rows of bony plates (scutes). ***(ILLUS. P. 14)***

•*Scaphirhynchus platorynchus* — Shovelnose Sturgeon

Habitat and Distribution

The shovelnose sturgeon inhabits deep channels of rivers near the bottom, often in areas of swift current with a sand or gravel bottom (Becker 1983). It is fairly tolerant of turbid water conditions (Pflieger 1975). The shovelnose sturgeon occurs in the UMR in local concentrations from Pool 4 to below Lock and Dam 26 (Rasmussen 1979). It is the sixth most abundant species captured near wingdams, closing dams, and other structures that accelerate water flow (Pitlo 1981; Becker 1983). Young-of-the-year have been collected in the main channel and in main channel border areas near wingdams (Farabee 1979). However, larvae have rarely been collected in drift studies on the UMR (Holland et al. 1984).

Reproduction and Characteristics

SPAWNING.

Location: Spawning is believed to occur in open channels of large rivers in areas of strong current over rocky or gravel bottoms (Pflieger 1975). Upstream migrations and into smaller streams for spawning have been reported (Forbes and Richardson 1920). Spawning may also occur in the tailwaters of UMR navigation dams (Farabee 1979). **Season:** Spawning has been reported in late April through early June (Christenson 1975). **Temperature:** 19-21°C (Becker 1983).

EGGS.

Characteristics: Shovelnose sturgeon eggs are black; 2.27 mm in diameter (Helms 1973); have no oil globule. **Deposition:** Eggs are deposited singly, are demersal, and adhesive.

LARVAE.

Information on larval shovelnose sturgeon is limited so the characteristics listed are for either the family or genus. **Length at hatching:** 7 mm (Carlson 1981). **Yolk sac:** The yolk sac is large, oval, and vascular (Jones et al. 1978) and is absorbed by 19 mm TL. **Preanal length:** In yolk-sac larvae, it is 65% of the TL; at 10-11 mm, 60% of the TL. **Myomeres:** In recently

hatched larvae, 33-34 + 20. **Dorsal fin insertion:** Posterior to vent. **Snout to dorsal finfold origin:** 25% of the TL. **Pigmentation (for genus):** Melanophores are present over most of the dorsal and lateral surfaces (Snyder 1980).

JUVENILES OR ADULTS.

Fin rays: Dorsal 30-36; anal 19-23. **Mouth:** The mouth is ventral, protrusible with four fringed barbels. **Body:** Covered with bony scutes (Eddy and Underhill 1974).

■ Polyodontidae — Paddlefishes

This primitive freshwater family has only two living species—*Polyodon spathula* in the Mississippi-Ohio-Missouri River systems and *Psephurus gladius* in the Yangtze River of China (Pflieger 1975). *Polyodon spathula* has become rare in the UMR due to the reduction of spawning grounds by impoundment of the river. The fish is characterized by a long, flat, paddle-shaped snout and a deeply forked, heterocercal tail. It has a smooth, almost scaleless skin, an internal cartilaginous skeleton, and only the lower jaw is ossified (Eddy and Underhill 1974). Paddlefish are among the largest freshwater fishes and often exceed 27 kg (Pflieger 1975). ***(ILLUS. P. 14)***

•*Polyodon spathula* — Paddlefish

Habitat and Distribution

The paddlefish inhabits quiet, slow-flowing, open waters (Pflieger 1975), most often in main channel border and tailwater habitats (Scott and Crossman 1973). It is a continuously swimming, filter-feeding planktivore with long, closely spaced gill rakers (Eddy and Underhill 1974).

In the UMR, paddlefish have occasionally been collected from Pool 9 to below Pool 26; rarely in Pools 4 to 8 (Rasmussen 1979). They also occur in Lake St. Croix, the St. Croix River, and in Pool 3 (Eddy and Underhill 1974). Larvae have been rarely collected and little is known of the early life history requirements.

Reproduction and Characteristics

SPAWNING.

Location: Paddlefish spawn in large, free-flowing rivers (Pflieger 1975) over sand and pebbles (Katz 1954) near gravel bars that are subject to sustained inundation during spring floods (Pflieger 1975). **Season:** Spawning occurs in March to June (Katz 1954; Purkett 1961; Ballard and Needham 1964) but not all adults spawn every year (Eddy and Underhill 1974). **Temperature:** 15-16°C (Purkett 1961).

EGGS.

Characteristics: The blastoderm area is gray; the yolk is a light tan; diameter 2.7-4.0 mm; there is no oil globule. **Deposition:** Eggs are broadcast during spawning. They are demersal and nonadhesive at release, become adhesive after fertilization, and stick singly at first

contact, usually on rocks or pebbles. **Incubation:** Hatching occurs in 7 days at 15.6-21.1°C (Purkett 1961; Yeager and Wallus 1982).

LARVAE.

Length at hatching: 8.0-9.5 mm. **Yolk sac:** The larvae are dark gray, 32.4% of the TL (Hogue et al. 1976); at 2-3 days, enough yolk sac has been absorbed to permit normal swimming (Purkett 1961). **Preanal length:** At hatching, it is 60% of the TL (Snyder 1980); at 16.9 mm, 50% of the TL (Hogue et al. 1976); at 20 mm, 50% of the TL (Snyder 1980). **Myomeres:** 31 to 35 + 20 to 22 (Hogue et al. 1976). **Dorsal fin insertion:** Anterior to vent (Snyder 1980), 43% of the TL (Hogue et al. 1976). **Pigmentation:** Larval are light in overall appearance and brownish; in early protolarvae, there is little pigmentation, except on the dorsolateral surface of the yolk sac (Snyder 1980). **Head depth:** 12.9% of the TL (Hogue et al. 1976). **Depth at anus:** 11% of the TL. **Dorsal fin length:** At 16.9 mm, 29% of the TL. **Snout to dorsal finfold origin:** About 35% of the TL (Snyder 1980). **Other:** Two barbel buds appear a few hours after hatching; at 9-11 mm, the barbel buds swell; at 15 mm (week 3), the rostrum and heterocercal tail are evident; the head is large; and the eyes are small (Purkett 1961). The posterior margin of the operculum is well beyond the base of the pectoral fin (Snyder 1980). Swimming is intermittent until yolk sac has been absorbed, then the larvae swim constantly (Purkett 1961).

JUVENILES OR ADULTS.

Fin rays: Dorsal 50-6; anal 50-65. **Vertebrae:** 45 (Jordan and Evermann 1896).

■ Lepisosteidae — Gars

Gars represent the only living family of Lepisosteiformes, an ancient order of bony fishes. These slender, cylindrical fishes have an elongate snout with many teeth and ganoid scales. The tail is rounded; the notochord is flexed upward and extends partly into the caudal fin (Pflieger 1975).

The family has only one existing genus, *Lepisosteus,* for which seven species have been described (Scott and Crossman 1973). Four species—spotted gar *(Lepisosteus oculatus),* longnose gar *(L. osseus),* shortnose gar *(L. platostomus),* and alligator gar *(L. spatula)*—occur in the UMR, but only the longnose and shortnose gars are common (Van Vooren 1983).

Gar larvae are distinctive; they have high myomere counts, a mound-like adhesive organ on the snout, and a heterocercal tail. ***(ILLUS. P. 15)***

•*Lepisosteus osseus* — Longnose Gar

Habitat and Distribution

These fish prefer quiet, weedy, shallow, warm lakes, and the backwaters of the UMR (Pflieger 1975). Longnose gar are common throughout the system and are occasionally collected below Lock and Dam 26 (Van Vooren 1983). Larvae are rarely collected with standard towed plankton nets because they are closely associated with vegetation in backwaters. Adults remain in deep waters; the young are often in aquatic vegetation in shallow backwaters (Pflieger 1975). Early developmental stages are uncommon in main channel drift collections (Holland et al. 1984).

Reproduction and Characteristics

SPAWNING.

Location: Gar spawn in quiet backwaters over vegetation. **Season:** Spawning occurs from early May to mid-June (Pflieger 1975). **Temperature:** 19-21°C (Dean 1895).

EGGS.

Characteristics: Eggs are green to slate gray at extrusion, but later turn yellow, green, or brown (Dean 1895); diameter 3.3-5.5 mm. **Deposition:** When laid, eggs are single, demersal, and adhesive (Lippson and Moran 1974). **Other:** Gar eggs are similar to the eggs of sturgeon, but are larger. **Incubation:** Hatching occurs in 6 days at 20°C (Becker 1983).

LARVAE.

Length at hatching: 9-10 mm. **Yolk sac:** The yolk sac is absorbed at 18-20 mm, normally about 9 days after hatching (Echelle and Riggs 1972). **Preanal length:** At 41 mm, it is 67% of the TL (Heufelder 1982a). **Myomeres:** Preanal 39-44; postanal (for genus) 11-16 (Hogue et al. 1976). **Dorsal fin insertion:** 77% of the TL. **Pigmentation:** There is little pigmentation at hatching, but later larvae become heavily pigmented. **Other:** In larvae up to 20 mm, there is a distinct suctorial disk. Later, it becomes reduced to a swelling on the tip of the upper jaw (Balfour and Parker 1882).

JUVENILES OR ADULTS.

Fin rays: Dorsal 7-8; anal 7-9; pectoral 10-13; pelvic 6 (Scott and Crossman 1973).
Vertebrae: 61-66 (Heufelder 1982a); convex in front, concave behind.
Gill rakers: 24-28 (Scott and Crossman 1973).

•*Lepisosteus platostomus* — Shortnose Gar

Habitat and Distribution

This species inhabits open turbid rivers, quiet pools, backwaters, and oxbows. It is apparently better adapted to murky environments than other species of gar (Pflieger 1975). Shortnose gars are common in all pools and river reaches of the UMR (Van Vooren 1983). Larvae are closely associated with vegetation and are rarely collected in drift studies. Little information is available on the ecology of early life history stages in the UMR.

Reproduction and Characteristics

SPAWNING.

Location: Shortnose gar spawn in backwaters or grassy, shallow sloughs (Becker 1983).
Season: May to July (Potter 1927). **Temperature:** 19-23.5°C (Shields 1957).

EGGS.

Characteristics: Eggs are bright green with a diameter of 2.5 mm (Potter 1927) or 3.5 mm (Eddy and Underhill 1974). **Deposition:** Spawns consist of small masses of eggs in a gelati-

nous substance (Potter 1927). Eggs are demersal (Richardson 1913), adhesive, and attach to vegetation (Potter 1927).

LARVAE.

Preanal length: 66-69% of the TL (Heufelder 1982a). **Myomeres:** Preanal 39-44; postanal (for genus) 11-16 (Hogue et al. 1976). **Dorsal fin insertion:** 66% of the TL.
Pigmentation: Heavy (Heufelder 1982a).

JUVENILES OR ADULTS.

Fin rays: Dorsal 8; anal 8; pectoral 11-12; pelvic 6. **Vertebrae:** 61 (Heufelder 1982a).
Pigmentation: In juveniles, there is a broad black lateral stripe on midside (Scott and Crossman 1973).

■ Amiidae — Bowfins

The Amiidae are the only living representatives of the order Amiiformes and only one species, *Amia calva,* exists. They have rounded heads, a toothed lower jaw, and a gular plate. Centra of the vertebrae are amphicoelous; scales are cycloid (Scott and Crossman 1973). ***(ILLUS. P. 15)***

•*Amia calva* — Bowfin

Habitat and Distribution

Bowfin live in sluggish rivers and lakes where the water is clear and vegetation is abundant (Carlander 1969). Their habitat also includes oxbows, marshes, and harbors. Bowfin are common in the UMR in all pools and in river reaches below Lock and Dam 26 (Van Vooren 1983). Little information is available on the requirements and ecology of early life stages in the UMR.

Reproduction and Characteristics

SPAWNING.

Location: The species is somewhat migratory at spawning (Dean 1895; Reighard 1900). Spawning occurs in shallow, sluggish, weedy, or stagnant water at depths of 305-610 mm (Reighard 1903; Scott and Crossman 1900). Nests are constructed and fanned by a male until a clean bed of roots, sand, or gravel is formed (Reighard 1903). **Season:** Spawning occurs from early April to early June in Missouri (Pflieger 1975) and in April in Illinois (Richardson 1913). **Temperature:** 16-19°C (Carlander 1953).

EGGS.

Characteristics: The animal pole is a yellow-brown color and the yolk is gray-brown; the diameter is 2.5-3.0 mm and doubles in size as the embryo develops (Whitman and Eycleshymer 1897). There is no oil globule. **Deposition:** Eggs are broadcast, demersal (Jones et al. 1978; Heufelder 1982b), and adhesive. They are attached to substrates by thread-like extensions of egg surface. **Incubation:** Hatching occurs in 6 days at 16-17°C (Pierson 1953).

LARVAE.

Length at hatching: 3.0-7.0 mm of the TL (Reighard 1903; Allen 1911). **Yolk sac:** The yolk sac is initially spherical with prominent vitelline vessels (Dean 1899) and has been absorbed at 13 mm TL (Pierson 1953). **Myomeres:** Total—60 (Hogue et al. 1976).
Preanal length: 64% of the TL. **Dorsal fin insertion:** At 13 mm, 26% of the TL; at 70 mm, 36% of the TL. **Pigmentation:** At 6-8 mm, larvae are pale with sepia-colored yolk, and there is pigment on the head (Whitman and Eycleshymer 1897); at 12 mm, larvae are dark green-ish-black dorsally and off-white ventrally. **Other:** At <10 mm, larvae have an adhesive organ on the snout and remain near the original spawning substrate; at lengths up to 100 mm, the young form a tight school guarded by the male until the school gradually dissipates (Reighard 1903).

JUVENILES OR ADULTS.

Fin rays: Dorsal 46-50; anal 9-10; pectoral 16-18 (Scott and Crossman 1973); pelvic 9 (Dean 1896). **Vertebrae:** 80-87 (Scott and Crossman 1973).

■ Clupeidae — Herrings

Clupeids are widely distributed, principally marine, fishes represented by only a few anadromous or freshwater genera. This family of small, pelagic schooling fishes comprises about 190 species (Scott and Crossman 1973), of which only three—skipjack herring *(Alosa chrysochloris),* gizzard shad *(Dorosoma cepedianum),* and threadfin shad *(D. petenense)*—are found in the UMR. However, only gizzard shad are common (Van Vooren 1983).

Clupeids have a single dorsal fin placed far ahead of the anal fin and an axillary process above the base of the pelvic fins. All members have a row of spiny scales or scutes along the ventral midline of the body (Pflieger 1975). ***(ILLUS. P. 16)***

•*Dorosoma cepedianum* — Gizzard Shad

Habitat and Distribution

This species inhabits quiet waters that may range from clear to extremely turbid. They avoid high-gradient streams and prefer waters of high productivity, such as the large permanent pools in the UMR (Pflieger 1975). Gizzard shad travel in large schools near the surface (Scott and Crossman 1973).

Adult gizzard shad are abundant in all pools of the UMR (Van Vooren 1983). Larvae are present in the ichthyoplankton drift from early June to early July and are much more numerous in backwaters than in main channel areas. Mesolarvae are common in surface and main channel border waters and are sometimes found in the main channel. They are twice as abundant at dusk as at any other time (Holland and Sylvester 1983).

Reproduction and Characteristics

SPAWNING.

Location: Spawning occurs in sloughs, ponds, lakes, large rivers, and protected bays (Miller 1960) over sand, gravel, and boulders in water 0.6-1.2 m deep (Scott and Crossman 1973). **Season:** Gizzard shad spawn from early April to May in Missouri (Pflieger 1975) and from mid-March to late August in Canada (Scott and Crossman 1973). **Temperature:** 17.2-22.8°C.

EGGS.

Characteristics: Eggs are creamy-yellow and transparent after fertilization (Miller 1960) and have a diameter of 0.75 mm (Scott and Crossman 1973) or 0.9-1.1 mm (Shelton and Stephans 1980). They have a single, clear oil globule with 1 to 5 smaller globules (Wang and Kernehan 1979) and a perivitelline space of 0.05-0.1 mm (Shelton and Stephans 1980). **Deposition:** The eggs are broadcast singly, demersal, and adhesive. **Incubation:** Hatching occurs after 36 h at 26.7°C (Miller 1960).

LARVAE.

Length at hatching: 3.25-3.45 mm (Shelton and Stephans 1980). **Yolk sac:** At hatching, the yolk sac is oval, 0.8 mm long (Miller 1960). It is absorbed at 6-7 mm TL. **Oil globule:** A single, posterior oil globule is present (Shelton and Stephans 1980). **Preanal length:** Protolarvae 80-89% of the TL; mesolarvae 84%; metalarvae 64-75%. **Myomeres:** 45-52 (39-44 + 6-8) (Shelton and Stephans 1980); at hatching, 32; at 5.5 mm, 40; at 10.8 mm, 48; at 12.5 mm, 49; at 14-15 mm, 48-50 (Miller 1960). **Pigmentation:** At hatching, there is none (Shelton and Stephans 1980); at 3 days, there is a line of melanophores on each side of the body, dorsal to the yolk that extends to the preanal finfold; other melanophores are present anterior to vent along each side of dorsal wall of the anterior one-third of the gut, scattered over the caudal fin base, and on each side of the anal fin. At about 20 mm, two rows of melanophores are present on the lower jaw, lips, and chin with three rows on the dorsolateral surface and a short fourth row on the base of the caudal fin (Warner 1940). **Other:** At 16-21 mm, there are 49-52 vertebrae (Kersh 1970).

JUVENILES OR ADULTS.

Fin rays: Dorsal 10-13; anal 27-34; pectoral 16-17; pelvic 8-10. **Vertebrae:** 47-49 (Scott and Crossman 1973). **Pigmentation:** At 20-26 mm, there is an irregular triangle of melanophores on the crown (Warner 1940); at up to 114 mm, the dorsal and caudal fins are uniformly sprinkled with melanophores but the pectorals and ventrals remain almost unpigmented (Miller 1960).

■ Hiodontidae — Mooneyes

This strictly North American family consists of a single genus containing two species—*Hiodon alosoide,* the goldeye, and *H. tergisus,* the mooneye. These primitive clupeiform fishes are moderately sized and have silvery, laterally compressed bodies, naked heads, and rounded snouts. Their large eyes and midline keel are particularly prominent features (Scott and Crossman 1973). Larvae of this family can be identified by their

blunt snouts, large eyes, high preanal myomere counts (29-35), nearly equal dorsal and anal fin insertions, and postanal myomere counts (≥16). ***(ILLUS. P. 16)***

•*Hiodon alosoides* — Goldeye

Habitat and Distribution

Adult goldeyes inhabit quiet, turbid waters of major rivers. Their large eyes are adapted to dim light (Carlander 1969). In the UMR, the species is occasionally collected below Pool 19 and is rare in pools farther upstream (Van Vooren 1983). Little information is available on the early life history of the goldeye in the UMR.

Reproduction and Characteristics

SPAWNING.

Location: Spawning occurs in pools or backwater areas of turbid rivers (Scott and Crossman 1973). **Season:** Goldeye spawn from April to May, after ice breakup in the UMR and from May to early July in Canada. **Temperature:** 10-13°C (Scott and Crossman 1973).

EGGS.

Characteristics: Eggs have a steel blue, translucent color (Scott and Crossman 1973) and a cream-colored yolk (Battle and Sprules 1960). They have a diameter of 4.0 mm, a perivitelline space of 0.9-1.0 mm, and a single, large oil globule measuring 0.67-0.95 mm. **Deposition:** Eggs are broadcast, semi-buoyant, and nonadhesive (Battle and Sprules 1960). **Incubation:** Hatching occurs in about 2 weeks (Scott and Crossman 1973).

LARVAE.

Length at hatching: 7.27-7.63 mm. **Yolk sac:** The yolk sac is large with a maximum length of 2.17 mm. It is absorbed at about 19 mm. **Oil globule:** There is a single, large oil globule located immediately posterior to heart. **Preanal length:** In yolk-sac larvae, it is 60% of the TL. **Myomeres:** Protolarvae, 28-29 + 31-32; metalarvae, 30 + 29 (Battle and Sprules 1960). **Dorsal fin insertion:** Located at 61% of the TL, slightly posterior to the anus and insertion of the anal fin. **Pigmentation:** In early stages, pigmentation is confined to the dorsolateral region of the iris. By 19-21 mm, melanophores are scattered over the anterior tip of the snout, occur on the margin of the lower jaw and are widely expanded in a quadrangular area over the mesencephalon. Irregular double rows occur along the mid-dorsal line from the head to the caudal fin and also along the lateral line. **Other:** At 11.8—13.5 mm, caudal hypurals number 5 (later, this increases to 13), and the pectoral ray number 0-1. At 15.0-15.6 mm, there are 0-3 dorsal rays; at 16 mm, anal rays 18-21; at 24.0-25.5 mm, pelvic rays 0-2; and at 33 mm, larvae have a blunt snout, large eyes, and high preanal myomere count (Battle and Sprules 1960).

JUVENILES OR ADULTS.

Fin rays: Dorsal 9-10; anal 29-34; pectoral 11-12; pelvic 7. **Vertebrae:** 56-61. **Gill rakers:** 15-17. **Branchiostegal rays:** 8-10. **Other:** A non-serrated ventral keel extends from behind the pectoral fins to the anus; a pelvic axillary process is present; and the fish have large eyes with a gold-colored iris (Scott and Crossman 1973).

•*Hiodon tergisus* — Mooneye

Habitat and Distribution

This species inhabits large, quiet pools of streams and has a lower tolerance for silt than the goldeye (Carlander 1969). It appears to move into swifter waters at night to feed (Pflieger 1975). In the UMR, it is common in Pools 1 to 19 and is occasionally collected in lower pools (Van Vooren 1983). Larvae are only rarely collected in the main channel, and occur from late May through mid-June; mesolarvae are found in vegetation in backwater and main channel border habitats (Holland et al. 1983).

Reproduction and Characteristics

SPAWNING.

Location: Mooneyes migrate up clear streams to spawn (Becker 1983).
Season: April and May. **Temperature:** 12-15°C.

EGGS.

Characteristics: Eggs are semi-transparent; probably similar to eggs of *H. alosoides.*
Deposition: Eggs are broadcast, semi-buoyant, nonadhesive (Battle and Sprules 1960), and found on artificial substrates near wingdams (J. Pitlo, personal communication).

LARVAE.

Length at hatching: 7.0 mm (Snyder and Douglas 1978). **Yolk sac:** The large yolk sac is absorbed at 21 mm (Jude 1982a). **Oil globule:** A single, large, oil globule is present in the anterior portion of the yolk sac. **Preanal length:** In yolk-sac larvae, it is 64% of the TL. **Myomeres:** In protolarvae, there are 30 preanal and 54 total myomeres (Snyder and Douglas 1978). **Dorsal fin insertion:** Occurs anterior to the anus and to the anal fin insertion at 55% of the TL. **Pigmentation:** Chromatophores occur posterior to the anus in ventral, dorsal, and caudal regions. **Other:** In metalarvae, there are 11-12 dorsal rays, as opposed to 9-10 in the goldeye (Snyder and Douglas 1978; Jude 1982).

JUVENILES OR ADULTS.

Fin rays: Dorsal 12; anal 26-29; pectoral 13-15; pelvic 7. **Vertebrae:** 53-57.
Branchiostegal rays: 7-9. **Other:** A pelvic axillary process is present and the large eyes have a silver-colored iris (Scott and Crossman 1973).

■ Esocidae — Pikes

Esocids are distributed extensively from arctic to subtropical regions of the Northern Hemisphere (Scott and Crossman 1973), where they inhabit a wide range of habitats in streams, lakes, and occasionally brackish waters. Of the five species in North America, three occur in the UMR: northern pike, *Esox lucius;* muskellunge, *E. masquinongy;* and grass pickerel, *E. americanus vermiculatus* (Eddy and Underhill 1974). Of these, the muskellunge and grass pickerel are rare and considered to be strays from tributaries to the UMR (Van Vooren 1983); only the northern pike occurs regularly.
(ILLUS. P. 17)

•*Esox lucius* — Northern Pike

Habitat and Distribution

Northern pike inhabit a variety of habitats, including lakes, reservoirs, and large streams (Pflieger 1975). They occur primarily in clear, warm, slow, meandering, heavily vegetated rivers, or in warm, weedy bays of lakes. They sometimes enter slightly brackish waters. Adults prefer shallow water in the spring and fall and move to deep water in the summer (Scott and Crossman 1973). In the UMR, northern pike are found commonly in Pools 1 to 13 and occasionally in Pools 14 to 26 (Van Vooren 1983). Newly hatched northern pike attach themselves to flooded emergent vegetation by means of an adhesive organ on their snout. Since they remain in shallow nursery areas, they rarely appear in standard towed or set plankton net collections of ichthyoplankton (Farabee 1979). Juveniles remain in or near submergent vegetation throughout the first summer (Holland and Huston 1984).

Reproduction and Characteristics

SPAWNING.

Location: Northern pike spawn in heavily vegetated flood plains of rivers, marshes, and bays over plant material (Pflieger 1975). **Season:** Spawning occurs from late March to early April (Becker 1983). **Temperature:** 4.4-11.1°C (Scott and Crossman 1973); adults move to the spawning areas at water temperatures of 1.0-4.5°C.

EGGS.

Characteristics: Eggs have a clear, amber color (Scott and Crossman 1973) with a yellow (Fish 1932) or green yolk (Frost and Kipling 1967). They have a diameter of 3.4 mm (Buynak and Mohr 1979a) and a perivitelline space that is moderate in size (Kennedy 1969). Often, there is no oil globule (Franklin and Smith 1963) or numerous small globules (Fish 1932).
Deposition: Eggs are broadcast, demersal (Frost and Kipling 1967), adhesive, and attach to vegetation (Becker 1983). **Incubation:** Hatching occurs in 10 days at about 10.9°C (Buynak and Mohr 1979a).

LARVAE.

Length at hatching: 7.9-8.5 mm. **Yolk sac:** The large, round yolk sac is absorbed at 13.2 mm (Buynak and Mohr 1979a). **Preanal length:** 70-75% of the TL (Kennedy 1969; Buynak and Mohr 1979a). **Myomeres:** At 8-13 mm, 41-46 + 20-24 (Buynak and Mohr 1979a).
Dorsal fin insertion: Occurs at 35% of the TL. **Pigmentation:** A pigmented band extends from the head to the caudal region; at 38.6 mm, several lateral pigment bands develop along the sides. **Other:** An adhesive organ on the snout is functional for 4-10 days after hatching (Frost and Kipling 1967; Scott and Crossman 1973) and helps larvae stay close to their natal spawning habitat (emergent vegetation). Larvae move to submerged vegetation and remain associated with it through the end of summer.

JUVENILES OR ADULTS.

Fin rays: Dorsal 15-19; anal 12-15; pectoral 14-17; pelvic 10-11. **Vertebrae:** 57-65.
Branchiostegal rays: 14-15, 7 ceratohyal and 8 epihyal (Scott and Crossman 1973).

■ Cyprinidae — Minnows and Carps

Cyprinidae constitute one of the largest families of fishes in the world; there are more than 1,500 known species in about 275 genera (Scott and Crossman 1973). Most cyprinids are small, but some, like the common carp, may weigh more than 22 kg. Cyprinids are restricted to fresh water, except for one salt-water Japanese species (McCrimmon 1968).

The body of minnows is elongate and covered with cycloid scales but the head is scaleless (Pflieger 1975). A lateral line is usually present (Scott and Crossman 1973). Species native to the Mississippi River have a single dorsal fin with less than 10 rays, abdominal pelvic fins with 19 principal rays, and an anal fin with 16 or fewer principal rays. All fins of native species are soft rayed (Pflieger 1975). The jaws have no teeth but the pharyngeal teeth are well-developed and are often important in the identification of genera and species (Heufelder and Fuiman 1982). During the breeding season, sexual dimorphism is usually conspicuous; breeding males are often brightly colored and have tubercles on the head, body, and fin rays (Scott and Crossman 1973).

The demersal, usually adhesive, eggs are small, measuring only 1.5 to 2.5 mm in diameter. They have a granular yolk and lack distinct oil globules (Heufelder and Fuiman 1982).

At hatching, the larvae are usually 4 to 7 mm long. Most larvae have a club-shaped yolk sac and usually have 19-39 preanal myomeres. The anus is located at 50 to 65% of the total length from the snout (Heufelder and Fuiman 1982). The number of species regularly reported in ichthyoplankton studies is small because identification to species is difficult and sampling schemes are often restricted. Many of the species collected are recorded simply as unidentified cyprinids. ***(ILLUS. P. 18)***

•*Cyprinus carpio* — Common Carp

Habitat and Distribution

The common carp prefers the relatively warm water of shallow mud-bottomed lakes and large streams (Becker 1983); it is especially prevalent in highly productive lakes, streams, and man-made impoundments (Pflieger 1975).

Common carp were successfully introduced into North America from Europe in 1877 and have spread throughout many stream systems of the United States (Eddy and Underhill 1974). They are abundant in all pools of the UMR and throughout the river system (Van Vooren 1983). Larval carp are most abundant in backwaters but they also occur in the main channel drift. They are present from early May (14°C) through late July and are at peak densities from mid-June to mid-July (22-27°C). They show a strong diel drift pattern (Holland and Sylvester 1983). Juveniles most often occur in shallow weedy areas but have been collected from a wide variety of habitats (Farabee 1979).

Reproduction and Characteristics

SPAWNING.

Location: Carp spawn in shallow, weedy areas of lakes, marshes, and swamps (Mansueti and Hardy 1967); in ponds and sheltered vegetated areas of streams (Heufelder and Fuiman 1982); or over tree roots, aquatic vegetation, and mud bottoms (Wang and Kernehan 1979).
Season: Spawning occurs from mid-May to early August in the Great Lakes Region (Swee and McCrimmon 1966). **Temperature:** 15-25°C, optimum 18-23°C (Wang and Kernehan 1979).

EGGS.

Characteristics: Eggs have a grayish white to yellow color, a diameter of 1.5-2.1 mm (Wang and Kernehan 1979), and a perivitelline space of 0.2-0.3 mm (Sigler 1958). There is either no oil globule (Hoda and Tsukahara 1971) or numerous minute globules (Wang and Kernehan 1979). **Deposition:** Eggs are laid in groups of 500 to 600 (Jester 1974) and are demersal and adhesive (Wang and Kernehan 1979). **Incubation:** Hatching occurs in 3-6 days depending on water temperature (Swee and McCrimmon 1966).

LARVAE.

Length at hatching: 3.0-3.5 mm (Jude et al. 1979). **Preanal length:** At 5.3-6.0 mm, it is 65-75% of the TL (Wang and Kernehan 1979); at 10-15 mm, it is 64% of the TL (Fish 1932).
Yolk sac: The yolk sac is club-shaped, measures 50-56% of the TL (Wang and Kernehan 1979), and is absorbed at 6.5-6.8 mm (Okada 1960) or 8.0 mm (McCrimmon and Swee 1967).
Myomeres: At 3-8 mm, 34-36 (Hoda and Tsukahara 1971); at 8-10 mm, 38 (Okada 1960).
Dorsal fin insertion: At 10 mm, it is 33% of the TL (Fish 1932). **Pigmentation:** Bands of melanophores branch posterior to the gill arches, forming Y-shaped patterns (Hogue et al. 1976).

JUVENILES OR ADULTS.

Fin rays: Dorsal I,18-20; anal I,5; pectoral 15-16 (14-17); pelvic 8 or 9.
Pharyngeal teeth: 1,1,3-3,1,1 molariform. **Vertebrae:** 35-36. **Lateral line scales:** 35-36.
Gill rakers: 21-27. **Other:** Two pairs of long barbels are present on the upper jaw and there is a strong spine in the dorsal and anal fins (Scott and Crossman 1973).

•*Notemigonus crysoleucas* — Golden Shiner

Habitat and Distribution

This species lives in quiet waters, such as pools of low-gradient streams, and in lakes and ponds (Trautman 1957). It thrives in clear, vegetated habitats but tolerates moderate turbidity (Scott and Crossman 1973) and highly eutrophic conditions and low oxygen concentrations (Eddy and Underhill 1974). It is occasionally found in most pools and reaches of the UMR from Pool 2 to the confluence of the Ohio River, but has not been reported in Pools 22 and 24 (Van Vooren 1983). The young live in small loosely aggregated schools at midwater or near the surface until late in the larval stage (Carlander 1969). They are occasionally collected in the UMR in ichthyoplankton drift samples from late May to early July.

Reproduction and Characteristics

SPAWNING.

Location: Spawning occurs in ponds (Dobie et al. 1956) and lakes (Schwartz 1963) over filamentous algae or submerged plants (Pflieger 1975). **Season:** Golden shiners spawn from May to July in New York and from June to August in Michigan (Scott and Crossman 1973). **Temperature:** 20-27°C (Becker 1983).

EGGS.

Characteristics: Eggs have yellow or white color and a diameter of 1.2-1.4 mm (Snyder et al. 1977). **Deposition:** They are demersal and adhesive (Schwartz 1963).
Incubation: Hatching occurs in 2-3 days at 21-24°C (Snyder et al. 1977).

LARVAE.

Length at hatching: 4.0-4.3 mm (Buynak and Mohr 1980). **Preanal length:** At 3 mm, it is 59-62% of the TL (Snyder et al. 1977). **Myomeres:** 23-25 + 15-17. **Dorsal fin insertion:** At 2.7-5.7 mm, it is 37-41% of the TL; at 10-21 mm, 45-49% of the TL (Snyder et al. 1977).
Pigmentation: In newly hatched larvae, the eyes are pigmented but the body is unpigmented; later, a midventral line of melanophores is prominent (Snyder et al. 1977). A dark band around the tip of the urostyle is species-specific into the juvenile stage (Loos et al. 1979). A preanal midventral line of melanophores (5-11 mm) is present, along with a patch of melanophores on the head and two distinct middorsal rows of melanophores from the nape to the caudal fin (Snyder et al. 1977).

JUVENILES OR ADULTS.

Fin rays: Dorsal 7-9; anal 12-14; pectoral 16 or 17; pelvic 9. **Pharyngeal teeth:** 0,5-5,0.
Vertebrae: 37-39 (Scott and Crossman 1973). **Lateral line scales:** 45-52, the lateral line has a distinct downward curve (Eddy and Underhill 1974). **Pigmentation:** A lateral band of pigment is prominent (Snyder et al. 1977). **Other:** A fleshy keel occurs posterior to pelvic fins (Scott and Crossman 1973).

•*Hybopsis aestivalis* — Speckled Chub

Habitat and Distribution

This species lives in fast water in open channels of large, low-gradient streams with bottoms of sand or small gravel. It occurs in moderately clear to highly turbid waters (Pflieger 1975). In the UMR, it is common from Pool 2 downstream (Van Vooren 1983). The eggs are sometimes common in drift samples from early June to early July in the main channel of the UMR; however, the eggs are often missed when samples are sorted because they are fragile and easily broken into unrecognizable pieces.

Reproduction and Characteristics

SPAWNING.

Location: Speckled chubs spawn in deep water with a swift current.
Season: Spawning occurs from May to early June and continues sporadically into August.
Temperature: Above 21.1°C (Becker 1983).

EGGS.

Characteristics: Eggs have a transparent, yellow or white color. **Deposition:** Eggs are broadcast, slightly heavier than water, nonadhesive, and develop as they drift in the current (Becker 1983).

LARVAE.

Myomeres: Preanal 22-24, commonly 23-24 (Fuiman et al. 1983). **Pigmentation:** Larvae are unpigmented and transparent (Becker 1983). **Other:** Larvae of this genus have flattened, oval eyes and differentiation to species is difficult (Fuiman et al. 1983).

JUVENILES OR ADULTS.

Fin rays: Dorsal 8; anal 8; pectoral 12-15; pelvic 8. **Pharyngeal teeth:** 0,4-4,0.
Lateral line scales: 36-40 (Becker 1983). **Mouth:** The mouth is inferior with barbels in the corners (Pflieger 1975).

•*Hybopsis storeriana* — Silver Chub

Habitat and Distribution

The silver chub lives in quiet pools and backwaters of large streams (Carlander 1969). It is common in all pools and reaches of the UMR (Van Vooren 1983). Eggs of *Hybopsis* are sometimes abundant in drift samples in the UMR from early June to early July. The fragile eggs are often broken into unrecognizable pieces during collection and missed during sorting.

Reproduction and Characteristics

SPAWNING.

Location: Silver chubs spawn in streams (Breder and Rosen 1966) and pelagic zones in streams and rivers (Williams 1963). **Season:** Spawning occurs in the UMR May and June (Eddy and Underhill 1974) and from mid-June to mid-August in Lake Erie (Kinney 1954).
Temperature: Spawning begins at 18.9°C and peaks at 22.8°C (Becker 1983).

EGGS.

Characteristics: Eggs may be buoyant, as in other members of genus (Bottrell et al. 1964).

LARVAE.

Preanal length: At 21 mm, it is 52% of the TL (Fish 1932). **Myomeres:** Preanal 24-27, commonly 25-26 (Fuiman et al. 1983). **Dorsal fin insertion:** At 6.5 mm, it is 36% of the TL.
Pigmentation: Two dorsal rows of melanophores extend from the head to the caudal peduncle. **Other:** A lateral line is absent and the eye is flattened (Fuiman et al. 1983). Larvae resemble those of the bullhead minnow but the snout is longer and the fins are larger and more slender (Taber 1969).

JUVENILES OR ADULTS.

Fin rays: Dorsal 8; anal 7-8; pectoral 16-18; pelvic 8-9. **Pharyngeal teeth:** 1,4-4,1.
Vertebrae: 38-41 (Scott and Crossman 1973). **Lateral line scales:** 37-41.
Mouth: Barbels are present at the corners of the mouth (Becker 1983).

•*Notropis atherinoides* — Emerald Shiner

Habitat and Distribution

The emerald shiner lives in open channels of large, low-gradient streams where there is noticeable current (Pflieger 1975). It is also found in reservoirs and lakes. This is a schooling species that stays close to the surface or at mid-depths (Trautman 1957). The emerald shiner is the most common minnow in the Mississippi River (Pflieger 1975). It is abundant in all pools and reaches of the UMR (Van Vooren 1983). Larvae are particularly common in the main channel drift (Holland et al. 1984) with peak abundance near mid-June.

Reproduction and Characteristics

SPAWNING.

Location: Emerald shiners spawn just beneath the surface in shallow water over sand or firm mud (Pflieger 1975). **Season:** Spawning occurs from late May to mid-August (Becker 1983). **Temperature:** 22°C.

EGGS.

Characteristics: Eggs have colorless yolk, a diameter of 3.0-3.3 mm (Flittner 1964), a large perivitelline space, and a star-shaped micropyle (Loos and Fuiman 1978).
Deposition: When deposited, the eggs are demersal and nonadhesive (Becker 1983).
Incubation: Hatching occurs in 24-36 h at 25°C (Loos and Fuiman 1978).

LARVAE.

Length at hatching: 4.0 mm. **Yolk sac:** Elongate (Flittner 1964). **Preanal length:** At hatching, it is 67% of the TL; at 14 mm, 59% of the TL. **Myomeres:** At hatching, total of 35-41 or 23-26 + 10-15 (Fish 1932). **Dorsal fin insertion:** At 13.5 mm, it is 44% of the TL (Loos and Fuiman 1978). **Pigmentation:** At hatching, there is none; all fins, except the caudal, are colorless (Heufelder and Fuiman 1982).

JUVENILES OR ADULTS.

Fin rays: Dorsal 7-8; anal 10-13; pectoral 13-17; pelvic 8-9. **Pharyngeal teeth:** 2,4-4,2; occasionally 1,4-4,2 or 2,4-3,2. **Vertebrae:** 38-41 (Scott and Crossman 1973).
Pigmentation: Melanophores are present on the sides above the lateral line (Heufelder and Fuiman 1982).

•*Notropis blennius* — River Shiner

Habitat and Distribution

River shiners live in large rivers (rarely in lakes) and prefer clear water. This species is a schooling minnow usually found at midwater (Trautman 1957). It is abundant in the UMR from the headwaters downstream through Pool 26 and less abundant from Pool 26 to the Ohio River (Van Vooren 1983). No information is available on the larvae of this species in the UMR, primarily because they are difficult to identify.

Reproduction and Characteristics

SPAWNING.

Location: River shiners spawn in rivers or streams over sand and gravel bottoms (Trautman 1957). **Season:** Spawning occurs from June to late August.

LARVAE.

Preanal length: At 6.1 mm, it is 53.2% of the TL. **Myomeres:** Preanal 21-23, commonly 22. **Dorsal fin insertion:** At 6.1 mm, it is 40% of the TL. **Pigmentation:** The gut is outlined with pigment on its ventral surface; the lateral band is indistinct or may be absent, and pigmentation may be diffuse posteriorly (Conner et al. 1980).

JUVENILES OR ADULTS.

Fin rays: Dorsal 7-8; anal 7; pectoral 13-15; pelvic 8. **Pharyngeal teeth:** 2,4-4,2 (occasionally 2,4-4,1; 1,4-4,1; or 3,4-4,1). **Vertebrae:** 36-37. **Other:** The origin of the dorsal fin is directly above that of the pelvic (Scott and Crossman 1973).

•*Notropis dorsalis* — Bigmouth Shiner

Habitat and Distribution

This species lives in small streams and brooks of moderate gradient with sand bottoms that are free of silt (Trautman 1957). It prefers broad expanses of shallow water in streams with slight current (Pflieger 1975). In the UMR, it is found occasionally from Pool 1 downstream to Pool 26; rarely downstream from there to the mouth of the Ohio River (Van Vooren 1983). Little information is available on the distribution or ecology of its early life stages in the UMR.

Reproduction and Characteristics

SPAWNING.

Location: Bigmouth shiners spawn in creeks and small rivers, or occasionally in large rivers (Smith 1979), over sand and gravel (Loos and Fuiman 1978). **Season:** Spawning occurs from May to June in Illinois (Smith 1979) and from late May to August in Wisconsin.

EGGS.

Characteristics: Yellow in color.

LARVAE.

Length at hatching: Up to 3.7 mm TL. **Preanal length:** In protolarvae, it is 59-63% of the TL; in metalarvae, it is 56-59% of the TL. **Myomeres:** At 4-5 mm, 20-21 + 13-14.
Dorsal fin insertion: In protolarvae, it is 38-44% of the TL; in metalarvae, 43-44% of the TL.
Pigmentation: At hatching, there is no pigmentation; at 3.8 mm, melanophores are scattered on dorsal surface of head and body (Perry and Menzel 1979); after yolk absorption, the entire dorsal surface is heavily pigmented. In mesolarvae, there is a prominent melanophore in the nasal pit; in older larvae, scattered melanophores are found on the breast (Heufelder and Fuiman 1982).

JUVENILES OR ADULTS.

Fin rays: Dorsal 8; anal 8; pectoral 14-15; pelvic 8. **Pharyngeal teeth:** 1,4-4,1, occasionally 0,4-4,1 or 1,4-4,0. **Vertebrae:** 34-37. **Pigmentation:** A distinct mid-dorsal stripe and lateral band are present, especially posteriorly; the peritoneum is silvery. **Other:** The origin of the dorsal fin is over or slightly behind the origin of the pelvics (Scott and Crossman 1973).

•*Notropis hudsonius* — Spottail Shiner

Habitat and Distribution

This species lives in large rivers and lakes with firm sand, gravel, or rubble bottoms. It avoids strong currents, silt bottoms, and turbid water (Trautman 1957). It is common in all pools of the UMR but is rare in downstream reaches below Pool 26 (Van Vooren 1983). Little information is available on the distribution or ecology of early life stages in the UMR.

Reproduction and Characteristics

SPAWNING.

Location: Spottail shiners spawn over sand shoals or gravel riffles in mass aggregations; migrations up tributary streams have been reported. **Season:** Spawning occurs from late May to early June (Becker 1983). **Temperature:** 15-20°C (Wang and Kernehan 1979).

EGGS.

Characteristics: Eggs are yellow and have a diameter of 1.0-1.4 mm (Wang and Kernehan 1979). **Deposition:** Eggs are laid in clusters on bottom; they are demersal (Lippson and Moran 1974) and adhesive until water-hardened (Wang and Kernehan 1979).

LARVAE.

Length at hatching: 4 mm (Heufelder and Fuiman 1982) or about 5-6 mm TL (Lippson and Moran 1974). **Yolk sac:** The club-shaped, elongate, yolk sac is absorbed at 6.5-7.0 mm. **Preanal length:** At hatching, it is 64% of the TL. **Myomeres:** 22-24 + 12-15. **Dorsal fin insertion:** At hatching, it is at 42% of the TL (Heufelder and Fuiman 1982). **Pigmentation:** At 8 mm, a double row of melanophores is present along the mid-dorsal surface, as one mid-lateral row, as a series extending along the ventral body myomeres, and as a mid-ventral row between the isthmus and the anus. **Other:** The yolk-sac larva is similar to that of the silvery minnow (Lippson and Moran 1974).

JUVENILES OR ADULTS.

Fin rays: Dorsal 8-9; anal 7-8; pectoral 12-17; pelvic 7-8. **Pharyngeal teeth:** 2,4-4,2. **Vertebrae:** 37-39 (usually 38). **Lateral line scales:** 36-41. **Pigmentation:** A large black spot is present at the base of the caudal fin; the peritoneum is silvery. **Other:** The origin of the pelvic fins is directly below that of the dorsal (Becker 1983); adult characteristics develop at 14 mm (Lippson and Moran 1974).

•*Notropis lutrensis* — Red Shiner

Habitat and Distribution

Although red shiners are occasionally found in impoundments, they are most common in large creeks and rivers. They are tolerant of high turbidity and siltation and avoid water that is continuously cool and clear (Pflieger 1975). In the UMR, they are uncommon in Pools 14 to 16 and common in Pools 18 to 26; they have not been reported in the other pools (Van Vooren 1983). Little information is available on the distribution or ecology of early life stages in the UMR.

Reproduction and Characteristics

SPAWNING.

Location: Red shiners spawn in shallow water, on clean, gravel riffles, or on submerged objects, often around the margins of sunfish nests. The male guards the nest. **Season:** Spawning occurs from May to September, peaks in June and July (Pflieger 1975). **Temperature:** 25°C (Saksena 1962) or 15.6-29.4°C (Cross 1967).

EGGS.

Characteristics: Eggs are yellow-white in color and have a diameter of 1.2 mm (Saksena 1962). **Deposition:** The eggs are broadcast (Pflieger 1975), demersal, and adhesive. **Incubation:** Hatching occurs in 57-72 h at 25-28°C (Saksena 1962).

LARVAE.

Length at hatching: 4.7 mm. **Yolk sac:** The yolk sac is elongated and compact; 4 days after hatching, it becomes a thin, narrow streak below the gut; at 7 days after hatching it has been absorbed. **Preanal length:** In protolarvae, it is 60% of the TL; at 12 mm, 50% of the TL. **Myomeres:** At 4.7-5.5 mm, 19 + 14; at 8.9-16.4 mm, 20 + 14. **Dorsal fin insertion:** At 8.9-12.0 mm, it is at 46% of the TL. **Pigmentation:** At hatching, the eyes are pigmented and one row of melanophores is present along the side of the yolk sac. After the yolk sac is absorbed, the dorsum is unpigmented, except for a few large melanophores on top of the head; a single row of large melanophores occurs along the upper border of the notochord from a point below the origin of the dorsal fin to the caudal end of the notochord (Saksena 1962).

JUVENILES OR ADULTS.

Fin rays: Dorsal 9; anal 8-10; pectoral 14; pelvic 6. **Pharyngeal teeth:** 0,4-4,0 or 0,4-4,1 (Becker 1983).

•*Notropis spilopterus* — Spotfin Shiner

Habitat and Distribution

Spotfin shiners prefer large rivers with sandy, silt bottoms (Eddy and Underhill 1974) and are tolerant of siltation and industrial or domestic pollution (Becker 1983). In the UMR, they are common in Pools 1 to 18 and occasionally collected in Pools 19 to 24, but have not been reported in Pools 25 or 26 (Van Vooren 1983). Little information is available on the distribution or ecology of early life stages in the UMR.

Reproduction and Characteristics

SPAWNING.

Location: Spotfin shiners spawn in crevices or on the underside of submerged objects (Raney 1969). **Season:** Spawning occurs from late May to September in Wisconsin (Becker 1983). **Temperature:** 21.1-23.9°C (Becker 1983).

EGGS.

Characteristics: Eggs have a diameter of 1.4-1.6 mm (Snyder et al. 1977). **Deposition:** They are laid in groups of 10-97 and are demersal and adhesive (Gale and Gale 1977). **Incubation:** Hatching occurs in 5-7 days at 21-24°C (Snyder et al. 1977).

LARVAE.

Length at hatching: 4.0 mm. **Yolk sac:** The anterior portion of the yolk sac is enlarged. **Preanal length:** 58-61% of the TL. **Myomeres:** 36-39 (21-22 + 15-17). **Dorsal fin insertion:** 37-42% of the TL. **Pigmentation:** At hatching, the eyes are dark, a few melanophores are present over the yolk, and there is no pigment on venter of head (Snyder et al. 1977). At 6-8 mm, double mid-ventral postanal rows of melanophores are distinct but the breast and abdomen have no pigment (Heufelder and Fuiman 1982).

JUVENILES OR ADULTS.

Fin rays: Dorsal 7-8; anal 7-9; pectoral 12-15; pelvic 7-9. **Pharyngeal teeth:** 1,4-4,1 or 0,4-4,0. **Vertebrae:** 37-39 (Scott and Crossman 1973). **Pigmentation:** At 16-20 mm, a mid-lateral pigment band is forming but the black blotch on posterior membranes of the dorsal fin may be absent in young fish (Heufelder and Fuiman 1982).

•*Notropis stramineus* — Sand Shiner

Habitat and Distribution

Sand shiners prefer medium-sized to large streams with moderate to strong currents and sand or gravel bottoms (Eddy and Underhill 1974; Becker 1983). They school in midwater or near the bottom. In the UMR, they are collected only occasionally (Van Vooren 1983). Little information is available on the distribution or ecology of early life stages in the UMR.

Reproduction and Characteristics

SPAWNING.

Location: Sand shiners spawn in shallow areas of lakes and large rivers, often in sparse vegetation (Scott and Crossman 1973), or at creek mouths (Raney 1969) over sand or gravel (Carlander 1969). **Season:** Spawning occurs from June to July in Lake Erie (Fish 1932), from July to August in Iowa (Starrett 1951), and from late May to mid-August in Wisconsin (Becker 1983). **Temperature:** 21-27°C (Summerfelt and Minckley 1969).

EGGS.

Characteristics: No data.

LARVAE.

Length at hatching: 3.9 mm. **Preanal length:** 59-64% of the TL. **Myomeres:** 22-23 + 13-14, usually 35 (22 + 13). **Dorsal fin insertion:** At 36-41% of the TL (Perry and Menzel 1979). **Pigmentation:** At hatching, larvae may lack pigment; at 6-7 mm, the dorsum of the swim bladder is dark, there are a few round melanophores on the top of the head (Fish 1932); at 12 mm, melanophores are present at the base of the dorsal fin (Perry and Menzel 1979).

JUVENILES OR ADULTS.

Fin rays: Dorsal 8; anal 6-8; pectoral 12-16; pelvic 8. **Pharyngeal teeth:** 0,4-4,0. **Vertebrae:** 33-36, usually 35 (Scott and Crossman 1973). **Pigmentation:** At 29 mm, the dorsum has 1-4 rows of melanophores along its entire length, the pectoral, caudal, dorsal fins are pigmented but the pelvics are unpigmented (Fish 1932). In adults, there is little or no pigment around the anus or at base of anal fin; there is a distinct mid-dorsal stripe; and lateral band is not continuous through the eye (Heufelder and Fuiman 1982).

•*Notropis texanus* — Weed Shiner

Habitat and Distribution

Weed shiners prefer weedy areas in large rivers and streams (Eddy and Underhill 1974) but are common in rivers with sandy bottoms and no aquatic vegetation. They school in midwater (Becker 1983). This species is uncommon and limited to Pools 4 to 12 (Van Vooren 1983), but it may be locally abundant (Farabee 1979; Huston 1984). Little information is available on the distribution or ecology of early life stages in the UMR.

Reproduction and Characteristics

SPAWNING.

Location: Weed shiners are believed to spawn over sand and gravel (Loos and Fuiman 1978). **Season:** Spawning occurs in late August in Illinois (Smith 1979) and in late June to mid-July in Wisconsin (Becker 1983).

EGGS.

Characteristics: Eggs are yellow. **Deposition:** Adhesive (Loos and Fuiman 1978).

LARVAE.

Yolk sac: A large yolk sac is present. **Pigmentation:** At hatching, the eye is unpigmented. **Other:** No cement glands are present (Loos and Fuiman 1978).

JUVENILES OR ADULTS.

Fin rays: Dorsal 8; anal 7-8; pectoral 12-14; pelvic 8. **Dorsal fin insertion:** Anterior to the origin of the pelvic fin. **Pharyngeal teeth:** 2,4-4,2 (Becker 1983). **Vertebrae:** 34-38 (Loos and Fuiman 1978). **Gill rakers:** Lower limb 3; upper limb 4. **Lateral line scales:** 34-37 (Becker 1983).

•*Pimephales notatus* — Bluntnose Minnow

Habitat and Distribution

Bluntnose minnows inhabit quiet pools and backwaters of medium to moderately large streams that have clear warm water, permanent flow, and moderate amounts of aquatic vegetation (Pflieger 1975). They occur occasionally throughout all pools and reaches of the UMR (Van Vooren 1983). Little information is available on the distribution or ecology of early life stages in the UMR.

Reproduction and Characteristics

SPAWNING.

Location: Bluntnose minnows spawn in rivers, streams, and lakes; males dig nests under submerged objects in sand or gravel shoals and later guard the eggs (Hubbs and Cooper 1936). **Season:** Spawning occurs from May to August. **Temperature:** 21-26°C (Becker 1983).

EGGS.

Characteristics: Eggs have a yellow-white color (Becker 1983) and a diameter of 1.5 mm. **Deposition:** Eggs are laid in oblong patches 8-10 cm or larger, usually one layer thick and are demersal and adhesive. **Incubation:** Hatching occurs in 6-10 days at 19-25°C (Westman 1938).

LARVAE.

Length at hatching: 4.9-5.9 mm. **Yolk sac:** A large, club-shaped yolk sac is present (Buynak and Mohr 1979b) but reduced at 5.5-5.7 mm (Fish 1932) and absorbed at 6.4 mm (Buynak and Mohr 1979b). **Preanal length:** At hatching, it is 65% of the TL (Fish 1932). **Myomeres:** At 4.9-7.0 mm, 36-38 (23-25 + 12-15). **Dorsal fin insertion:** At 39-41% of the TL. **Pigmentation:** At hatching, melanophores are present on the ventral surface, posterior to the vent, on the yolk sac, on the swim bladder, and along the lateral line; at 8.3 mm, a caudal spot is faintly evident (Buynak and Mohr 1979b); at 12 mm, the caudal spot is distinct, the lateral band is present, and the belly is pigmented (Fish 1932).

JUVENILES OR ADULTS.

Fin rays: Dorsal 8; anal 7; pectoral 15-16; pelvic 8. **Pharyngeal teeth:** 0,4-4,0. **Vertebrae:** 37-38 (Scott and Crossman 1973). **Lateral line scales:** 40-44. **Gill rakers:** 8-10. **Other:** The origin of the dorsal fin is slightly behind that of the pelvic fins (Becker 1983).

•*Pimephales promelas* — Fathead Minnow

Habitat and Distribution

Fathead minnows thrive in shallow lakes, ponds, and ditches where there is little predation. They are tolerant of high water temperatures, extreme turbidity, and low oxygen (Eddy and Underhill 1974). The fish is reported as uncommon in all pools of the UMR (Van Vooren 1983). Larval *Pimephales* have rarely been collected in ichthyoplankton of the UMR (Holland et al. 1984) and little information is available on the distribution and ecology of this species.

Reproduction and Characteristics

SPAWNING.

Location: Fathead minnows spawn in ponds and slow-moving waters (Heufelder and Fuiman 1982). Males construct nests beneath submerged objects and eggs are laid on the underside of objects (Andrews and Flickinger 1974); males guard the eggs (Becker 1983). **Season:** Spawning occurs intermittently from late May to mid-August (Thomsen and Hasler 1944). **Temperature:** 15.6-18.4°C (Prather 1957).

EGGS.

Characteristics: Eggs are orange in color (Becker 1983) with a diameter of 1.4-1.6 mm (Wynne-Edwards 1932). **Deposition:** Eggs are laid in clusters (Becker 1983), demersal (Wynne-Edwards 1932), and adhesive (Andrews and Flickinger 1974). **Incubation:** Hatching occurs in 5 days at 23-30°C (Markus 1934).

LARVAE.

Length at hatching: 4.8 mm (Markus 1934) or 4.9-5.2 mm (Buynak and Mohr 1979b). **Yolk sac:** The bulbous yolk sac is absorbed at 5.6 mm. **Preanal length:** At hatching, it is 57-64% of the TL. **Myomeres:** At 5.6-12.2 mm, 34-37 or 22-24 + 11-15 (Buynak and Mohr 1979b); predorsal 9-11. **Dorsal fin insertion:** At hatching, it is at 37-42% of the TL (Snyder et al. 1977). **Pigmentation:** At 5.0-5.5 mm, there is heavy pigmentation over the head and body (Perry and Menzel 1979); at 6.0-9.0 mm, there is prominent pigment on venter of gill cover (Snyder et al. 1977); at 9.0-17.0 mm, there are 3-6 dorsal lines of pigment to the caudal fin, there are 2 postanal melanophore series, the caudal fin spot is absent but there is faint pigment near hypurals (Fish 1932).

JUVENILES OR ADULTS.

Fin rays: Dorsal 8; anal 7; pectoral 14-18; pelvic 8. **Pharyngeal teeth:** 0,4-4,0. **Vertebrae:** 35-38 (Scott and Crossman 1973). **Lateral line scales:** 43-49, the lateral line is short and incomplete. **Gill rakers:** 12-14 (Becker 1983).

•*Pimephales vigilax* — Bullhead Minnow

Habitat and Distribution

This species inhabits sluggish pools and backwaters of medium-sized and large streams and is fairly tolerant of turbidity and siltation (Pflieger 1975). It is abundant in all pools of the UMR (Van Vooren 1983). Larval *Pimephales* have rarely been collected in studies of UMR ichthyoplankton and little information is available on their distribution and ecology.

Reproduction and Characteristics

SPAWNING.

Location: Bullhead minnows spawn in ponds, shallow pools, and slow-flowing waters (Becker 1983). Males construct nests under submerged objects and the eggs are deposited on the undersides of objects. Males guard the eggs (Parker 1964). **Season:** Spawning occurs from June to August in Wisconsin (Becker 1983). **Temperature:** ≥25.6°C (Becker 1983).

EGGS.

Characteristics: The eggs are iridescent (Parker 1964) or orange (Becker 1983) with a diameter of 1.0-1.5 mm. **Deposition:** The eggs are adhesive. **Incubation:** Hatching occurs at 4.5-6 days at 26-28°C (Parker 1964).

LARVAE.

Yolk sac: The yolk sac is absorbed at 6.0 mm. **Preanal length:** At 7.7 mm, it is 60% of the TL (Taber 1969). **Myomeres:** Preanal 23-25, commonly 23 (Fuiman et al. 1983). **Dorsal fin insertion:** At 7.7 mm, it is 37% of the TL (Taber 1969). **Pigmentation:** Larvae have intermittent a mid-ventral row of melanophores, a caudal spot, pigment on the dorsal fin base, and a spot on anterior portion of dorsal fin. **Other:** The eye is flattened (Fuiman et al. 1983).

JUVENILES OR ADULTS.

Fin rays: Dorsal 8; anal 7; pectoral 15-16; pelvic 8. **Pharyngeal teeth:** 0,4-4,0. **Gill rakers:** 6-8. **Lateral line scales:** 40-45. **Other:** The origin of the dorsal fin is over or slightly behind the origin of pelvic fins (Becker 1983).

■ Catostomidae — Suckers

This large family of mainly freshwater North American fishes consists of 12 genera and about 60 species (Becker 1983); 5 genera and 11 species are common in the UMR (Van Vooren 1983). Suckers are generally bottom-dwellers with ventral, protrusible mouths, sucking lips (except *Ictiobus*), and one row of 16 or more pharyngeal teeth. The large

swim bladder is physostomous and has two or three chambers (Scott and Crossman 1973). Vertebral counts listed for fishes of this family include the Weberian ossicles, unless indicated otherwise.

Most species make spawning migrations in the spring and run up small streams where they bury their eggs in gravel. The anus of the young at hatching is located posteriorly on the body (Fuiman 1982a). The head is deflected over the yolk sac and the mouth is incomplete. Later, when the yolk sac is reduced, the mouth develops into a terminal position. During the larval stage, the mouth eventually migrates to its final inferior position (except in *Ictiobus*). Catostomid larvae are similar to cyprinid larvae but have 27-33 preanal myomeres compared to 18-25 in cyprinids. *Ictiobus* and *Carpiodes* spp. regularly occur in ichthyoplankton samples from the UMR but they are difficult to separate accurately and consistently (Endris 1983). ***(ILLUS. P. 18)***

•*Carpiodes carpio* — River Carpsucker

Habitat and Distribution

Quiet still pools, backwaters, and oxbows of large streams with low gradients are preferred habitats of the river carpsucker. It occurs in large schools, feeds at the bottom, and seems to prefer turbid waters (Pflieger 1975). In the UMR, adult river carpsuckers have been collected occasionally in Pools 1 to 4, commonly in Pools 5 to 26, and abundantly in the lower reaches of the river (Van Vooren 1983). Larvae of *Ictiobus* and *Carpiodes* are common in backwater habitats of the UMR and are consistently collected in the main channel drift; peak densities occur in late May (Holland 1985).

Reproduction and Characteristics

SPAWNING.

Location: River carpsuckers spawn over silt or sand bottoms of rivers or tributaries, but not in lakes or reservoirs (Jester 1972). They are most successful in years of high water levels when meadows or marshes flood (Walburg 1976). **Season:** Spawning occurs in May in Wisconsin (Becker 1983) and peaks in early June to late July in Iowa (Behmer 1965). **Temperature:** 18.3-24°C, peaks at 21°C (Jester 1972).

EGGS.

Characteristics: Eggs have pale yellow yolk and a diameter of 1.8 mm (Yeager 1980). **Deposition:** The eggs are scattered, demersal, and adhesive (Yeager 1980). **Incubation:** Hatching occurs in 8-15 days (Becker 1983).

LARVAE.

Length at hatching: 5.3 mm. **Yolk sac:** The yolk sac is bulbous and is absorbed at 7.7-8.2 mm. **Preanal length:** At 5.0-5.5 mm, it is 73% of the TL. **Myomeres:** At 5.0-5.5 mm, 27-31 + 5-10. **Dorsal fin insertion:** At 15.1 mm, it is 37.6% of the TL. **Pigmentation:** At hatching, the eyes are moderately pigmented, and there is a mid-ventral stripe on yolk sac. At 6-8 mm, there are double postanal ventral rows and 2 dorsal rows, stitched at the mid-lateral line. At 8-16 mm, there is a diffuse line of pigmentation from the pectoral fins to the caudal, with

postanal ventral pigment in double row. The pectoral fin base has a single melanophore and the gill arches and snout are pigmented (Yeager 1980). **Other:** Cartilage and bone development is of little value in separating species among the carpsuckers; the shape of the premaxillary is the most consistent characteristic used to identify larvae (Endris 1983).

JUVENILES OR ADULTS.

Fin rays: Dorsal 24-30; anal 7-9; pectoral 15-18; pelvic 8-10. **Vertebrae:** 35-36 (Yeager 1980). **Lateral line scales:** 34-36 (Becker 1983). **Mouth:** The mouth is inferior with a nipple-like projection on the middle of lower lip (Fuiman 1982a).

•*Carpiodes cyprinus* — Quillback Carpsucker

Habitat and Distribution

Quillback carpsuckers live in moderately clear, highly productive streams with permanent pools and stable bottoms. They remain in quiet water except when spawning (Pflieger 1975). This fish is common in all pools of the UMR (Van Vooren 1983). Larvae of *Carpiodes,* like those of *Ictiobus,* are common in backwater habitats of the UMR. They occur consistently in the main channel drift with peak densities in late May.

Reproduction and Characteristics

SPAWNING.

Location: Quillback carpsuckers spawn in quiet waters of streams, in overflow areas (Harland and Speaker 1969), and in large rivers over sand, mud (Scott and Crossman 1973), gravel, or organic matter (Gerlach 1973). **Season:** Spawning begins in late April to May in Iowa (Harland and Speaker 1969). **Temperature:** 19-28°C (Becker 1983).

EGGS.

Characteristics: Eggs have a pale yellow yolk and a diameter of 2.0-2.2 mm (Yeager 1980). **Deposition:** The eggs are deposited randomly (Harland and Speaker 1956) and are demersal and adhesive (Gale and Mohr 1976; Yeager 1980).

LARVAE.

Length at hatching: 5.8-11.0 mm; mean, 6.5 mm. **Yolk sac:** At hatching, the yolk sac is elongate and club-shaped with the head deflected over it. At 7.2-7.9 mm, the yolk sac becomes tubular and it is normally absorbed at 9.1-9.6 mm (8 days after hatching). **Preanal length:** At 6-9 mm, it is 73% of the TL (Yeager 1980). **Myomeres:** 6-9 mm, 38-40 total myomeres or 30-31 + 8-9 (Fuiman 1979). **Dorsal fin insertion:** At 15.1 mm, it is 38% of the TL. **Pigmentation:** Larvae are heavily pigmented (Yeager 1980) with a double row of melanophores on the dorsum (McGuire 1981). **Other:** Details of the cartilage and bone development in larvae were described by Endris (1983); the shape of the premaxillary is the most consistent useful characteristic for separating species of carpsuckers.

JUVENILES OR ADULTS.

Fin rays: Dorsal 25-30; anal 7-9; pectoral 16-18; pelvic 8-10. **Vertebrae:** 38-40 (Scott and Crossman 1973). **Lateral line scales:** Usually 36-40 (Becker 1983). **Gill rakers:** 25-29. **Branchiostegal rays:** 3 (Scott and Crossman 1973). **Mouth:** The mouth is ventral and subterminal (Yeager 1980).

•*Carpiodes velifer* — Highfin Carpsucker

Habitat and Distribution

This species prefers clearer water and firmer substrate than the river carpsucker and it is less tolerant of turbidity and siltation than other carpsuckers (Pflieger 1975). Highfin carpsuckers are occasionally found in Pools 1 to 13 and 21 to 26 and are reported as uncommon in Pools 14 to 20 (Van Vooren 1983). Larvae of *Carpiodes* and *Ictiobus* are common in backwater habitats of the UMR and occur consistently in the drift with peak densities in late May.

Reproduction and Characteristics

SPAWNING.

Location: Large numbers of spawners migrate to shallows or overflow areas of streams (Harland and Speaker 1956) where they spawn over gravel (Pflieger 1975), sand, or mud bottoms (Scott and Crossman 1973). **Season:** Spawning occurs from mid-May to July (Becker 1983). **Temperature:** 19-28°C (Woodward and Wissing 1976).

EGGS.

Characteristics: The eggs have a diameter of 1.9-2.0 mm (J. W. Wiltz in Fuiman 1982a). **Deposition:** When laid, the eggs are demersal and adhesive (J. W. Wiltz in Fuiman 1982a).

LARVAE.

Yolk sac: The yolk sac is club-shaped (Yeager 1980) and absorbed at 7-9 mm (J. W. Wiltz in Fuiman 1982a). **Preanal length:** At 6-10 mm, it is 70-71% of the TL; at 16.2 mm, 61.1% of the TL. **Myomeres:** 35-37 (27-29 + 7-10). **Dorsal fin insertion:** At 16.2 mm, it is 39% of the TL (Yeager 1980). **Pigmentation:** A double row of melanophores is present on the dorsal surface and a ventral row on the back side of anal fin is joined with a mid-ventral peduncle row. The mid-lateral stripe is indistinct (J. W. Wiltz in Fuiman 1982a).

JUVENILES OR ADULTS.

Fin rays: Dorsal 23-30; anal 7-9; pectoral 14-18; pelvic 8-10. **Vertebrae:** 35-36 (Scott and Crossman 1973). **Lateral line scales:** 33-35 (Becker 1983). **Mouth:** The mouth is inferior with a nipple-like projection on the middle of the lower lip (Fuiman 1982a).

•*Catostomus commersoni* — White Sucker

Habitat and Distribution

White suckers most frequently occur in clear to slightly turbid waters with sand or gravel bottoms, but they sometimes live in turbid and highly polluted water. They tolerate a wide range of stream gradients (Becker 1983). These fish are common in Pools 1 to 11 of the UMR and are occasionally found in Pools 12 to 26 (Van Vooren 1983). *Catostomus* larvae are rare in collections from mainstem waters of the UMR.

Reproduction and Characteristics

SPAWNING.

Location: White suckers migrate up streams (Eddy and Underhill 1974) to spawn in riffles and pools (Raney 1959) over clean, silt-free gravel (Pflieger 1975). **Season:** Spawning occurs in April and early May in Wisconsin (Becker 1983). **Temperature:** 7.2°C (Becker 1983) to 10°C (Geen et al. 1966).

EGGS.

Characteristics: The eggs have a light yellow yolk and a diameter of 2.0-3.6 mm (Fuiman 1979). No oil globule is present but many clear, minute droplets are present in the yolk and along the edge of the blastodisc (Stewart 1926). **Deposition:** Eggs are laid singly or in small groups (Raney and Webster 1942); they are demersal and nonadhesive after water-hardened. **Incubation:** Hatching occurs in 12-21 days at an average of 10°C (Stewart 1926).

LARVAE.

Length at hatching: Variable, 6.0 mm (Crawford 1923) to 8.0 mm (Stewart 1926) but can be up to 12 mm (Long and Ballard 1976). **Yolk sac:** The yolk sac is initially cylindrical (Stewart 1926) and is absorbed at 11 mm (Raney 1959) to 14.4 mm (Buynak and Mohr 1978). **Preanal length:** At 8-10 mm, it is 82% of the TL (Stewart 1926); at 12-18 mm, 73% of the TL. **Myomeres:** At 8-10 mm, 37-39 + 7-10. **Dorsal fin insertion:** At 14.6 mm, it is 34% of the TL. **Pigmentation:** At hatching, the eyes are partly pigmented, but there is no other pigmentation. At 11-13 mm, there is dense pigmentation on the head; at 12-18 mm, three rows of melanophores are present on the dorsal surface posterior to the insertion of the pectoral fins (Fuiman 1979). **Other:** A two-chambered swim bladder is present (Fuiman 1982a).

JUVENILES OR ADULTS.

Fin rays: Dorsal 10-13; anal 7; pectoral 16-18; pelvic 10-11. **Vertebrae:** 45-48 (Scott and Crossman 1973). **Lateral line scales:** 58-85 but usually 60-70 (Becker 1983). **Gill rakers:** 20-23. **Branchiostegal rays:** 3. **Mouth:** The mouth is subterminal (Scott and Crossman 1973).

•*Ictiobus bubalus* — Smallmouth Buffalo

Habitat and Distribution

Smallmouth buffalo prefer clean, clear, deep waters with a moderate current. They live in pools, oxbows, and the deeper water of large rivers (Becker 1983). This fish is the most abundant species of *Ictiobus* in the Mississippi River; it is common in Pools 10 to 26 of the UMR and is occasionally collected upstream from Pool 9 (Van Vooren 1983). Larvae are common in backwater habitats of the UMR and occur consistently in the main channel drift with peak densities in late May.

Reproduction and Characteristics

SPAWNING.

Location: Smallmouth buffalo spawn in shallow areas (Becker 1983), randomly over bottom, often in vegetation (Heard 1958) that may be submerged or floating (Canfield 1922). **Season:** Spawning occurs in April to early June. **Temperature:** 15.6-18.3°C (Becker 1983).

EGGS.

Characteristics: The eggs have a pale yellow yolk and a diameter of 1.6-2.2 mm (Wrenn and Grinstead 1971; Yeager 1980). **Deposition:** Eggs are scattered randomly (Becker 1983); they are demersal and adhesive (Wrenn and Grinstead 1971). **Incubation:** Hatching occurs in 96-100 h (Wrenn 1968), 100-108 h (Wrenn and Grinstead 1971), 8-14 days at 21°C (Nord 1967).

LARVAE.

Length at hatching: The mean length is 6.0 mm (Wrenn and Grinstead 1971). **Yolk sac:** The yolk sac is pale yellow, club-shaped, and absorbed by 7.5 mm.

Preanal length: At 9.5 mm, it is 74% of the TL; at about 15.3 mm, 68% of the TL. **Myomeres:** Total myomeres, 35-39 or 28-31 + 6-9 (Yeager and Baker 1981). **Dorsal fin insertion:** At 10.4 mm, it is 39% of the TL. **Pigmentation:** At hatching, the eyes are pigmented (Yeager and Baker 1981) and there are several mid-ventral melanophores. At 6-8 mm, mid-dorsal, dorsal head, and mid-lateral pigmentation is developing and there is a mid-dorsal stripe of melanophores on the dorsum of the yolk. At 8-20 mm, the gill arches are pigmented and melanophores occur along the sides of gut and along the caudal fin rays (Wrenn and Grinstead 1971).

JUVENILES OR ADULTS.

Fin rays: Dorsal 26-31; anal 9 (Becker 1983); pectoral 15-17 (Yeager and Baker 1981); pelvic 9-11 (Becker 1983). **Vertebrae:** 36-37 (Cross 1967). **Lateral line scales:** 36-38 (Becker 1983). **Mouth:** The mouth is inferior with an inverted U-shape (Wrenn and Grinstead 1971).

•*Ictiobus cyprinellus* — Bigmouth Buffalo

Habitat and Distribution

Bigmouth buffalo inhabit pools of large streams, lowland lakes, and impoundments but they sometimes enter small creeks to spawn. This species is more tolerant of high turbidity than other species of *Ictiobus* and inhabits deep, slow, sluggish, or still waters of large rivers and reservoirs such as those found in the UMR. Bigmouth buffalo often congregate in schools of 25 or more fish at midwater or near the bottom (Pflieger 1975). They are common in all pools of the UMR (Van Vooren 1983). Larvae occur in backwater habitats of the UMR and are often in the main channel drift; their density peaks in late May.

Reproduction and Characteristics

SPAWNING.

Location: Bigmouth buffalo migrate to small streams to spawn on riprap in quiet backwaters, shallow waters (Pflieger 1975) over sand or gravel bottoms (Walburg 1976), or on aquatic vegetation (Canfield 1922). **Season:** Spawning occurs in late April to May in Wisconsin (Becker 1983). **Temperature:** 15.5-18.3°C (Carlander 1969).

EGGS.

Characteristics: The eggs have a diameter of 1.9-2.1 mm (Yeager and Baker 1981) or 1.2-1.8 mm (Becker 1983). **Deposition:** The eggs are broadcast, demersal, and adhesive and adhere to vegetation (Johnson 1963). **Incubation:** Hatching occurs in 12-13 days at 14-17°C (Eddy and Surber 1947).

LARVAE.

Length at hatching: The mean length is 5.6 mm. **Yolk sac:** The yolk sac is granular, pale yellow, bulbous, and club-shaped and is absorbed at 6.7-7.3 mm. **Preanal length:** At 5.4 mm, it is 76% of the TL; at 17.8 mm, 69.1% of the TL; and at 25.7 mm, 61% of the TL (Yeager and Baker 1981). **Myomeres:** At 9-24 mm, 34-39 or 28-31 + 5-9 (Yeager 1980). **Dorsal fin insertion:** At 17.4 mm, it is 37.9% of the TL. **Pigmentation:** In newly hatched larvae, the eyes are pigmented; at 5-7 mm, the dorsum of the head is darkly pigmented and a mid-lateral stripe is present; at 7-8 mm, melanophores are scattered over the dorsum and there

is a dark mid-ventral stripe. **Other:** The fin rays are complete at 29-30 mm (Yeager and Baker 1981).

JUVENILES OR ADULTS.

Fin rays: Dorsal 27-28 (23-30); anal 7-8; pectoral 14-15; pelvic 10-11. **Vertebrae:** 36-37 (Scott and Crossman 1973). **Lateral line scales:** 34-39 (Becker 1983). **Gill rakers:** At least 60. **Branchiostegal rays:** 3 (Scott and Crossman 1973).

•*Minytrema melanops* — Spotted Sucker

Habitat and Distribution

Spotted suckers prefer clear warm waters with no noticeable current, abundant aquatic vegetation, and a soft substrate with large amounts of organic debris. They are intolerant of turbid water and industrial pollution (Carlander 1969). In the UMR, they are common in Pools 4 to 11, occasionally collected in Pools 3 and 12 to 15, and uncommon in other pools (Van Vooren 1983).

Reproduction and Characteristics

SPAWNING.

Location: Spotted suckers spawn in riffle areas over rubble bottoms (McSwain and Gennings 1972). **Season:** The spawning season extends from April to May (Pflieger 1975). **Temperature:** 15-18°C (Jackson 1957).

EGGS.

Characteristics: The eggs have a diameter of 2.3-2.6 mm (Hogue and Buchanan 1977) or 3.1 mm just before hatching (White 1977). **Deposition:** The eggs are demersal and adhesive. **Incubation:** Hatching occurs in 4.5-6.4 days at 16-20°C (Hogue and Buchanan 1977), 7-12 days at 15-18°C (Jackson 1957).

LARVAE.

Length at hatching: 4.2-6.8 mm (Hogue and Buchanan 1977) or 8.0-9.2 mm. **Yolk sac:** At hatching, 3 unequal lobes, unique among catostomids; absorbed at 10.5-11.0 mm (White 1977). **Preanal length:** At hatching, 86% of the TL; at 11-24 mm, 67% of the TL (Hogue and Buchanan 1977). **Myomeres:** Prolarvae 31-35 + 4-7; postlarvae 31-33 + 6-9 (Hogue et al. 1976). **Dorsal fin insertion:** At 17.5 mm, it is 38% of the TL (Hogue and Buchanan 1977). **Pigmentation:** At hatching, the body is opaque and the eyes are faintly yellow or green (White 1977); at 8-11 mm, mid-lateral, mid-ventral, and mid-dorsal stripes are present; at 11.5 mm, three longitudinal stripes occur on the dorsum (Hogue and Buchanan 1977).

JUVENILES OR ADULTS.

Fin rays: Dorsal 11-12; anal 7; pectoral 16; pelvic 9-10. **Vertebrae:** 43-44. **Lateral line scales:** 44-47. **Branchiostegal rays:** 3. **Mouth:** The mouth is inferior and horizontal (Scott and Crossman 1973).

•*Moxostoma anisurum* — Silver Redhorse

Habitat and Distribution

The silver redhorse prefers streams with slow current and long pools; it avoids heavy silt, sedimentation, and pollution (Scott and Crossman 1973). It is found occasionally in Pools 2-9 of the UMR but is uncommon to rare in other pools (Van Vooren 1983). The young inhabit slow-moving waters with overhanging banks (Scott and Crossman 1973). Larval *Moxostoma* are usually associated with vegetation in backwater areas of the UMR.

Reproduction and Characteristics

SPAWNING.

Location: In shallow riffles (Hackney et al. 1971), the main channel of rivers, at depths of 0.4-1.0 m over rocks, gravel, and rubble (Meyer 1962). They sometimes migrate upstream (Fish 1932). **Season:** April to May (Becker 1983). **Temperature:** 14°C (Hackney et al. 1971).

EGGS.

Characteristics: No data.

LARVAE.

Preanal length: 63% TL. **Dorsal fin insertion:** at 19.5 mm, 37%TL.

JUVENILES OR ADULTS.

Fin rays: Dorsal 14-15; anal 7; pectoral 17-18; pelvic 9. **Vertebrae:** 40-44. **Lateral line scales:** 42-44. **Gill rakers:** 25-28. **Branchiostegal rays:** 3 (Scott and Crossman 1973). **Pigmentation:** at 20 mm, melanophores on top of head and snout, two dorsal stripes, mid-lateral stripe, double row of spots from anus to tail. Pectoral and pelvic fins are lightly pigmented, and caudal, dorsal, and anal fins are heavily pigmented (Fish 1932).

•*Moxostoma erythrurum* — Golden Redhorse

Habitat and Distribution

The golden redhorse is most abundant in clear unpolluted streams with permanent pools and riffle areas, but tolerates moderate turbidity and intermittent flows (Pflieger 1975). It is uncommon in most pools and reaches of the UMR (Van Vooren 1983). Larval *Moxostoma* are usually found associated with vegetation in backwater areas of the UMR.

Reproduction and Characteristics

SPAWNING.

Location: In downstream ends of pools, in water 0.3-1.0 m deep (Becker 1983), and riffles in main streams (Gerking 1953) over loose gravel (R.E. Jenkins, in Fuiman 1982a). **Season:** May (Becker 1983). **Temperature:** 17-22°C (Hankinson 1932; Jenkins 1970).

EGGS.

Characteristics: Yolk pale yellow (Fuiman and Whitman 1979); diameter 2.2-2.5 mm (Becker 1983). **Deposition:** Demersal and nonadhesive (Fuiman 1982a).

LARVAE.

Length at hatching: 9.4 mm. **Yolk sac:** Bulbous anteriorly, absorbed at 13.4 mm. **Preanal length:** 82% TL. **Myomeres:** 40-42 (33-35 + 7-8). **Dorsal fin insertion:** At 16

mm, 37% TL. **Pigmentation:** At hatching, eyes are slightly pigmented; at 11 mm, occiput is heavily pigmented, predorsal stripe, eyes are black, mid-lateral and narrow mid-ventral stripes; at 14 mm, melanophores along all dorsal fin rays (Fuiman and Whitman 1979).

JUVENILES OR ADULTS.

Fin rays: Dorsal 11-14; anal 7; pectoral 16; pelvic 9. **Vertebrae:** 36, plus Weberian ossicles (Scott and Crossman 1973). **Lateral line scales:** 40-42 (Becker 1983). **Mouth:** Inferior, posterior margin of lower lip has moderately acute angle (Pflieger 1975). **Gill rakers:** 25-27. **Branchiostegals:** 3 (Scott and Crossman 1973). **Other:** Three-chambered swim bladder (Fuiman 1982a).

•*Moxostoma macrolepidotum* — Shorthead Redhorse

Habitat and Distribution

Shorthead redhorse are found in moderately large rivers having gravel or rocky bottoms and a permanent, strong flow. However, this species may also occur in pools with no noticeable current (Scott and Crossman 1973). In the UMR, this species is common upstream from Pool 26 and uncommon downstream (Van Vooren 1983). Larvae of *Moxostoma* are usually associated with vegetation in backwater areas of the UMR.

Reproduction and Characteristics

SPAWNING.

Location: Shorthead redhorse spawn in small rivers or streams in shallow riffles at depths of 15-21 cm (Burr and Morris 1977), over gravel (Pflieger 1975), sand, stones, or rubble (Burr and Morris 1977). **Season:** Spawning occurs in April and May. **Temperature:** 8.3-16°C (Becker 1983).

EGGS.

Characteristics: The eggs are pale yellow (Buynak and Mohr 1979c) and have a diameter of 3.0-3.3 mm (Gale and Mohr 1976; Fuiman 1979). **Deposition:** The eggs are scattered (Reighard 1920), demersal, and nonadhesive. **Incubation:** Hatching occurs in 8 days at 16°C (Buynak and Mohr 1979c).

LARVAE.

Length at hatching: 7.7-10.4 mm (Buynak and Mohr 1979c; Fuiman 1979). **Yolk sac:** The yolk sac is pale yellow, granular, and absorbed at 13.9 mm (Fuiman 1979). **Preanal length:** At 9-12 mm, it is 75-78% of the TL; at 16-19 mm, 66-69% of the TL. **Myomeres:** At 16-19 mm, 38-41 total myomeres or 30-35 + 6-8 (Buynak and Mohr 1979c). **Dorsal fin insertion:** At 26.6 mm, it is 37% of the TL (Fuiman 1979). **Pigmentation:** In newly hatched larvae, pigmentation is absent; at 4 days after hatch, the eyes are dark brown to black (Fuiman 1979).

JUVENILES OR ADULTS.

Fin rays: Dorsal 12-14; anal 7; pectoral 16-17; pelvic 9-10. **Vertebrae:** 41-44 (Jenkins 1970). **Lateral line scales**: 40-46. **Mouth:** The mouth is small, inferior, and protrusible (Scott and Crossman 1973). **Gill rakers:** 22-30. **Branchiostegal rays:** 3 (Scott and Crossman 1973). **Other:** The origin of the pelvic fins is opposite the midpoint of the dorsal fin base (Jenkins 1970) and a three-chambered air bladder is present (Fuiman 1979).

■ Ictaluridae — Catfishes

This family consists of 5 genera and 37 species, all restricted to North America (Pflieger 1975). Five species—black, yellow, and brown bullheads, and channel and flathead catfish—occur regularly in the UMR (Van Vooren 1983). Catfishes have broad flat heads with four pairs of barbels and a cylindrical body that becomes laterally compressed behind the dorsal fin. All species are scaleless and have an adipose fin (Becker 1983). All vertebral counts listed include Weberian ossicles.

Catfishes spawn in natural cavities, in excavated nests, or in hollow objects. One or both parents (usually the male) remains with the eggs until they hatch. After the young have completely absorbed the yolk sac, they have a full complement of adult fin rays and are considered to be juveniles (Tin 1982b) and are sometimes called alevins. Catfishes are most active at night and are secretive during the day (Pflieger 1975). ***(ILLUS. P. 17)***

•*Ictalurus melas* — Black Bullhead

Habitat and Distribution

Black bullheads are most abundant in areas with turbid water, a silt substrate, little current, and limited fish fauna. Backwaters, impoundments, ponds, and lakes are typical habitats (Pflieger 1975). In the UMR, they are occasionally collected in Pools 1 to 26 and in the lower river reaches (Van Vooren 1983). The young remain in a tight school for several weeks after hatching (Farabee 1979).

Reproduction and Characteristics

SPAWNING.

Location: Black bullheads spawn in muddy shallow waters of ponds, pools, and streams (Langlois 1954) beneath moderate to heavy vegetation, in sand or mud nests that are constructed and guarded by the female (Scott and Crossman 1973). **Season:** Spawning occurs in April to June. **Temperature:** Beginning at 21°C (Becker 1983).

EGGS.

Characteristics: The eggs have a pale cream to golden color and a diameter of 3 mm, including a gelatinous coat (Scott and Crossman 1973). **Deposition:** The eggs are laid in a single mass (Cross 1967) and are demersal and adhesive (Scott and Crossman 1973). **Incubation:** Hatching occurs in 5-10 days, depending on the temperature (Becker 1983).

YOLK-SAC LARVAE.

Preanal length: At 9-10 mm, it is 50-51% of the TL (Tin 1982b). **Dorsal fin insertion:** At 27% of the TL (Auer 1982a).

JUVENILES OR ADULTS.

Fin rays: Dorsal I,5-6; anal 15-19 (without two anterior rudiments); pectoral I,8; pelvic 8. **Vertebrae:** 38-39. **Gill rakers:** 14-20. **Branchiostegal rays**: 8-9 on each side (Scott and Crossman 1973). **Pigmentation:** The body is a dark, brownish gray to black with dark maxillary and chin barbels (Cloutman 1979). **Other:** Young juveniles school for 2 weeks or

longer (Forney 1955); the pectoral spine barbs are short, the width is greater than the length, and serrations occur on less than half of the leading edge (Cloutman 1979).

•*Ictalurus natalis* — Yellow Bullhead

Habitat and Distribution

Yellow bullheads prefer clear waters with a permanent flow but they avoid strong currents (Scott and Crossman 1973). They often live in areas of moderate to heavy aquatic vegetation in shallows of clear-water lakes, ponds, and streams (Trautman 1957). Yellow bullheads are occasionally collected in Pools 1 to 12, 16 to 21, and 24 to 26 (uncommon in the other pools), and in some of the unpooled reaches of the lower Mississippi River (Van Vooren 1983). The young remain in a school for several weeks after hatching (Farabee 1979).

Reproduction and Characteristics

SPAWNING.

Location: Yellow bullheads spawn in shallow waters, at depths of 0.5-1.2 m (Miller 1966a), in nests built under stream banks or protected by stones or stumps. The parents guard the nest and young (Scott and Crossman 1973). **Season:** Spawning occurs in May to July (Becker 1983).

EGGS.

Characteristics: The eggs have a creamy white to yellowish color (Mansueti and Hardy 1967; Scott and Crossman 1973) and a diameter of 2.2-3.0 mm (Wallace 1972; Becker 1983). **Deposition:** Eggs are laid in clusters and are demersal and adhesive (Mansueti and Hardy 1967). **Incubation:** Hatching occurs in 5-10 days, depending on the temperature (Harlan and Speaker 1956).

YOLK-SAC LARVAE.

Preanal length: 46% of the TL. **Dorsal fin insertion:** 31% of the TL (Auer 1982a). **Pigmentation:** Closely set small melanophores occur over head, body, and fins; the underbelly is colorless and the body is yellowish-brown to brown. The chin barbels are light in color (Fish 1932) and the maxillary barbels are brown to dark brown. **Other:** The pectoral spine barbs are sharp and relatively short, not as long as in brown bullhead (Cloutman 1979).

JUVENILES OR ADULTS.

Fin rays: Dorsal I,6; anal 22-25 (without two anterior rudiments); pectoral I,7-8; pelvic 8. **Vertebrae:** 42. **Gill rakers:** 14-16. **Branchiostegal rays:** 8-9 (Scott and Crossman 1973).

•*Ictalurus nebulosus* — Brown Bullhead

Habitat and Distribution

Brown bullheads live near or on the bottom of warm water ponds and lakes in shallow areas with abundant vegetation. They prefer sand or mud bottoms into which they can burrow. This behavior helps them tolerate a wide range of temperatures, oxygen concentrations, and pollution that might limit other species (Scott and Crossman 1973). Brown bullheads occur occasionally in Pools 2 to

11 of the UMR and are rare or not reported downstream (Van Vooren 1983). The young do not swim until about 7 days after hatching. They school and are guarded by a parent until they are about 50 mm long, and then disperse (Scott and Crossman 1973).

Reproduction and Characteristics

SPAWNING.

Location: Brown bullhead nests are usually built by the females in sand or gravel, often in the shelter of submerged objects (Mansueti and Hardy 1967), and usually in water less than 1.2 m deep (Lagler 1956). **Season:** Spawning occurs from May to July in Wisconsin (Becker 1983). **Temperature:** 21-25°C (Mansueti and Hardy 1967).

EGGS.

Characteristics: The eggs are a light orange (Scott and Crossman 1973) or pale cream color (Stranahan 1910) with a diameter of 3.0 mm (Breder 1935). **Deposition:** Eggs are laid in clusters and are demersal and adhesive (Scott and Crossman 1973).
Incubation: Hatching occurs in 8 days at 20-21°C (Armstrong and Child 1962).

YOLK-SAC LARVAE.

Length at hatching: 6-8 mm (Eycleshymer 1901; Lippson and Moran 1974).
Yolk-sac: At 6-12 mm, the yolk sac is large (Wang and Kernehan 1979); it is absorbed 7-9 days after hatching (Smith and Harron 1903; Armstrong and Child 1962).
Preanal length: 45% of the TL. **Dorsal fin insertion:** At 12 mm, it is at 28% of the TL.
Pigmentation: At hatching, the barbels are transparent (Wang and Kernehan 1979) and the body is transparent, yellowish, cream color (Breder 1935). At 4 days, the upper body is uniformly dark, the underparts are white (Smith and Harron 1903), and the barbels are becoming dark (Wang and Kernehan 1979).

JUVENILES OR ADULTS.

Fin rays: Dorsal I,6-7; anal 19-24; pectoral I,7-9; pelvic 8. **Vertebrae:** 38-43.
Gill rakers: 13-14. **Branchiostegal rays:** 8-10 on each side (Scott and Crossman 1973).
Pigmentation: Chin barbels dark. **Other:** The adipose fin is free (Becker 1983) and the pectoral fin spines have 4-8 long recurved barbs on the posterior edge (Wang and Kernehan 1979).

•*Ictalurus punctatus* — Channel Catfish

Habitat and Distribution

Channel catfish frequent channels of large rivers in areas with currents that vary from nil to swift (Miller 1966). In the UMR, they seek cover during the day on or near the bottom in cool deep waters and are most active in shallow sloughs and along river shores at dusk and dawn (Farabee 1979). Yolk-sac larvae are rarely collected in main channel drift samples; however, alevins are abundant in main channel trawl catches and are most commonly collected at night. Channel catfish are common in all pools of the UMR (Van Vooren 1983).

Reproduction and Characteristics

SPAWNING.

Location: Channel catfish nests are made on the bottom in mud or under rock ledges in

protected (Becker 1983) or weedy areas (Fish 1932). **Season:** Spawning occurs from May to July. **Temperature:** Spawning begins at 24°C (Becker 1983), 21-29°C (Lippson and Moran 1974).

EGGS.

Characteristics: The eggs are a golden yellow color and darken with age during incubation (J. Davis 1959). They have a diameter of 3.5-4.0 mm (Shira 1917; Menzel 1945).
Deposition: Eggs are deposited as a large gelatinous mass and are demersal and adhesive (Becker 1983). **Incubation:** Hatching occurs in 9-10 days at 15-18°C (Brown 1942) and in 6-7 days at 26-28°C (Clemens and Sneed 1957).

YOLK-SAC LARVAE.

Length at hatching: 6.4 mm. **Yolk-sac:** At 6-13 mm, the yolk sac is elongate, bluntly pointed posteriorly (Lippson and Moran 1974), and absorbed 3-6 days after hatching (Greeley and Bishop 1932). **Preanal length:** 43-49% of the TL. **Myomeres:** 45-48 or 18 to 19 + 26 to 29 (Tin 1982b). **Dorsal fin insertion:** At 26% of the TL, above middle of pectoral.
Pigmentation: At hatching, the body is transparent (Surber 1920; Doze 1925); at 13 mm, melanophores are present in a triangular patch on the head and in a line on either side of mid-dorsal line to caudal base; at 14.5 mm, pigmentation is present on the snout and sides of the head, in a line from the head to the caudal fin, and on the fins and fin bases (Greeley and Bishop 1932).

JUVENILES OR ADULTS.

Fin rays: Dorsal I,6; anal 23-25 (without anterior rudiments); pectoral I,8-9; pelvic 8.
Vertebrae: 46-48. **Gill rakers:** 14-18. **Branchiostegal rays:** 8-9 (Scott and Crossman 1973).
Pigmentation: In juveniles, the body is white with scattered melanophores (Fish 1932).

•*Pylodictis olivaris* — Flathead Catfish

Habitat and Distribution

Flathead catfish inhabit a variety of streams but avoid those with high gradients or intermittent flows. Adults occur in pools near logs, piles of drift, or other cover. The young live among rocks in riffle areas and are most active at night (Pflieger 1975). Flathead catfish are commonly to occasionally collected throughout the UMR (Van Vooren 1983).

Reproduction and Characteristics

SPAWNING.

Location: Flathead catfish build nests or shallow depressions near submerged objects (Pflieger 1975) or in secluded shelters and dark areas (Harlan and Speaker 1969). Males guard the nest and young (Katz 1954). **Season:** Spawning occurs in June and July (Becker 1983).
Temperature: 23.9-25°C (Snow 1959).

EGGS.

Characteristics: The eggs are cream colored with a dark yolk (Snow 1959) and have a diameter of 5 mm (Minckley and Deacon 1959). **Deposition:** The eggs are deposited as a compact, golden yellow mass of up to 100,000 eggs (Pflieger 1975). The eggs are demersal and adhesive (Cross 1967).

YOLK-SAC LARVAE.

Length at hatching: 11 mm (Snow 1959). **Yolk-sac:** The yolk sac is opaque at 15 mm (Minckley and Deacon 1959) and absorbed 6 days after hatching (Fontaine 1944). **Preanal length:** 52% of the TL. **Dorsal fin insertion:** At 29% of the TL. **Pigmentation:** In newly hatched larvae, the body is not pigmented (Minckley and Deacon 1959); at 2 days, the color changes from cream to brown; at 15 mm, the head is almost black and the body is becoming darker (Snow 1959); the barbels are almost black after yolk absorption (Cloutman 1979). **Other:** The young stay in a compact school near the nest but later become solitary. The tail is not forked (Tin 1982b).

JUVENILES OR ADULTS.

Fin rays: Dorsal I,6; anal 14-16 (Becker 1983); pectoral I,9 (Tin 1982b); pelvic 9-10 (Taylor 1969). **Vertebrae:** 50-51 (Cross 1967). **Other:** The lower jaw projects beyond upper jaw after the fish reach a size >25 mm TL (Tin 1982b).

■ Aphredoderidae — Pirate Perches

This family is represented by only one species, *Aphredoderus sayanus,* a small spiny-rayed fish with ctenoid scales that rarely exceeds 110 mm TL. The pirate perch has a sharp spine on the rear margin of the opercle and a serrate preopercle. It spawns in the spring and parents guard the nest and young (Becker 1983). The anus is located in a posterior position in larvae, but migrates forward toward the isthmus during the juvenile stage. Larvae are characterized by an anterior oil globule in the yolk sac and total myomere counts of <30 (Pflieger 1975). ***(ILLUS. P. 19)***

•*Aphredoderus sayanus* — Pirate Perch

Habitat and Distribution

Pirate perch are solitary during the day but active at night. They live in aquatic vegetation or among organic debris over a mucky bottom and prefer slow-moving or standing water (Pflieger 1975). They are occasionally reported in Pools 5 to 9 of the UMR but have not been reported in other pools (Van Vooren 1983). Large breeding populations occur in many heavily vegetated backwater areas of Pool 7. Little information is available on the ecology and distribution of early life stages in the UMR.

Reproduction and Characteristics

SPAWNING.

Location: Pirate perch are nest builders (Eddy 1969) and gill cavity brooders (Martin and Hubbs 1973; Pflieger 1975). **Season:** Spawning occurs in May (Becker 1983).

EGGS.

Characteristics: The eggs are white, have a diameter of 1.0 mm (Martin and Hubbs 1973) or 0.50 to 0.75 mm (Hardy 1978), and a single oil globule measuring less than 0.4 mm (Martin

and Hubbs 1973). **Incubation:** Hatching occurs in 5-7 days at 19-20°C (Martin and Hubbs 1973).

LARVAE.

Preanal length: At 12.2 mm, it is 29% of the TL (Mansueti 1963). **Myomeres:** 25-31 or 12-15 + 13-16 (Hogue et al. 1976). **Dorsal fin insertion:** At 12.2 mm, it is 40% of the TL (Mansueti 1963). **Pigmentation:** In yolk-sac larvae, large melanophores cover the body, subocular pigment becomes a vertical bar, and pigmentation intensifies with growth (Hogue et al. 1976). **Other:** The preopercle is serrate, the opercle has a sharp spine, and the number of preanal myomeres decreases as the anus migrates forward.

JUVENILES OR ADULTS.

Fin rays: Dorsal II or III,10 or 11; anal II or III,6 or 7 (Becker 1983); pectoral 10-14 (Hardy 1978); pelvic I,6 (Becker 1983). **Vertebrae:** 29 (Bortone 1972). **Lateral line scales:** 48-59, incomplete. **Branchiostegal rays:** 6 (Nelson 1876).

■ Percopsidae — Trout-Perches

This monogeneric family contains only two species. The trout perch, *Percopsis omiscomaycus,* is distributed in streams and lakes in parts of the Great Lakes basin and the Upper Mississippi River drainage. The sand roller, *Percopsis transmontana,* is found only in the lower Columbia River drainage (Scott and Crossman 1973; Eddy and Underhill 1974). These small fish (maximum length 15-20 cm) have both spines and soft rays in their fins and an adipose fin. The large head has subterminal jaws and nonprotractile premaxillaries (Scott and Crossman 1973). ***(ILLUS. P. 19)***

•*Percopsis omiscomaycus* — Trout-Perch

Habitat and Distribution

Trout-perch are nocturnal, feed in shallow water at night, and move to deeper areas or hide in debris during the day (Pflieger 1975). They prefer intermediate to shallow waters of large lakes, avoid muddy shallow areas, and are frequently found in clear to slightly turbid waters (Becker 1983). The species is reported as rare to occasional in collections from Pools 1 to 11 of the UMR (Van Vooren 1983). Little information is available on the ecology and distribution of early life stages in the UMR.

Reproduction and Characteristics

SPAWNING.

Location: Trout perch spawn in shallow waters of lakes (Scott and Crossman 1973) or in shallow rocky streams (Muth and Tartar 1975) over sand or gravel (Becker 1983). **Season:** Spawning occurs in May to August (Magnuson and Smith 1963). **Temperature:** 15.6-20.0°C (Priegel 1962).

EGGS.

Characteristics: The eggs are yellow, have a diameter of 1.36-1.85 mm (Fish 1932; Magnuson and Smith 1963) or 1.25-1.45 mm (Lawler 1954), and contain a single, anterior oil globule measuring 0.7 mm in diameter (Fish 1932). **Deposition:** The eggs are broadcast, demersal, and adhesive. **Incubation:** Hatching occurs in 6.5 days at 20-23°C (Magnuson and Smith 1963).

LARVAE.

Length at hatching: 5.3-6.0 mm TL (Fish 1932; Magnuson and Smith 1963; Jude et al. 1979). **Yolk-sac:** The yolk sac is oval and is absorbed at 6.2 mm TL (Magnuson and Smith 1963) or 6.7 mm TL (Auer 1982c). **Preanal length:** At 6-7 mm, it is 44-45% of the TL (Jude et al. 1979) or 50% of the TL (Fish 1932); at 7-12 mm, 48-52% of the TL.
Myomeres: At 6-7 mm TL, 32-33 (14 + 18-20). **Dorsal fin insertion:** At 36% of the TL.
Pigmentation: At 6-7 mm, stellate melanophores occur on the anterior ventral side of yolk sac and the eyes are pigmented (Auer 1982c). **Other:** There is a single swim bladder; the mouth is developed at hatching (Fish 1932) and the position of the adipose fin is evident early (Auer 1982c).

JUVENILES OR ADULTS.

Fin rays: Dorsal II,9 to 11; anal I,5 to 8; pectoral 12 to 15; pelvic I,8 to 9. **Vertebrae:** 33-34.
Lateral line scales: Usually 44-50. **Gill rakers:** 8-13. **Branchiostegal rays:** 6 (6-7) (Scott and Crossman 1973).

■ Gadidae — Codfishes

The Gadidae comprise about 60 species of primarily marine bottom dwellers. Only one species, *Lota lota,* occurs in the UMR. Codfishes have laterally compressed, elongate bodies, soft rayed fins, and small cycloid scales. They have wide gill openings and a single, slender barbel on the chin. The larvae are easily distinguished by their early-season occurrence in the ichthyoplankton, their moderately short preanal length (42-44% TL), and the unusual placement of the anal opening (on the right side of the finfold, rather than at the edge of the finfold). ***(ILLUS. P. 23)***

•*Lota lota* — Burbot

Habitat and Distribution

Burbot are secretive fish, hiding near submerged objects during the day and foraging at night. The UMR system represents the southernmost extension of its range (Pflieger 1975). In northern pools of the UMR, it is uncommon to occasional (Van Vooren 1983). Eggs, larvae, and juveniles have been collected as far downstream as Pool 8.

Reproduction and Characteristics

SPAWNING.

Location: Burbot usually spawn in shallow areas of backwaters at depths of 0.3 to 4.6 m over sand or gravel (Scott and Crossman 1973). **Season:** Spawning occurs in late January and early February (Weber 1971). **Temperature:** 0.6-1.7°C.

EGGS.

Characteristics: The eggs have a clear yolk, a light yellow color (Muth and Smith 1974), a diameter of 1.25-1.77 mm (Scott and Crossman 1973), and contain a single large, clear, oil globule (Chen 1969). **Deposition:** The eggs are broadcast (Breder and Rosen 1966), semibuoyant (Muth and Smith 1974), and nonadhesive.

LARVAE.

Length at hatching: 3-4 mm (Snyder 1979). **Oil globule:** A single, anterioventral globule is present (Jude 1982b). **Preanal length:** 39-43% of the TL. **Myomeres:** 16 + 40.
Dorsal fin insertion: At 4.9 mm, it is at 29% of the TL (Snyder 1979). **Pigmentation:** At hatching, the larvae are transparent with pigmented eyes and a yellow oil globule (Sorokin 1968); at 10 mm, 25 black spots are present on top of the head; at 14 mm, there are distinct pigmented preorbital, postorbital, and opercular patches and the dorsum has irregularly arranged pigment (Fish 1932). **Other:** A single chin barbel is present, the median fins are elongate and soft-rayed, and the anus is ventral on the right side of the body but not at the edge of the finfold (Jude 1982b).

JUVENILES OR ADULTS.

Fin rays: Dorsal 8-16, 60-79; anal 59-76; pectoral 17-21; pelvic 5-8. **Vertebrae:** 50-66.
Gill rakers: 7-12. **Branchiostegal rays:** 7 (Scott and Crossman 1973).

■ Cyprinodontidae — Killifishes

Forty-five genera and over 300 species make up the family Cyprinodontidae. Most inhabit shallow freshwaters but some occur in brackish habitats and saltwaters (Pflieger 1975). Four species inhabit the UMR; three are relatively rare *(Fundulus catenatus, F. notti, and F. olivaceus),* and only the blackstripe topminnow *(F. notatus)* occurs regularly in collections (Van Vooren 1983). The head in the killifishes is adapted for surface feeding. The lower jaw projects well beyond the upper jaw of the small terminal mouth. The body is stout, small, laterally compressed and has cycloid scales.
(ILLUS. P. 20)

•*Fundulus notatus* — Blackstripe Topminnow

Habitat and Distribution

Blackstripe topminnows are found in large lowland rivers, low-gradient streams with moderate current, and in the pools of streams (Pflieger 1975). They are the most frequently collected

topminnow in the middle and lower reaches of the Mississippi River but are not common in any pool of the UMR (Van Vooren 1983). The collection of larval topminnows has not been reported in the UMR.

Reproduction and Characteristics

SPAWNING.

Location: Blackstripe topminnows spawn in inshore areas of backwaters on algae or submergent vegetation (Pflieger 1975) or on fibrous bottom materials (Foster 1967). The 20-30 eggs are deposited at a time and spawning may be repeated as more eggs mature (Carranza and Winn 1954). **Season:** Spawning occurs from May to August with multiple spawns.

EGGS.

Characteristics: The eggs have a diameter of 1.8 mm and contain many small oil globules (Foster 1967). **Deposition:** Eggs are single and demersal and have adhesive filaments to hold the eggs to vegetation (Carranza and Winn 1954). **Incubation:** Hatching occurs in 7 to 21 days (Foster 1967).

LARVAE.

Myomeres: 11 + 22-24 (genus *Fundulus,* Hogue et al. 1976). **Predorsal length:** 50% of the TL. **Snout to preanal finfold:** 33% of the TL (Foster 1967). **Pigmentation:** Larval have dorsal and ventral stripes of melanophores, the dorsal stripe is irregular; a few melanophores are present on the pectoral fins (Foster 1967).

JUVENILES OR ADULTS.

Fin rays: Dorsal 9; anal 12 (Becker 1983); pectoral 14-15 (Brown 1957); pelvic 6.
Lateral line scales: 31-36 (Becker 1983).

■ Atherinidae — Silversides

The silversides (50 genera, 160-170 species) are wide-ranging, mostly marine species; a few occur in fresh water (Pflieger 1975). Only the brook silverside *(Labidesthes sicculus)* is common in the UMR. Atherinids have laterally compressed, fusiform bodies with a beak-like snout and a long anal fin (Pflieger 1975). The two dorsal fins are widely separated and the pectoral fins are attached near the upper end of the gill opening. The mouth is directed obliquely upward. A characteristic bright silver stripe extends along the sides of the body (Scott and Crossman 1973). Eggs and larvae of this family are distinctive. The short preanal length (about 27% TL) in the larva separates this family from most others in the UMR. The eggs have long, adhesive filaments that hold them to vegetation. ***(ILLUS. P. 20)***

•*Labidesthes sicculus* — Brook Silverside

Habitat and Distribution

Brook silversides inhabit clear warm waters with little noticeable flow. In lakes and reservoirs, they are most abundant in coves and along the shore. They are usually at or near the surface and are clearly adapted to surface feeding. They have a daily cycle of activity that suggests a positive phototropism (Pflieger 1975).

In the UMR, brook silversides are reported as common in Pools 3 to 13 and occasional to uncommon downstream (Van Vooren 1983). Larvae are collected in many UMR backwater habitats, usually in vegetation. Collections in towed nets do not accurately reflect the abundance of larvae because they appear to avoid open water.

Reproduction and Characteristics

SPAWNING.

Location: Brook silversides spawn in shallow areas over gravel shoals or in beds of submerged vegetation (Scott and Crossman 1973). **Season:** Spawning occurs from May to early August. **Temperature:** 20°C, peaks at 22.7°C.

EGGS.

Characteristics: The eggs are orange, have a diameter of 1.1-1.4 mm (Rasmussen 1980), a perivitelline space ≤17% of egg radius, an oil globule and several spherical, oval, or asymmetrical oil globules 18-23 h after fertilization. However, only one globule remains in the yolk by the late embryo stage. **Deposition:** Eggs are laid singly and attached to vegetation by two or three long adhesive filaments that originate from the chorion (Rasmussen 1980).

LARVAE.

Length at hatching: 4.7-5.6 mm. **Yolk sac:** The yolk sac is oval and transparent; 13% of the TL and absorbed at 5.2-7.3 mm. **Oil globule:** Usually, only a single globule is present (1-3), 0.1-0.4 mm long. **Preanal length:** 27-28% of the TL. **Myomeres:** At hatching, 6-7 + 28-31; at 11.3 mm, 9 + 28; at 15.3 mm, 12 + 25. **Dorsal fin insertion:** First dorsal is at 48% of the TL; second dorsal at 56% of the TL. **Anal fin insertion:** At 46% of the TL.
Pigmentation: In newly hatched larvae, melanophores are concentrated in the occipital region, later they are irregularly spaced (Frietsche et al. 1979; Rasmussen 1980). There is pigmentation on the swim bladder and 1-6 melanophores on the mid-ventral gut (May and Gasaway 1967). **Other:** The swim bladder and vent are extremely anterior.

JUVENILES OR ADULTS.

Fin rays: Dorsal IV-I,9 to 11; anal I,20 to 26 (Becker 1983); pectoral 12-13; pelvic I,5.
Vertebrae: 40-43. **Lateral line scales:** 95. **Gill rakers:** 24-29.
Branchiostegal rays: 6 (Scott and Crossman 1973).

■ Percichthyidae — Temperate Basses

White *(Morone chrysops)* and yellow bass *(M. mississippiensis)* are the only two species of Percichthyidae that occur naturally and regularly in the UMR (Van Vooren 1983). These fishes are typical of many other Perciformes; they have deep, laterally compressed bodies, strongly ossified skulls, ctenoid scales, and 24 or more vertebra. The spiny- and soft-rayed dorsal fins are usually distinct and the pelvic fins are thoracic. Pseudobranchia are present and well developed. ***(ILLUS. P. 21)***

•*Morone chrysops* — White Bass

Habitat and Distribution

White bass travel in large schools and feed at the surface (Scott and Crossman 1973). They prefer open waters of lakes and reservoirs or rivers with moderate current (Becker 1983) and often are found in the main channel of the Mississippi River. They are common in all pools and reaches of the UMR (Van Vooren 1983). In Pools 7 and 8, concentrations of larvae are greatest in side channel areas with flooded hardwoods. Due to the abundance of adult white bass and the scarcity of yellow bass, most small *Morone* collected are assumed to be white bass. *Morone* spp. are sometimes predominant in the drift in late May and are often abundant in areas that receive flow from flooded woodlands. Juveniles inhabit main channel areas almost exclusively and move into main channel border areas at night, presumably from open water.

Reproduction and Characteristics

SPAWNING.

Location: White bass spawn in flowing waters of tributary streams but also use shallow shoreward areas with some current. They require a firm bottom of gravel, sand, or rubble (Riggs 1955). **Season:** Spawning occurs from late April to early June.
Temperature: 12.5-26.1°C (Becker 1983); spawning begins at 17°C in Pools 7 and 8 of the UMR and peaks about 1 week later at 17-20°C.

EGGS.

Characteristics: The eggs have a whitish yellow yolk (Dorsa and Fritzsche 1979), a diameter of 0.7 to 1.0 mm (Riggs 1955), a perivitelline space of 0.04-0.08 mm (Dorsa and Fritzsche 1979), and a single oil globule. **Deposition:** The eggs are broadcast at surface and are demersal and adhesive. They attach to gravel or vegetation after fertilization (Scott and Crossman 1973). **Incubation:** Hatching occurs in 48 to 50 h at 16-17°C (Yellayi and Kilambi 1969).

LARVAE.

Length at hatching: 1.7-2.8 mm (Dorsa and Fritzsche 1979). **Yolk sac:** The yolk sac is oval and is absorbed by 4.6 mm TL (Taber 1969) or after 8 days (Yellayi and Kilambi 1969).
Oil globule: Anterior (Dorsa and Fritzsche 1979). **Preanal length:** 58% of the TL (Taber 1969). **Myomeres:** 11-13 + 7-9 (Dorsa and Fritzsche 1979); prolarvae of *Morone* sp. 12-15 + 8-12; postlarvae 13-15 + 10-12 (Hogue et al. 1976). **Dorsal fin insertion:** At 10.5 mm, it is at 46% of the TL; at 19 mm, at 30% of the TL (Taber 1969). **Pigmentation:** At hatching, there

is little pigmentation lateral to and anterior of the oil globule; the pigmentation is not distinctive (Dorsa and Fritzsche 1979).

JUVENILES OR ADULTS.

Fin rays: Dorsal IX-I,13 to 15; anal III,12 to 13 (Becker 1983); pectoral 15 to 17; pelvic I,5. Vertebrae: 24. **Lateral line scales:** 52-60. **Gill rakers:** 23-25. **Branchiostegal rays:** 7 (Scott and Crossman 1973).

•*Morone mississippiensis* — Yellow Bass

Habitat and Distribution

Yellow bass inhabit quiet pools and backwaters of large streams, reservoirs, and natural lakes. They prefer open water free of vegetation (Pflieger 1975). They are rarely to occasionally collected from Pool 6 to Pool 24 but are more common in the UMR below its confluence with the Missouri River (Pflieger 1975; Van Vooren 1983). Because yellow bass are scarce in the UMR, collected larvae of *Morone* spp. are usually assumed to be white bass.

Reproduction and Characteristics

SPAWNING.

Location: Yellow bass spawn in shallow waters 0.7-1.0 m deep (Burnham 1909; Bulkley 1970), in open water over gravel bottoms (Phillips et al. 1982), and commonly in tributary streams. **Season:** Spawning occurs from May to June in Wisconsin (Becker 1983).
Temperature: 16-20°C (Atchinson 1967).

EGGS.

Characteristics: Eggs have an average diameter of 0.8 mm (Bulkley 1970) and a single oil globule. **Deposition:** The eggs are broadcast (Burnham 1909), demersal, and adhesive (Atchinson 1967).

LARVAE.

Length at hatching: 2.5-3.0 mm (Atchinson 1967); 3.2 to 4.8 mm (Burnham 1909).
Yolk sac: There is an oval yolk sac, similar to that of *M. chrysops;* it is absorbed at 6.4 mm TL or at 4 days (Burnham 1909). **Oil globule:** Anterior. **Preanal length:** 60% of the SL.
Myomeres: 11-12 + 12. **Pigmentation:** In yolk-sac larvae, there are two dorsal rows of pigment over the yolk sac; later, pigment develops over the snout, dorsum of head, operculum, and post anal mid-lateral region.

JUVENILES OR ADULTS.

Fin rays: Dorsal IX-I,11 to 13; anal III,8 to 10 (Becker 1983); pectoral 11-15 (F. E. Schultz in Fuiman 1982b); pelvic I,5 (Becker 1983). **Vertebrae:** 25 (Woolcott 1957).

■ Centrarchidae — Sunfishes

This North American family contains 9 genera and 32 species that are sometimes divided into three groups: sunfishes, crappies, and black basses. Nine sunfishes, three black basses, and two crappies have known distributions in the UMR (Van Vooren 1983). Centrarchids are laterally compressed and gibbose. The dorsal fin consists of two portions, a spiny-rayed first portion and a second portion that is soft-rayed. The pelvic fins are thoracic and the pectorals are positioned relatively high on the body. Scales are generally ctenoid. Villiform teeth are present on the jaws, vomer, palatines, and tongue (Scott and Crossman 1973; Becker 1983).

Larvae of centrarchids generally are easily distinguished to family. A large oil globule is located posteriorly in the yolk sac, rather than anteriorly as in the Percidae and Percichthyidae. Total myomeres exceed 26. The gut generally coils with growth.

Larvae of this family are collected regularly in the UMR. Identification has been primarily to genus because of difficulty in consistent identification to species without extensive effort, particularly in *Lepomis* and *Pomoxis* spp. All genera are much more abundant in backwater areas or border areas than in the main channel (Holland et al. 1984). However, centrarchids regularly make up a small part (4%) of the main channel drift. An estimated 400 million *Lepomis* and 94 million *Pomoxis* drifted through Lock and Dam 5 during 1984 (Holland 1985). ***(ILLUS. P. 21)***

•*Ambloplites rupestris* — Rock Bass

Habitat and Distribution

As the name implies, this species inhabits rocky shallow areas of lakes and warm, lower reaches of streams (Scott and Crossman 1973); it may also occur in mud-bottomed lakes and creeks (Pflieger 1975). It is common in the UMR from Pools 1 to 11 but is rarely found downstream (Van Vooren 1983). Little information is available on the ecology of larval stages of this species in the UMR. However, young-of-the-year inhabit backwaters with other sunfishes in submergent vegetation early in the year; they later switch to habitats with emergent vegetation (Holland and Huston 1985).

Reproduction and Characteristics

SPAWNING.

Location: Rock bass build nests constructed in shallow water along the shores of lakes and streams (Forbes and Richardson 1920) near aquatic vegetation (Pflieger 1975) over a bottom of coarse sand, gravel, or marl. **Season:** They spawn in late May or early June in Wisconsin (Becker 1983). **Temperature:** 15.6-21.1°C.

EGGS.

Characteristics: Eggs have a clear, pale yellow, or whitish color (Powles et al. 1980), a diameter of 2.0-2.1 mm, and a single oil globule, 0.76 mm in diameter.

Deposition: The eggs are demersal and adhesive (Buynak and Mohr 1979d).
Incubation: Hatching occurs in 3-4 days at 20.5-21°C.

LARVAE.

Length at hatching: 4.9-5.1 mm. **Yolk sac:** The yolk sac is oval and is absorbed at 7.4 mm. **Oil globule:** A single oil globule is located in the middle (Powles et al. 1980) or posterior portion of yolk sac (Buynak and Mohr 1979d). **Preanal length:** 41-46% of the TL (Powles et al. 1980). **Myomeres:** 28-31 (12-13 + 16-18). **Dorsal fin insertion:** At 8.6 mm, it is 38% of the TL. **Pigmentation:** At hatching, larvae are unpigmented; at 6.8 mm, the eyes are pigmented, large melanophores are present on top of the head, and developing into two dense patches (Buynak and Mohr 1979d). At 10-17 mm, stellate melanophores cover the body, especially on the tip of the jaws, snout, top of the head, dorsum, venter, and around fins (Fish 1932).

JUVENILES OR ADULTS.

Fin rays: Dorsal X to XII,10 or 11; anal V to VII,9 or 10; pectoral 12-14; pelvic I,5. **Vertebrae:** 29-30. **Lateral line scales:** 37-51. **Gill rakers:** 16. **Branchiostegal rays:** 6 (Scott and Crossman 1973). **Pigmentation:** In juveniles, there are vertical bands on the body, saddles on lateral surface, and the scales below lateral line have a black spot (Buynak and Mohr 1979d).

•*Lepomis cyanellus* — Green Sunfish

Habitat and Distribution

This species tolerates extremes in turbidity, dissolved oxygen, temperature, and flow (Pflieger 1975). It is found in warm shallow areas of ponds, lakes, and low-gradient rivers (Becker 1983). In the UMR, it is abundant in Pools 2 through 26 but uncommon in unpooled reaches of the river (Van Vooren 1983). Larvae have seldom been identified to species in studies in the UMR. Larval *Lepomis* spp. are abundant in backwaters and occur regularly in drift; however, most collected specimens are probably bluegills.

Reproduction and Characteristics

SPAWNING.

Location: Green sunfish build nests in shallow waters of lakes, sloughs, and ponds (Cahn 1927) constructed in the shelter of logs, rocks, or vegetation on a variety of substrates, including sand, mud, and roots (Becker 1983). **Season:** They spawn in late May to early August. **Temperature:** 15.6-28°C (Hunter 1963).

EGGS.

Characteristics: Eggs are yellow (Scott and Crossman 1973) or white (Cahn 1927), have a diameter of 1.0-1.4 mm (Meyer 1970), a single oil globule measuring 0.45 mm in diameter, and a perivitelline space of 0.08 mm (Taubert 1977). **Deposition:** Eggs are laid in a mass (Cahn 1927) and are demersal and adhesive (Taubert 1977).

LARVAE.

Length at hatching: 3.6-3.7 mm. **Yolk sac:** The yolk sac is absorbed at 6 mm TL (Taubert 1977). **Oil globule:** There is a single, posterior oil globule (Champion and Whitt 1976).

Preanal length: 47% of the TL. **Myomeres:** 11 + 16-17. **Dorsal fin insertion:** At 8.3 mm, it is 43% of the TL. **Pigmentation:** At hatching, larvae have no pigment; at 5.0-5.1 mm, 10 stellate melanophores dorsal to the swim bladder and 3 near anus are present; pigmentation increases with age. **Other:** Green sunfish have more preanal and fewer postanal myomeres than other sunfishes; yolk is still present when melanophores first appear on the top of the head; bluegills have no yolk and are feeding by this time; pumpkinseeds are similar to green sunfish (Taubert 1977).

JUVENILES OR ADULTS.

Fin rays: Dorsal IX to XI,10 to 12; anal III,9-10 (Becker 1983); pectoral 12-13; pelvic I,5. **Vertebrae:** 28-29. **Lateral line scales:** 40-50. **Gill rakers:** 14 on lower and 4-5 on upper arch. **Branchiostegal rays:** Usually 6 (Scott and Crossman 1973).

•*Lepomis gibbosus* — Pumpkinseed

Habitat and Distribution

Pumpkinseeds live in clear, quiet waters with aquatic vegetation. Weedy ponds, lakes, and reservoirs are common habitats (Scott and Crossman 1973). This sunfish is collected occasionally in most pools of the UMR (except Pool 1) but is uncommon or rare in unpooled stretches of the river (Van Vooren 1983). Larvae of *Lepomis* spp. are abundant in backwaters and occur regularly in the ichthyoplankton drift; however, most of the specimens collected are probably bluegills. Little is known about larvae of the pumpkinseed in the UMR.

Reproduction and Characteristics

SPAWNING.

Location: Pumpkinseeds build nests in ponds, lakes, and slow-moving streams (Scott and Crossman 1973) constructed on clay, gravel, or sand in water 0.3-0.8 m deep (Becker 1983).
Season: Spawning occurs in early May to August (Becker 1983).
Temperature: 20-28°C (optimum 21-24°C).

EGGS.

Characteristics: The eggs are transparent (Hardy 1978), have a diameter of 0.8-1.2 mm (Anjard 1974), and a single oil globule with a diameter of 0.3-0.4 mm. **Deposition:** Eggs are demersal and adhesive (Wang and Kernehan 1979). **Incubation:** Hatching occurs in 47 h at 19.0-24.7°C (Balon 1959); 3 days at 27.8°C (Breder 1936).

LARVAE.

Length at hatching: 2.6-3.1 mm. **Yolk sac:** The yolk sac is absorbed by 5.2 mm (Taubert 1977). **Oil globule:** A single oil globule located posteriorly in yolk sac is present (Anjard 1974). **Preanal length:** 37-45% of the TL (Tin 1982a). **Myomeres:** 10-13 + 17-21 (Taubert 1977). **Dorsal fin insertion:** At 5.4 mm, it is 32% of the TL (Anjard 1974); at 18.5 mm, it is 30% of the TL (Fish 1932). **Pigmentation:** At hatching, larvae are unpigmented (Wang and Kernehan 1979); at 4.6 mm, a few melanophores are present on the venter between the caudal fin and the anus; at 5.2 mm, pigmentation increases between anus and caudal fin (Balon 1959).

JUVENILES OR ADULTS.

Fin rays: Dorsal X to XI,10 to 12; anal III,8 to 11; pectoral 12 to 14; pelvic I,5. **Vertebrae:** 28-29. **Lateral line scales:** 35-47. **Gill rakers:** Short, stubby, 8 on lower and 4 on upper arch. **Branchiostegal rays:** 6-7 (Scott and Crossman 1973).

•*Lepomis humilis* — Orangespotted Sunfish

Habitat and Distribution

Orangespotted sunfish prefer small, sand-bottomed streams and lakes (Eddy and Underhill 1974). They tolerate high turbidity and siltation and avoid clear, cool water, high-gradient streams, and strong current (Pflieger 1975). In the UMR, they are collected occasionally from Pools 2 to 8, commonly in vegetated habitats Pools 9 to 26, and uncommonly below Pool 26 (Van Vooren 1983). Larvae of *Lepomis* are abundant in backwaters and occur regularly in main channel ichthyoplankton drift; however, most larvae are probably bluegills. Little is known about larvae of orangespotted sunfish in the UMR.

Reproduction and Characteristics

SPAWNING.

Location: Orangespotted sunfish spawn in shallow areas of lakes and impoundments (Barney and Anson 1923) over fine gravel, sand, and probably mud bottoms (Cross 1967).
Season: They spawn in late May to August (Breder and Rosen 1966).
Temperature: 18.4-31.6°C (Barney and Anson 1923; Cross 1967).

EGGS.

Characteristics: The eggs are nearly colorless (Cross 1967), transparent, or amber (Becker 1983) and have a diameter of 1 mm (Barney and Anson 1923). **Deposition:** Eggs are demersal and adhesive (Becker 1983). **Incubation:** Hatching occurs in 5 days at 18.3-21.1°C (Barney and Anson 1923; Langlois 1954).

LARVAE.

Preanal length: 44-48% of the TL. **Myomeres:** 29-31 or 13-15 + 14-17 (J. V. Conner, in Tin 1982a). **Dorsal fin insertion:** At 11.4 mm, it is 28% of the TL (Conner 1979).

JUVENILES OR ADULTS.

Fin rays: Dorsal X,10; anal III,8 to 9 (Becker 1983); pectoral 12 to 14; pelvic I,5 (Cross 1967). **Vertebrae:** 28-30 (Bailey 1938). **Lateral line scales:** 32-39 (Pflieger 1975).
Pigmentation: In juveniles, the vertical bars are fewer and wider than in young bluegills; all fins are transparent in young (Trautman 1957). **Other:** Large sensory pits are present on the head between the eyes; the pectoral fins are long and pointed (Conner 1979).

•*Lepomis macrochirus* — Bluegill

Habitat and Distribution

The bluegill is a schooling species found in lakes, ponds, reservoirs, and streams. It prefers substrates of sand, gravel, or muck associated with dense growths of aquatic vegetation. It is common in all habitats of the Mississippi River, including deep and shallow waters, but is most abundant in

shallow, slow-moving waters (Farabee 1979). It is abundant in all pools of the UMR and abundant to occasional in the lower reaches (Van Vooren 1983). Larvae stay closely associated with the nest bottom until after yolk absorption, then remain in the littoral zone through at least the juvenile stage. Larvae of *Lepomis*—probably mostly bluegills—are abundant in backwater habitats and occur regularly in the main-channel ichthyoplankton drift. Densities in both backwater and main channel collections peak in late June. Young-of-the-year are closely associated with submergent vegetation in backwaters of the UMR (Holland and Huston 1985).

Reproduction and Characteristics

SPAWNING.

Location: Bluegill build nests in shallows of lentic habitats (Becker 1983) near shore on sand or gravel. **Season:** Spawning occurs in May to early July in the UMR.
Temperature: 17-31°C (Breder 1936).

EGGS.

Characteristics: Eggs have an amber color (Scott and Crossman 1973), a diameter of 1.2-1.4 mm (Morgan 1951; Meyer 1970), and a single oil globule with a diameter of 0.38 mm (Childers 1967). **Deposition:** Eggs are demersal and adhesive (Becker 1983).
Incubation: Hatching occurs in 3-5 days (Scott and Crossman 1973).

LARVAE.

Length at hatching: 2.2-3.2 mm (Morgan 1951; Anjard 1974; Snow et al. 1978).
Yolk sac: The yolk sac is absorbed at 4.9-5.8 mm TL or 7-10 days after hatching (Morgan 1951; Toetz 1965, 1966). **Oil globule:** A single, posterior oil globule is present at hatching (Wang and Kernehan 1979); it is anterior at 4.9-5.7 mm (Toetz 1965).
Preanal length: At 2-5 mm, it is 55% of the TL (Morgan 1951); at 5-12 mm, it is 44% of the TL. **Myomeres:** 11-13 + 15-18. **Dorsal fin insertion:** At 6.8 mm, it is 30% of the TL (Taber 1969). **Pigmentation:** There is none at hatching; a ventral row of melanophores later develops posterior to the anus (Toetz 1965); a series of 3-5 melanophores is present on the venter between the isthmus and the vent (Lippson and Moran 1974).

JUVENILES OR ADULTS.

Fin rays: Dorsal X,10 to 12; anal III,11; pectoral 13-14; pelvic I,5. **Vertebrae:** 28-29.
Lateral line scales: 40-44. **Gill rakers:** Long and slender; 12 on the lower arch, 4 on the upper. **Branchiostegal rays:** 6 (Scott and Crossman 1973).

•*Micropterus dolomieui* — Smallmouth Bass

Habitat and Distribution

During daylight, smallmouth bass may be observed almost motionless near submerged cover or cruising about their home territory (Pflieger 1975). They prefer habitats with rocks and submerged logs, such as areas near wingdams and riprap in the UMR, and their affinity for vegetation is less than in largemouth bass (Scott and Crossman 1973; Farabee 1979). In the UMR, smallmouth bass are occasionally present in Pools 1 to 11, but uncommon in Pools 12 to 26 (Van Vooren 1983). Little information is available on the early life history in the UMR. Fry leave the nest as a school 6 to 15 days post-hatch (Farabee 1979) and are guarded by the male for a few days. Larvae are rarely collected in the main channel or associated backwaters of the UMR.

Reproduction and Characteristics

SPAWNING.

Location: Smallmouth bass spawn in sheltered areas (Farabee 1979) with current over clean gravel and sand (Eddy and Underhill 1974). **Season:** Spawning occurs in May through June (Becker 1983). **Temperature:** 11.7-21°C.

EGGS.

Characteristics: The eggs have a grayish white (Beeman 1924) or golden yellow color (Pflieger 1975), a diameter of 1.8-2.2 mm (Meyer 1970), and a single oil globule; many small droplets may also be present (Reighard 1906). **Deposition:** Eggs are laid in a mass and are demersal (Scott and Crossman 1973) and adhesive (James 1930). **Incubation:** Hatching occurs in 3-5 days (Schneberger 1977).

LARVAE.

Length at hatching: 4.6-5.7 mm (Reighard 1906; Tester 1930). **Yolk sac:** The yolk sac is absorbed at 8.7-9.9 mm (Scott and Crossman 1973). **Oil globule:** At 7.5 mm, a single anterior oil globule is present (Reighard 1906). **Preanal length:** In yolk-sac larvae, it is 45% of the TL; in older larvae, it is 51-54%. **Myomeres:** At 8.8 mm, 10 + 19. **Dorsal fin insertion:** At 19.0 mm, it is at 33% of the TL (Fish 1932). **Pigmentation:** There is little pigmentation at hatching but it soon develops along the junction of the yolk sac and body; the body then rapidly becomes covered with pigment; by 27 mm, 10 distinctive dark vertical bars have developed along the lateral line (Reighard 1906).

JUVENILES OR ADULTS.

Fin rays: Dorsal X,12 to 15; anal III,10-12; pectoral 13 to 15; pelvic I,5. **Vertebrae:** 31-32.
Lateral line scales: 68-78. **Gill rakers:** 8 on lower and 3 on upper arch.
Branchiostegal rays: 6; 6 and 7; or 7 (Scott and Crossman 1973).

•*Micropterus salmoides* — Largemouth Bass

Habitat and Distribution

This species is characteristic of natural lowland lakes, man-made impoundments, permanent pools of small streams with low or intermittent flow, and quiet backwaters of large rivers. It is intolerant of excessive turbidity and siltation and thrives in warm, moderately clear water having no noticeable current (Pflieger 1975). It is frequently associated with soft bottoms, stumps, and extensive growths of emergent and submergent vegetation (Scott and Crossman 1973) but can be found in most UMR habitat types (Farabee 1979). Largemouth bass are common in the pooled portions of the UMR and common to uncommon in lower stretches of the river (Van Vooren 1983). Larvae remain in the nest until the yolk is absorbed and then form a school that is guarded by the male. In many areas of the UMR, larvae and juveniles are specifically associated with dense beds of submerged vegetation.

Reproduction and Characteristics

SPAWNING.

Location: Largemouth bass build nests in shallow quiet water, in emergent vegetation (Scott and Crossman 1973) on sand, gravel, rubble, or marl (Mraz et al. 1978).
Season: Spawning occurs in April to early July. **Temperature:** 16.7-18.3°C (Becker 1983).

EGGS.

Characteristics: The eggs have an amber, pale yellow (Scott and Crossman 1973) or orange color, a diameter of 1.49-1.67 mm, a single large oil globule with a diameter of 0.54-0.67 mm (Chew 1974). **Deposition:** Eggs are laid as a mass that is not as compact as that of smallmouth bass (Scott and Crossman 1973), and are demersal and adhesiv (Mraz et al. 1978).

LARVAE.

Length at hatching: 3.6-4.1 mm (Wang and Kernehan 1979). **Yolk sac:** The yolk sac is large and oval (Wang and Kernehan 1979) and is absorbed at 6.5-8.0 mm (Reighard 1906; Anjard 1974). **Oil globule:** A large, single, posterior oil globule is present. **Preanal length:** At hatching, it is 62% of the TL (Carr 1942); after 5 mm, it is 44-50% of the TL (Tin 1982a). **Myomeres:** At 3.4 mm, 11 + 23-25 (Carr 1942). **Dorsal fin insertion:** At 15.5 mm, it is 33% of the TL (Meyer 1970). **Pigmentation:** At hatching, there is none (Carr 1942); a characteristic lateral band develops at about 10 mm (Meyer 1970).

JUVENILES OR ADULTS.

Fin rays: Dorsal X,12 to 14; anal III,10 to 11; pectoral 13-15; pelvic I,5. **Vertebrae:** 30-32. **Lateral line scales:** 60-68. **Gill rakers:** 6-8 on lower, 2 rudiments on upper arch. **Branchiostegal rays:** 6, 6 and 7, or 7 (Scott and Crossman 1973). **Other:** Juveniles are not as heavily pigmented as smallmouth bass and have a horizontal bar rather than vertical bars.

•*Pomoxis annularis* — White Crappie

Habitat and Distribution

White crappies do not school, but congregate in loose aggregations. They are usually found in silted streams, slow-moving areas of rivers, and impoundments. They avoid areas of excessive turbidity and continuously cool water (Scott and Crossman 1973). White crappies occur in all habitat types of the UMR but prefer deep quiet waters (Farabee 1979). They are common in all pools of the UMR, but are less evenly distributed below Pool 26 (Van Vooren 1983). Larvae occur in ichthyoplankton collections in early to mid-May, are most abundant in backwaters, and demonstrate a significant drift into the main channel at dusk (Holland and Sylvester 1983).

Reproduction and Characteristics

SPAWNING.

Location: White crappies spawn in ponds, lakes, reservoirs in deeper water than other centrarchids (Raney 1965) over clay, mud, sand, gravel, rocks, or on aquatic vegetation (Hansen 1943; Becker 1983). **Season:** Spawning occurs in May and June. **Temperature:** 14-23°C (Becker 1983).

EGGS.

Characteristics: The eggs have an amber to pale yellow color (Scott and Crossman 1973), a diameter of 0.8-0.9 mm (Hansen 1951), and a single, large oil globule. **Deposition:** Eggs are demersal and adhesive. **Incubation:** Hatching occurs in 93 h at 14.4°C (Morgan 1954).

LARVAE.

Length at hatching: 1.2-2.6 mm (Morgan 1954; Siefert 1969). **Yolk sac:** The yolk sac is absorbed at 4.0-4.6 mm (Siefert 1968; Chatry and Conner 1980). **Oil globule:** At ≥3.5 mm, a single large oil globule is present near the dorsum of yolk sac (Wang and Kernehan 1979); at >3.5 mm, it is located near the posterior end of the yolk sac (Chatry and Conner 1980). **Preanal length:** At 11.2 mm, 36% of the TL (Taber 1969). **Myomeres:** 29-33 total myomeres or 11-13 + 17-22 (Chatry and Conner 1980). **Dorsal fin insertion:** At 11.2 mm, it is at 38% of the TL (Taber 1969). **Pigmentation:** At hatching, the eyes are unpigmented; there is some pigment on the swim bladder and between the anus and the caudal peduncle; at 4-16 mm, large melanophores occur on the swim bladder (Morgan 1954); at 11 mm, there is a ventral row of melanophores and a few on the head (Wang and Kernehan 1979).

JUVENILES OR ADULTS.

Fin rays: Dorsal VI to VII,13 to 15; anal VI to VII,16 to 18; pectoral 13; pelvic I,5. **Vertebrae:** 30-32. **Lateral line scales:** 34-44. **Gill rakers:** 22-24 on lower arch; 6-8 on upper. **Branchiostegal rays:** 7 (Scott and Crossman 1973). **Pigmentation:** Juveniles and adults have pale, vertical bars (Tin 1982a).

•*Pomoxis nigromaculatus* — Black Crappie

Habitat and Distribution

Black crappies usually form moderately large schools in association with abundant growths of vegetation over sand to muck bottoms. They are found less often than white crappies in turbid environments (Scott and Crossman 1973). Black crappies are common in all pools of the UMR, but are only occasionally encountered in lower reaches of the river (Van Vooren 1983). Larvae occur in ichthyoplankton collections in the UMR from early to mid-May. They are most abundant in backwaters but tend to drift into the main channel at dusk (Holland and Sylvester 1983).

Reproduction and Characteristics

SPAWNING.

Location: Black crappies spawn in vegetated areas or in protection of undercut banks, where the water depth is 25-61 cm (Scott and Crossman 1973). Their nests are constructed in sand, gravel, or mud (Scott and Crossman 1973) on bottoms that are softer and muddier than those used by other centrarchids (Eddy and Underhill 1974). **Season:** Spawning occurs in May and June. **Temperature:** 17.8-20°C (Becker 1983).

EGGS.

Characteristics: The eggs are whitish in color, have a diameter less than 1 mm (Scott and Crossman 1973), and contain a single oil globule (Merriner 1971). **Deposition:** Eggs are demersal and adhesive (Scott and Crossman 1973).

LARVAE.

Length at hatching: 2.3 mm (Siefert 1969). **Yolk sac:** The oval yolk sac is absorbed at 3.5-3.9 mm (Chatry and Conner 1980). **Oil globule:** Single. **Preanal length:** At 13 mm, it is 41% of the TL (Auer 1982a); at 24.5 mm, 33% of the TL (Wang and Kernehan 1979).

Myomeres: 29-32 or 10-13 + 18-20 (Siefert 1969). **Dorsal fin insertion:** At 13 mm, it is at 41% of the TL (Auer 1982a); at 24.5 mm, 30% of the TL (Wang and Kernehan 1979). **Pigmentation:** There is none at hatching; at 6-18 mm, pigmentation develops on the dorsum of the swim bladder, the side of the head, and along the mid-ventral line. At 14 mm, there is a double row of melanophores along the dorsal fin (Faber 1963). **Other:** At <5 mm, larval black crappie cannot be separated from white crappie; at 5-6.5 mm, white crappie have ≤19 postanal myomeres, whereas black crappie have ≥21; at 6-16 mm, white crappie have ≤31 total myomeres, black crappie 32; at ≥16 mm, there are 5-6 dorsal spines in white crappie and 7 in black crappie (Siefert 1969).

JUVENILES OR ADULTS.

Fin rays: Dorsal VII to VIII,14 to 16; anal VI to VII,16 to 18; pectoral 13 to 15; pelvic I,5. **Vertebrae:** 31-33. **Gill rakers:** 22-23 on lower arch; 5-6 on upper. **Branchiostegal rays:** 7 (Scott and Crossman 1973).

■ Percidae — Perches

Members of the Percidae usually have elongate, laterally compressed bodies with dorsal fins distinctly separate; their pectoral fins are moderately long; the pelvic fins are thoracic; the anal fin is small; and the caudal fin is lunate to rounded. Although 18 species of percids are found in the UMR, only 7 occur commonly (Van Vooren 1983).

Larvae of all percids can be distinguished from related families by the nearly equal preanal to postanal length, the single anterior oil globule, the highly developed pectoral fin buds or finfolds, and a bulbous yolk sac. ***(ILLUS. P. 22)***

•*Ammocrypta clara* — Western Sand Darter

Habitat and Distribution

The western sand darter is found primarily in areas with slight to moderate current over sand (Phillips et al. 1982). It is primarily nocturnal and presumably buries itself in sand during daylight, emerging only at dusk and night to forage. It is very common in daylight collections from main channel border habitats (Pflieger 1975). The Western sand darter is intolerant of high turbidity and suspended solids, and its habitat in the UMR is being reduced by siltation (Smith 1979). This fish is listed as occasionally present below Pool 3 (Van Vooren 1983). The species prefers main channel border habitats and appears to be more common than indicated in most lists of fishes of the UMR. Metalarvae and juveniles live in sandy, main channel border areas where they have been collected with small-mesh seines. Earlier stages are probably also present there but they are not susceptible to capture in standard towed nets.

Reproduction and Characteristics

SPAWNING.

Location: Spawning occurs in littoral areas with slight current, such as main channel border habitats (Pflieger 1975), over coarse sand. **Season:** They spawn in late June through July (Lutterbie 1976).

EGGS.

Characteristics: The eggs have an orange (mature) or yellow (maturing) color, a diameter of 0.75-1.0 mm (Becker 1983), and a single oil globule.

LARVAE.

Length at hatching: 41.5 mm TL. **Yolk sac:** The yolk sac is small and bulbous and is absorbed at 5.0 mm TL. **Oil globule:** A single, anterior oil globule is present. **Preanal length:** 51% of the TL. **Myomeres:** 18-19 + 22-23. **Dorsal fin insertion:** Anterior to the anus at 27% of the TL. **Pigmentation:** There is no pigmentation up to 8.0 mm; thereafter, melanophores develop on the dorsal cranium concentrated on the optic lobe, cerebellum and snout, and on about every third myomere from nape posteriad. Laterally, a continuous line of melanophores is present along the midline and at base of caudal peduncle; ventrally, a single melanophore develops at the base of each post-anal myoseptum.

JUVENILES OR ADULTS.

Fin rays: Dorsal X to XII,9-12; anal I,7-10 (Becker 1983). **Vertebrae:** 39-40 (Bailey and Gosline 1955). **Lateral line scales:** 69-81. **Gill rakers:** 8. **Branchiostegal rays:** 6 (Becker 1983).

•*Etheostoma nigrum* — Johnny Darter

Habitat and Distribution

The johnny darter is most common in waters of moderate to no current, over a bottom of sand, sand and gravel, or sand and silt (Pflieger 1975). It occasionally occurs among aquatic macrophytes (Trautman 1981). This species is the most abundant darter in the UMR and is common in all 26 pools (Van Vooren 1983). Larval *Etheostoma* spp. occur in collections from backwater habitats but they are uncommon in ichthyoplankton samples collected with standard townets.

Reproduction and Characteristics

SPAWNING.

Location: Johnny darters spawn in protected shallow areas on the underside or sides of rocks (Scott and Crossman 1973). **Season:** They spawn in April to June (Becker 1983). **Temperature:** 11.7-21.1°C (Fish 1932).

EGGS.

Characteristics: The eggs have a pale yellow yolk, are translucent with a clear chorion, a diameter of 1.4-1.5 mm (Fish 1932), and a single large oil globule (Speare 1965). **Deposition:** The eggs are demersal and adhesive. **Incubation:** Hatching occurs in 10 days at 20°C (Winn 1958a).

LARVAE.

Length at hatching: 4.8-5.0 mm TL. **Yolk sac:** The oval yolk sac is absorbed at 5.8-6.2 mm TL. **Oil globule:** At hatching, it is located near the center of the yolk sac (Fish 1932); at 5-7 mm, it is large and anterior. **Preanal length:** At hatching, it is 45% of the TL; at 9-10 mm, 53% of the TL. **Myomeres:** 15 + 22-23, 11-15 + 22 (Fish 1932). **Dorsal fin insertion:** It is anterior to anus at 25% of the TL. **Pigmentation:** Larvae have little pigmentation at hatching; melanophores develop on every fourth postanal myomere and are scattered over the yolk sac (Fish 1932).

JUVENILES OR ADULTS.

Fin rays: Dorsal VIII to XI,10 to 13; anal I,7 to 10; pectoral 12; pelvic I,5. **Vertebrae:** 37-39. **Lateral line scales:** 41-52 (Scott and Crossman 1973). **Gill rakers:** 7. **Branchiostegal rays:** 6 (Becker 1983).

•*Perca flavescens* — Yellow Perch

Habitat and Distribution

Yellow perch inhabit clear waters in lakes or low-gradient river systems with abundant rooted aquatic macrophytes and bottoms of silt, organic debris, sand, or gravel (Scott and Crossman 1973; Pflieger 1975; Trautman 1981); they are intolerant of turbidity and siltation. In the UMR, yellow perch are found in backwater areas where the turbidity is low and current is reduced. They prefer shallow, littoral areas associated with aquatic macrophytes (Scott and Crossman 1973). Yellow perch are found commonly in most pools of the UMR—particularly those with extensive backwater areas (Pools 1 to 11). They are occasionally collected in Pools 12 to 20 but not in channelized portions of the river (Van Vooren 1983). Larvae are abundant in weedy littoral backwaters of the UMR and are sometimes a major component of the main channel ichthyoplankton drift in early spring, before most other species of fish have spawned.

Reproduction and Characteristics

SPAWNING.

Location: Yellow perch spawn in shallow, littoral zones over firm sand and gravel, usually in association with aquatic macrophytes (Mansueti 1964; Scott and Crossman 1973; Pflieger 1975). **Season:** Spawning occurs in April and early May (Becker 1983). **Temperature:** 7.2-11.1°C (Herman et al. 1959).

EGGS.

Characteristics: The eggs are transparent (Scott and Crossman 1973), have amber-colored yolk, a diameter of 1.9 to 2.8 mm, and a single oil globule (Mansueti 1964). **Deposition:** The eggs are released in long, folded, transparent, gelatinous strands that are semi-demersal (Becker 1983). **Incubation:** Hatching occurs in 8-10 days in situ (Herman et al. 1959), 27 days at 8.3°C (Mansueti 1964), and 17-20 days in situ (Weber 1975).

LARVAE.

Length at hatching: 4.7 to 6.6 mm TL (Mansueti 1964; Houde 1969; Nelson 1977). **Yolk sac:** The oval yolk sac is absorbed at 7.0 mm (Faber 1963). **Oil globule:** A single, anterior oil globule is present. **Preanal length:** At 11-15 mm, it is 50-52% of the TL.

Myomeres: 18-19 + 17-18 (Mansueti 1964). **Dorsal fin insertion:** Anterior to anus. **Snout to dorsal finfold origin:** About 25% of the TL. **Pigmentation:** In larvae, melanophores are present on the bottom of the yolk sac, on the anus, and at the base of each postanal myomere (Norden 1961); a pair of melanophores is present at the base of the pectoral fin bud (Faber 1963).

JUVENILES OR ADULTS.

Fin rays: Dorsal first XIII to XV, second I to II,12 to 15; anal II,6 to 8; pectoral 13 to 15; pelvic I,5. **Vertebrae:** 38-41. **Lateral line scales:** 51-61. **Gill rakers:** 12-16 on the lower arch, 4-8 on the upper. **Branchiostegal rays:** 7,7 (Scott and Crossman 1973).

•*Percina caprodes* — Logperch

Habitat and Distribution

Logperch prefer sand and gravel bars of medium or large, clean-bottomed streams of moderate gradients. They avoid excessive turbidity and silt (Hardy 1978; Trautman 1981). Logperch are one of the most abundant percids in the UMR and are common in Pools 1 to 17 but less abundant in the lower pools (Van Vooren 1983). Larvae are abundant in backwater areas of the UMR and occur occasionally in main channel ichthyoplankton drift; densities peak in early May.

Reproduction and Characteristics

SPAWNING.

Location: Logfish spawn in stream riffles or sandy shoals (Winn 1958b) in water 10 to 200 cm deep (Lutterbie 1976) over fine sand and gravel (Winn 1958a; Cooper 1978). **Season:** Spawning occurs in the UMR from mid-April through May. **Temperature:** 10-15°C (Hardy 1978).

EGGS.

Characteristics: The eggs are colorless or amber-colored (Cooper 1978), transparent (Winn 1958b), have a diameter of 1.09-1.15 mm (Winn 1958a; Cooper 1978) or 1.3 (Becker 1983), and a single, large oil globule (Stevenson 1971). **Deposition:** 10-20 eggs are deposited during each spawning act (Winn 1958b); the eggs are demersal and adhesive (Reighard 1913).

LARVAE.

Length at hatching: 4.5-5.0 mm (Fish 1932; Cooper 1978). **Yolk sac:** The elongate, granular yolk sac is absorbed at 6.3-7.0 mm (Cooper 1978). **Oil globule:** A single, anterior oil globule is present (Auer 1982b). **Preanal length:** At 6.6 mm, it is 62% of the TL; at 12-14 mm, 54-58% of the TL (Fish 1932). **Myomeres:** 20 + 17-18 (Cooper 1978) or 18-19 + 20-22. **Dorsal fin insertion:** Anterior to anus. **Snout to dorsal finfold origin:** 27 to 29% of the TL. **Pigmentation:** A single melanophore is present below the base of each pectoral fin, melanophores are found on the gut (Fish 1932), and a single melanophore is present on almost every postanal myomere.

JUVENILES OR ADULTS.

Fin rays: Dorsal XIII to XVI,15 to 16; anal II,9 to 12; pectoral 13-14. **Vertebrae:** 40-42 (Scott and Crossman 1973). **Gill rakers:** 12. **Branchiostegal rays:** 6 (Becker 1983).

•*Percina shumardi* — River Darter

Habitat and Distribution

River darters prefer swift chutes and riffles in moderate to large streams with gravel or rock bottoms (Pflieger 1975; Trautman 1981). They inhabit main channel border habitats where the current is strong enough to prevent siltation and are occasionally collected in all pools of the UMR (Van Vooren 1983). Little information is available on the ecology and distribution of early life stages in the UMR.

Reproduction and Characteristics

SPAWNING.

Location: River darters spawn in shallow side chutes or riffles over rock or gravel substrates (Cross 1967). **Season:** They spawn from April to June (Becker 1983). **Temperature:** 9.0-12°C.

EGGS.

Characteristics: The eggs have an amber yolk and chorion, a diameter of 1.3-1.67 mm (Hubbs 1967) or 1.2 mm (Becker 1983), and a single oil globule. **Deposition:** The eggs are demersal (Hubbs 1967) and nonadhesive.

LARVAE.

Length at hatching: 4.1-4.6 mm TL. **Yolk sac:** The oval, elongate yolk sac is absorbed at 5.0 mm TL. **Preanal length:** 48-50% of the TL. **Myomeres:** 18-19 + 23-25.
Dorsal fin insertion: Anterior to anus. **Snout to dorsal finfold origin:** 26% of the TL.
Pigmentation: Melanophores are distributed dorsally, on the optic lobe, preanally, and on myomeres 2 through 4, 7, 10, 14, 15, and 18. Laterally, melanophores occur around the gill area; ventrally, pigmentation is scattered over the yolk sac and on every other postanal myomere (Hubbs 1967).

JUVENILES OR ADULTS.

Fin rays: Dorsal IX to XI,13 to 15; anal II,11-12. **Vertebrae:** 38-40.
Lateral line scales: 48-60. **Gill rakers:** 9. **Branchiostegal rays:** 6 or 7 (Becker 1983).

•*Stizostedion canadense* — Sauger

Habitat and Distribution

Saugers prefer large, turbid, slow-flowing rivers or shallow, turbid lakes (Scott and Crossman 1973). In the UMR, they live in the shallow, more turbid, littoral zones (Collette and Banarescu 1977), and are the most numerous game fish collected from wingdam habitats (Pitlo 1981); they are also common in tailwaters. Saugers are common in all 26 pools of the UMR (Van Vooren 1983). Juveniles have occasionally been collected on shallow mud flat areas (Farabee 1979). The photophobic larvae spend much of the time scattered among bottom materials and are rarely collected with standard townets. Young saugers represent a minor component of the total ichthyoplankton drift in the UMR and never exceed 3% of the catch, even during their peak density in early May (Holland 1985).

Reproduction and Characteristics

SPAWNING.

Location: Sauger spawn over shallow shoals or bars (61-366 cm deep) (Scott and Crossman 1973) in main channel border areas, mussel beds (Pitlo, pers. comm.), or over rock or gravel substrates (Scott and Crossman 1973). **Season:** They spawn in April or early May in the Mississippi River (Nelson 1968a). **Temperature:** 3.9-6.1°C.

EGGS.

Characteristics: The eggs have a pale yellow color (Pitlo 1981), a diameter of 1.0-1.5 mm (Priegel 1969) or 1.8 mm (Nelson et al. 1965), and a single oil globule. **Deposition:** The eggs are demersal (Nelson et al. 1965) or semi-buoyant (Priegel 1969), adhesive after water hardening (Nelson et al. 1965), or nonadhesive (Scott and Crossman 1973).

LARVAE.

Length at hatching: 4.8-7.5 mm (Nelson 1968b) or 4.5-5.8 mm (Nelson 1968a).
Yolk sac: The large, oval yolk sac is absorbed at 8.3 mm TL (Pitlo 1981) or 7 to 9 days (Nelson 1968b). **Oil globule:** A single, anterior oil globule is present. **Preanal length:** 47% of the TL (Nelson 1968b) or 49-51% of the TL (Nelson 1968a). **Myomeres:** At 10-15 mm, 19-22 + 21-24 (Nelson 1968b). **Dorsal fin insertion:** Anterior to anus. **Snout to dorsal finfold origin:** About 22% of the TL. **Pigmentation:** A few melanophores are concentrated on cranium just posterior to the maxillary and are profuse on the yolk sac. Ventrally, there are melanophores at the base of the anus and at myomeres 5, 7, 10, 11, 13, 14, 15, 21, 22, and 24; laterally, melanophores are present from the head to the pectoral fins and above the gut to the anus (Nelson 1968a,b).

JUVENILES OR ADULTS.

Fin rays: Dorsal XIII to XV-I,16 to 21; anal II,11 to 14; pectoral 12-14; pelvic I,5.
Vertebrae: 43 to 45. **Lateral line scales:** Usually 88-95. **Gill rakers:** 6-8 on the lower arch, 3-5 on the upper. **Branchiostegal rays:** 6-8 (Scott and Crossman 1973).
Pigmentation: Juveniles are without dark dorsal pigmentation over the cranium.

•*Stizostedion vitreum vitreum* — Walleye

Habitat and Distribution

Walleyes inhabit areas in lakes and large rivers with gravel, bedrock, and firm substrates where the turbidity is low (Scott and Crossman 1973). Both adults and juveniles have been collected in main channel, main channel border, deep slough, and backwater areas of the UMR (Rasmussen 1979). During high water, walleyes may move into stands of flooded timber; during low water, they congregate around wing and closing dams (J. V. Pitlo, pers. comm.). Walleyes are common in Pools 1 to 20 of the UMR and are occasionally collected in Pools 21 to 26 (Van Vooren 1983). Larvae are minor components of ichthyoplankton drift samples. The density of larval walleyes in the drift peaks in early May.

Reproduction and Characteristics

SPAWNING.

Location: Walleyes spawn over rocky areas below falls and dams, coarse gravel shoals of lakes, or in some areas of Wisconsin over vegetation (Scott and Crossman 1973); in the UMR,

spawning sites have been verified in areas of flooded emergent vegetation and in outer bends of the main channel. **Season:** Spawning occurs from mid-April to early May.
Temperature: 3.3-6.7°C; peak at 5.6-10°C (Becker 1983).

EGGS.

Characteristics: The eggs are light-colored and semi-transparent (Brinley 1938), have a diameter of 1.8-2.1 mm (Priegel 1969), and a single oil globule (Nelson 1968a).
Deposition: The eggs are broadcast, demersal (Mansueti 1964), and briefly adhesive, but nonadhesive after water-hardening (Becker 1983). **Incubation:** Hatching occurs in 26 days at 4.4°C, 21 days at 10-12.8°C, and 7 days at 13.9°C (Niemuth et al. 1959).

LARVAE.

Length at hatching: 6-8 mm (Scott and Crossman 1973). **Yolk sac:** The large, oval yolk sac is absorbed at 8.9 mm TL. **Oil globule:** A single, anterior oil globule is present.
Preanal length: In yolk-sac larvae, it is 49% of the TL. **Myomeres:** 18-22 + 20-29 (Nelson 1968a; Hardy 1978). **Dorsal fin insertion:** Anterior to anus. **Snout to dorsal finfold origin:** About 22% of the TL. **Pigmentation:** Melanophores occur dorsally over the cranium and on every second preanal myomere to myomere 8 and every third postanally. Ventrally, pigmentation is profuse over the yolk sac and postanal myomeres; laterally, melanophores are present over the dorsal portion of the gut and anus.

JUVENILES OR ADULTS.

Fin rays: Dorsal XII to XVI,18 to 22; anal II,11 to 14; pectoral 13 to 16; pelvic I,5.
Vertebrae: 44-48. **Lateral line scales:** 83-104. **Gill rakers:** 6-8 on the lower arch, 4 or 5 on the upper. **Branchiostegal rays:** 7 and 7 or 7 and 8 (Scott and Crossman 1973).
Pigmentation: At >25 mm, there is a dark spot on the cranium.

■ Sciaenidae — Drums

The Sciaenidae are widely distributed throughout most temperate and tropical continental shelf habitats. Of the 160 species described, only 1—*Aplodinotus grunniens*—completes its life cycle in freshwater in North America. Members of the family are characterized by a heavy, laterally compressed body, a strongly ossified skull, well-developed sagitta, and sometimes fused lower pharyngeals with crushing teeth (Scott and Crossman 1973). ***(ILLUS. P. 22)***

•*Aplodinotus grunniens* — Freshwater Drum

Habitat and Distribution

Freshwater drum live near the bottom in large rivers, lakes, and impoundments (Pflieger 1975). Adults move into shallow water in the spring and back into deep main channel waters in the late fall (Farabee 1979). In the UMR, this fish is common to abundant in all pools and reaches (Van Vooren 1983). Concentrations of eggs and protolarvae are greatest in surface waters just upstream of locks

and dams. Eggs are sometimes five times more abundant here than in other areas of the pool. Eggs and protolarvae are also abundant just below the locks and dams; this suggests that a large percentage of the protolarvae and eggs go through or over dams. Mesolarvae and metalarvae are found in main channel bottom waters and tend to migrate to the surface at night.

Reproduction and Characteristics

SPAWNING.

Location: Freshwater drum spawn in open water near the surface (Priegel 1966).
Season: Spawning occurs from mid-May to mid-July in the UMR.
Temperature: 18.9-22.2°C (Butler 1965; Nord 1967).

EGGS.

Characteristics: The eggs are semi-transparent, have a diameter of 1.15-1.7 mm (C. C. Davis 1959; Swedberg and Walburg 1970), a perivitelline space 12.5% of egg diameter, and a large oil globule that is 48% of the egg diameter. **Deposition:** Eggs are broadcast singly and semi-buoyant (Raney 1959), pelagic (C. C. Davis 1959), and can be collected primarily in surface waters.

LARVAE.

Length at hatching: 3.2-4.2 mm (C. C. Davis 1959; Swedberg and Walburg 1970).
Yolk sac: In newly hatched larvae, the yolk sac is 45% of the TL; it is absorbed by 4.4 mm TL (Swedberg and Walburg 1970). **Oil globule:** A single, large, posterior, spherical oil globule is present (C. C. Davis 1959; Swedberg and Walburg 1970). **Preanal length:** 43-46% of the TL, expanding to 51-53% of the TL by the juvenile stage. **Myomeres:** 10-14 + 9-11 (Hogue et al. 1976). **Dorsal fin insertion:** At 31-33% of the TL (Taber 1969).
Pigmentation: At hatching, small melanophores occur on the dorsal side of the yolk sac and in the head region (Swedberg and Walburg 1970). **Other:** Walleye larvae can be easily recognized by their large head, robust body, curved notochord (Hogue et al. 1976), predominant teeth, and preopercular spines.

JUVENILES OR ADULTS.

Fin rays: Dorsal VIII to IX,25 to 33; anal II,7; pectoral 17; pelvic I,5. **Vertebrae:** 24.
Lateral line scales: 48-53. **Gill rakers:** 15 + 8. **Branchiostegal rays:** 7 (Scott and Crossman 1973).

5 A Compendium of Completed Research on Egg, Larval, and Juvenile Stages of Fishes of the Upper Mississippi River

Little information is available on the early life history of many fishes in the Upper Mississippi River. Most of the data are in little-circulated or unpublished environmental impact assessment reports or state agency annual and quarterly reports. Completion of the Master Plan for the UMR revealed that a major data gap exists for early life history information. Since then, research on early life stages of fishes has increased. However, relatively few of the studies have been completed and the results have not yet been published.

In this section, we list known oral presentations, reports, and published research on early life stages of fishes of the UMR, by pool and date. The type of research and a brief description of each study design are also provided.

Upper Mississippi River—General

1. Mississippi River Master Plan (Kennedy et al. 1981)

As part of the Master Plan for the Upper Mississippi River System (UMRS) under the Inland Waterways Authorization Act (P.L. 95-502), a series of panels was established in 1981 to evaluate the status of information available on the impact of navigation on fish populations. An abstract from the document prepared on egg, larval, and juvenile fishes follows.

At a symposium held in La Crosse, Wisconsin on May 27-28, 1981, an expert panel discussed the topic "Effects of navigation and operation and maintenance of the navigation channel on larval and juvenile fish" of the UMRS.

The panel was convened to discuss the potential impact of navigation, operation, and maintenance of the navigational channel on larval and juvenile fish in the UMRS. This was in response to a Congressional mandate to determine the impact of navigation before changes are made to the system to allow for increased levels of navigation.

The study area included the Mississippi River from the head of navigation at Minneapolis, Minnesota to Cairo, Illinois, the Illinois Waterway, and navigable portions of the Minnesota, St. Croix, Black, and Kaskaskia Rivers.

Direct effects of barge and tow passages in main channel and main channel border habitats were discussed. Though mortalities to eggs and larvae can result from direct impact with barges, the degree of impact is unknown. Studies need to be done to assess the proportion of the total mortality to eggs and larvae caused by direct interference with barges. Also discussed were the system-wide indirect effects of navigation, operation, and maintenance. Indirect effects were categorized as those occurring as a result of increased suspended sediments, sedimentation, and wave wash/drawdown. Sedimentation can cause egg suffocation or developmental abnormalities in those fish that do not care for their nests and lay small eggs with long incubation times. This effect on walleye and sauger was of particular concern.

Other concerns included impacts associated with winter navigation, accidents, chemical spills,

chronic releases of wastes from boat operations, water level fluctuations, barge fleeting, and port development.

Though a data gap exists concerning the effects of winter navigation on all fish species, special concern was expressed over the impacts on channel catfish because of their lethargic wintering condition.

Accidental chemical spills and low level chronic releases of waste could impact all species of fish in the river system. The main channel species, however, would be most affected.

Pool level fluctuations could impact nest-builders, such as bluegills and catfish, by forcing the parent to abandon the nest or by exposing the eggs to atmospheric stress.

The loss of aquatic habitat was identified as the most significant impact resulting from barge fleeting areas and port development.

The direct and indirect effects of navigation on endangered species were briefly discussed. Blue catfish, for example, has been extirpated from pooled portions of the Mississippi River because the locks and dams interfere with the fishes' migration and because of spawning habitat changes caused by clearing and snagging.

Methodologies and study needs related to implementation of a Long-Term Resource Monitoring Plan were discussed. Suggestions were offered as to the types of equipment and techniques that could be used to monitor larval and juvenile fish populations in the Mississippi River.

Finally, fourteen data gaps were identified. Methodologies for specific studies that could provide the needed information were discussed. The most important data needs concern the immediate effects of barge passage on larval fish, effects of increased suspended sediments on larval fish, and the effects of increased flow velocities on larval fish. In addition, the habitat requirements of juvenile fish, especially during the winter, are unknown and in need of immediate further study.

Data gaps (modified from Kennedy et al. 1981)

Studies needed to fill major data gaps as identified by the expert panel are listed below, along with the assigned priority and estimated duration.

High priority, short-term

A. Estimate the damage to larval and juvenile fish caused by direct impacts with tow passages by sampling before and immediately after barge passages.

B. Determine the tolerance of larval fish to increasing levels of suspended sediments. Data from the Master Plan studies can be used to guide future studies.

C. Determine the orientation of larval and juvenile fish in relation to flow velocities and directions and to flow reversals. This could be conducted in a laboratory setting by introducing several species to different flows.

D. Analyze predator-prey relationships as they relate to the orientation of larval fish to current velocities and to flow reversals.

E. Identify the origins of juvenile fish found in channelized, unpooled portions of the river.

F. Determine the degree of use of sand troughs by larval and juvenile fish.

High priority, long-term

A. Determine the winter distribution of juvenile fish, especially freshwater drum, catfishes, and walleyes.

B. Determine the influence of barge-induced increases in sedimentation on fish abundance and on the productivity of backwater habitats.

C. Determine the general distribution of eggs, larvae, and juveniles in the river system. This could be partly accomplished by a literature review of existing data, especially from the power plant siting studies.

D. Determine a total mortality pattern for an appropriate indicator species to relate barge-induced mortalities to natural mortalities. Freshwater drum would probably be the species most suitable for this type of study.

E. Determine the extent of use of wingdam habitats by larval and juvenile fishes.

Medium priority, short-term

A. Determine the effects of waves generated by commercial and recreational boat traffic on nearshore fish.

Medium priority, long-term

A. Determine the effects of light fuel oils on pelagic eggs and larvae. Freshwater drum could be used.

B. Study the use of main channel habitats by main channel spawners in an area without navigation as a control. Suggestions for control areas include Chain of Rocks, Savanna, Illinois; East Channel, Prairie du Chien, Wisconsin; and Dresbach Island, Pool 7. The best control site would have to be identified and then monitored.

Low priority, short-term

A. Monitor fish health (parasites, bacterial, and fungal infections) below dams.

2. Ichthyoplankton drift in Navigation Pools 1-14 (Holland et al. 1984)

Existing data on the main channel ichthyoplankton drift were analyzed to provide information on the possible effects of hydropower development. Objectives were to identify affected fish species and to determine peak drift periods. Gizzard shad, common carp, emerald shiner, channel catfish, white bass, black crappie, sauger, and freshwater drum were chosen as the species most likely to be adversely affected by hydropower development. The behavior of these species in relation to occurrence in drift and the status of the populations was examined. Data gaps for these species and the approaches recommended to fill these gaps were assessed and evaluated with reference to hydropower development.

3. Distribution of early life history stages of fishes in selected pools of the Upper Mississippi River (Holland 1986)

Effective management of the fishery resources of the UMR and successful mitigation of the loss of critical habitat depend in part on an understanding of the reproductive and early life history requirements of the affected fishes. However, little is known about the use of nursery areas by fishes in the river. Of the nearly 130 species identified as adults, only a few are represented proportionally in the available data on early life stages because study designs have not included consideration of the early stages, collection gears have not adequately sampled the young, and eggs and larvae of some species are difficult to sample by conventional approaches.

For the species collected, information is available on seasonal variations in total densities, composition, and catch among different habitat types. However, the data are most accurate for species with buoyant early life stages, such as freshwater drum and gizzard shad. Eggs and larvae of freshwater drum dominate in collections made in the main channel, whereas other larval fishes are usually most abundant in backwater habitats. The species found there usually deposit eggs on the substrate or on vegetation. Habitat preferences (as indicated by relative abundance) often shift as development proceeds and physical and behavioral changes occur in the larvae. Only limited information is available on the distribution of larvae within habitats, but it is clear that variations within habitats are significant.

Above St. Anthony Falls Locks

4. Entrainment of fishes (Amish et al. 1978)

Entrainment was monitored with stationary nets in intake bays of the Northern States Power Company Monticello Nuclear Generating Plant and upstream from the intake at surface, mid-depth, and bottom. Samples were collected every 4 h for a 24-h period, weekly from April to late August 1976.

5. Ichthyoplankton monitoring (Environmental Research and Technology, Inc. 1977)

The objective was to investigate temporal and spatial patterns during peak ichthyoplankton densities near the water intake of the Northern States Power Company Sherburne County Generating Plant, five miles upstream from Monticello, Minnesota. Replicate samples were collected with a combination of towed nets and stationary sets once during the day and once at night, weekly from May 2 to July 4, 1977. Three stations in a transect across the river near the plant intake were sampled.

Pool 1

6. Ichthyoplankton entrainment (Heberling et al. 1981)

Entrainment was monitored near shore and at midstream near the intake of the Northern States Power Company Riverside Generating Plant at River mile (Rm) 857.0 (miles above confluence of the Ohio River) and at two locations upstream. Stationary 0.5-m, 0.560-mm mesh nets were fished at surface and bottom until 100 cm of water was filtered per net; the duration of sets therefore, varied with current velocity. Samples were collected every 4 h over a 24-h period weekly from mid-April to mid-August 1980. Seventeen taxonomic groups were identified in ichthyoplankton collections.

7. Ichthyoplankton entrainment and monitoring (NUS Corporation 1976)

Entrainment of ichthyoplankton was monitored with stationary nets (surface, mid-depth, bottom) in the intake bays of the Northern States Power Company Black Dog Generating Plant located on the Minnesota River near its confluence with the Mississippi River. Samples were also taken in the river by towing nets. Samples were collected every 4 h over a 24-h period weekly from April to September 1976.

Pool 3

8. Ichthyoplankton monitoring (Gustafson et al. 1975)

Ichthyoplankton was monitored with stationary nets (surface and bottom) at the intake and recirculation canal of the Northern States Power Company Prairie Island Nuclear Generating Plant. Samples were collected with a conical 0.787- or 0.560-mm mesh net every 4 h over a 24-h period weekly from April to August 1975. Surface tows were also taken at various backwater sites on the river near the plant, weekly from mid-May to August 1975. Larvae and eggs were counted but no attempt was made to identify larval fish.

9. Ichthyoplankton entrainment (Kranz et al. 1978)

Species composition, density, and distribution of early life stages of fish were monitored in Lake St. Croix (St. Croix River 21.5 miles upstream from its confluence with the Mississippi River) near the Northern States Power Company Allen S. King Generating Plant. Larval tows of 5 to 15 min were made in the approach canal and river with a 0.5-m, 0.505-mm mesh net. In addition, nets were set in intake bays at surface, mid-depth, and bottom. Samples were collected every 4 h over a 24-h period weekly, April to September 1976.

10. Ichthyoplankton monitoring (Henninson, Durham and Richardson, Inc. 1979)

The objective of this study was to evaluate ichthyoplankton drift in the vicinity of the Northern States Power Company Prairie Island Nuclear Generating Plant (Rm 798.2). Three sites were established in main channel waters; ichthyoplankton at these sites was sampled six times, June 6 to June 17, between midnight and 4 a.m. Replicate oblique tows were taken with a 0.560-mm mesh net.

Pool 4

11. Ichthyoplankton sampling (NUS Corporation 1975)

Collections were made to provide a general picture of fish reproduction rates and to determine spatial and seasonal variations of ichthyoplankton. Drifting fish eggs and larvae were sampled in the Chippewa River and nearby creeks in the vicinity of the Northern States Power Company Tyrone Energy Park (19 miles west of Eau Claire, Wisconsin). Ichthyoplankton sampling was conducted monthly from April to September 1973, and every 2 weeks from April to August 1974, with stationary nets.

12. Intake siting study (Kranz 1978)

Sampling was conducted to determine the distribution of fish, as an aid in selecting a site for the Tyrone Energy Park intake that would have the least impact on the fish community of the lower Chippewa River. Sampling included electrofishing, seining, dip netting, and stationary plankton netting. Ichthyoplankton was sampled with set nets and dip nets from late March to August 1977. Fluctuating water levels regulated the use of surface, mid-depth, and bottom nets. Sampling for all programs was conducted weekly during daylight. Additional nighttime ichthyoplankton samples were taken once every three weeks from March to May and during alternate weeks from June to August.

Pool 5

13. Impingement and entrainment of fish (Wapora, Inc. 1976a)

Young-of-the-year (YOY) and adult fish were collected in 1974-1976 to analyze impingement at the Dairyland Power Cooperative Alma Generating Plant (Rm 751.5). Most fish impinged were YOY and yearlings. In 1975 and 1976, entrainment of larval fish was monitored with stationary plankton nets (0.423-mm mesh) set for 30 min twice a week; a 24-h sampling was done in April.

14. Pre-operational fish study (Dairyland Power Cooperative 1981a)

Juvenile and adult fish were collected by seining in upper portions of Pools 5 and 5A during June and August 1979 for a pre-operational study for the Dairyland Power Cooperative Alma Generating Plant.

15. Larval and juvenile fish study (Dairyland Power Cooperative 1981b)

Surface drift sampling was conducted at five stations near the Dairyland Power Cooperative J. P. Madgett Generating Station (Rm 751.1) nine times from April 23 to July 21, 1980. Mid-depth and bottom samples were collected with stationary nets (0.5-m, 0.500-mm mesh) every 6 h at two stations on June 17 and 18. Nine taxa were collected during the study. Larvae and juveniles were collected biweekly with a 20-foot, 1/8-inch mesh seine at seven locations (Rm 750-752).

16. Ichthyoplankton survey (Kowalski et al. 1981; Dairyland Power Cooperative 1982; Kowalski et al. 1984)

Ichthyoplankton was monitored during 1980, 1981, and 1982 near the Dairyland Power Cooperative Alma Generating Plant (Rm 751.5). The study was designed to assess vertical and cross channel distributions of species of ichthyoplankton and to determine the concentration and species patterns based on time and water temperature. Samples were taken with a 0.5-m diameter 0.45-mm mesh conical plankton net in stationary 10-min sets. Simul-

taneous collections were made at dusk at surface, mid-depth, and bottom along a transect from the screen house on the east shore, across the main channel, and into two side channels. In 1980, a 24-h drift study was conducted during which samples were taken every 6 h from noon to noon.

17. Walleye recruitment assessment (Talbot 1982, 1983)

The purpose of this investigation was to discern trends in walleye populations and to determine relationships between year-class abundance and potential controlling factors (water temperature, availability of spawning habitat, water level). Young walleyes were monitored by the Wisconsin Department of Natural Resources to develop annual indices of abundance. Collections were made with electroshocking gear in fall each year, 1980-1982. In the first year, 46 sampling sites that included all major habitat types of Pool 5 were sampled. Young walleyes were most abundant in shallow areas with sandy bottoms, sparse submerged vegetation, and moderate current. Effort was later reduced to monitoring at 13 sites selected from those initially sampled in 1980.

18. Ichthyoplankton drift (Holland 1985)

During 1984, 844 samples were collected immediately above Lock and Dam 5 to estimate total ichthyoplankton drift with respect to potential impacts from hydropower development. Twelve stations were established in a cross section of the river 1500 feet above the dam. Drift samples were collected at each station in triplicate, weekly to semimonthly from May 1 to August 8. Diel periodicity was analyzed for one 24-h period in May, June, and July with collections at each station at dusk, midnight, dawn, and midday.

Pool 5A

19. Ichthyoplankton study (Oak Ridge National Laboratory 1978)

Ichthyoplankton was collected in June 1978 at the Northern States Power Company Prairie Island Generating Station to provide additional data for the Minnesota Pollution Control Agency's use in assessing impacts of the present intake system and in examining potential alternate cooling water intakes for the Prairie Island Plant. Nighttime oblique tows were made to collect larvae and eggs in the main channel, main channel border, and backwater lake adjacent to the plant intake.

20. Ichthyoplankton monitoring (Ecological Analysts, Inc. 1984)

Weekly dip net samples were collected at various main channel border habitats of Pool 5A from May to August 1982 for the St. Paul District Army Corps of Engineers.

Pool 7

21. Larval fish distribution study (Holland and Sylvester 1983)

Ichthyoplankton was collected to assess temporal, spatial, diel, and species-specific variations in larval fish distributions at 12 stations from Rm 702.5 to 714.0 as related to potential impacts of navigation. Surface and bottom tows were made with a 1-m conical plankton net (0.505-mm mesh Nitex) downstream in the main channel. Backwater and main channel border samples were collected at the surface only. Samples were collected twice monthly from April to August 1982 and, in addition, three diel studies were made, one each in May, June, and July. These samples were taken in duplicate every 6 h over a 24-h period.

22. Resource partitioning of juveniles (Holland and Huston 1985)

Observations of habitat and food partitioning were made on YOY of several species to determine the importance of vegetation type to nursery habitat value. Over 1000 YOY were collected from May to September 1982 with a small mesh minnow seine from several backwater habitats (Rm 706.5 to 709.5). Stomach contents of largemouth bass, northern pike, bluegills, white bass, and black crappies were analyzed to determine means by which YOY fishes use various habitats.

23. Distribution and feeding of YOY northern pike (Holland and Huston 1984)

Association of YOY northern pike with different aquatic plant types was studied to evaluate possible impacts of backwater habitat loss on fish nursery habitat. Twice monthly, May to September 1982, collections were made with a bag seine (30 x 4 feet, 1/4-in. mesh with 1/8-in. liner) over a 24-h period at six representative lentic microhabitats.

24. Effects of barge traffic on early life stages (Holland 1986)

Larvae, eggs, and juvenile fish were collected (Rm 708.4) to assess the effects of barge passages on distribution and survival of early life stages. A series of collections were made (before, during, and 45 and 90 min after passage) for upstream and downstream barge traffic in spring and summer 1983. In addition, 24-h collections were made every 2 weeks, June to September, at main channel, and three main channel border habitats—riprap, dredge spoil, and natural border. Eggs and larvae were collected with a 0.5-m, 0.505-mm mesh conical plankton net at surface and bottom. Juveniles collected with a 16-foot semi-balloon surface trawl with 1/4-in. cod-end liner and 10-foot bottom trawl. Captured larvae and juveniles were observed for injury and mortality.

Pool 8

25. Northern pike spawning study (Holzer and Larson 1977)

Various habitats were sampled to document northern pike spawning areas by the Wisconsin Department of Natural Resources. Thirteen sites (Rm 689 to 693) were sampled March 23 to May 11, 1976; eggs were collected with a fine mesh dip net, and fry with a small-mesh seine.

26. Northern pike spawning study (Holzer and Von Ruden 1977; Holzer and Von Ruden1978)

These investigations were a continuation of the previous study begun in 1976. Northern pike eggs were collected at Goose Island (Rm 693), April 11-22, 1977, with dip nets; fry were collected on May 19 with a minnow seine (50 feet long, 1/2-in. mesh). No eggs or larvae were found in the Goose Island study area. Eggs and larvae were also collected from Rm 689 to Rm 693, April 20 to May 22, 1978. Eggs were collected with a fine mesh dip net; dip nets and minnow seines (50 feet long, 1/2-in. mesh) were used to collect larvae.

27. Walleye spawning project (Holzer and Von Ruden 1982)

Walleye movement patterns were monitored by the Wisconsin Department of Natural Resources in Target Lake (Rm 696.5) by radiotelemetry. Suspected spawning sites were sampled with small-mesh dip nets. Target Lake was verified as a spawning site; spawning areas were typified by flooded mats of reed canarygrass and moderate current. Egg development and water levels were monitored. A drop in water level left the site exposed before the eggs hatched; mortality was assumed to be 100%.

28. Larval fish study (Holland et al. 1983)

The importance of various main channel border habitats as nursery sites was examined on the basis of composition and density of larval fishes. Various types of larval fish assemblages specific to four main channel border habitats (riprap, natural banks, wingdams, and dredgespoil) were sampled (Rm 694 to 697). Downstream 5-min tows were made with a 0.5-m conical plankton net (0.505-mm mesh). Twelve taxa were collected from main channel sites, 16 from the main channel borders, and 20 from backwaters.

Pool 9

29. Entrainment of eggs and fry (Wapora, Inc. 1975)

Collection of samples was made near the Dairyland Power Cooperative Genoa Generating Plant (Rm 678.5), March to June 1974. Stationary plankton nets (1 m, 0.423-mm mesh) were set for 30 min to 24 h in front of the intake of the plant. In May and June, a diaphragm pump was used to obtain samples of known volumes.

30. Ichthyoplankton drift and entrainment (McInerny 1980)

Drift samples were collected near the Dairyland Power Cooperative Genoa Generating Station weekly from May 21 to June 25, 1980, at four sampling stations. Samples were collected with a plankton net (0.5-m, 0.5-mm mesh) during the day, except on June 25, when two samples were taken during the day and one at night. For determination of sample volumes, current velocities were estimated by measuring the time required for a bottle to float a fixed distance. Grab samples were collected on June 18, 1979, and weekly from May 20 to June 25, 1980. A plankton net (0.5-mm mesh) or a bucket were used for grab sampling. Samples were collected only along the shorelines.

Sampling for entrainment of fish eggs and larvae at La Crosse Boiler Water Reactor was conducted weekly for a 24-h period from May 7 to September 10, 1979, and from March 12 to June 17, 1980. Sampling at the other plant, Genoa #3, was conducted weekly from February 26 to September 10, 1979, and from February 6 to June 30, 1980. Samples were collected from water flowing through an intake pipe filter into a 0.5-mm mesh plankton net suspended in a 190-L drum.

Pool 11

31. Ichthyoplankton entrainment (Wapora, Inc. 1976b)

Entrainment was monitored near the Northern States Power Company E. J. Stoneman Generating Station (Rm 606) from April 1975 to March 1976. Samples were collected from the drain valve near the condenser or in the intake tunnel. Weekly collections were made over a 24-h period. "All of the fish collected were in the fry, alevin, young-of-the-year, or adult stage. No egg or prelarval stages were collected."

Pool 13

32. Sturgeon spawning sites (Hurley 1983)

This study involved the identification of shovelnose sturgeon spawning sites in Pool 13 above Savanna, Illinois. Samples were collected with a benthic sled and set or towed nets. Collections were made daily during the spawning period and weekly thereafter through August.

33. Ichthyoplankton drift (Sheaffer 1984)

In this study, the drift of eggs and larvae from flowing backwaters to the main channel was determined. Three running slough areas were sampled weekly from April 24 to August 14, 1983. At each area, stations were located 0.8 km downstream and upstream of the confluence of the backwater area and the main channel, and in the backwater area itself. Replicate samples were collected at night with a plankton net (0.505-mm mesh) towed at the surface and a benthic sled dragged 0.25 m above bottom.

34. Walleye and sauger egg drift (Iowa Conservation Commission Fisheries Section 1983)

Walleye and sauger eggs were collected with stationary drift nets (6 in. x 18 in., 13 meshes/in.) set on the bottom near wing and closing dams. Artificial substrates were also used to collect eggs from similar areas. Spawning locations, timing, and temperatures of both species were identified.

35. Disposal of dredge spoil (Stand et al. 1984)

The effect on eggs and larvae from thalweg disposal of dredge materials on the river was evaluated by pre-disposal sampling. Duplicate surface and bottom tows were taken at eight sites in late spring 1983 and 1984, with 0.5-m, 0.505-mm mesh plankton nets.

Pool 14

36. Inventory of spawning sites and ichthyoplankton monitoring (Commonwealth Edison Company 1980a,b; Environmental Research and Technology, Inc. 1981, 1982)

This study was conducted in 1971-1977 near the Commonwealth Edison Company Quad-Cities Generating Station to identify species that spawn in the pool, determine when spawning occurs, and document the seasonal abundance of common species. The study was changed in 1978-1979 to place additional emphasis on diel, vertical, and horizontal variations in ichthyoplankton distribution. In 1980-1981, the effort was reduced to one location in the vicinity of the power plant intake. Sampling locations and study design differed somewhat from year to year. In general, samples were collected weekly from April to September at 1-8 main channel and main channel border sites. Samples were collected with stationary nets before 1978. Later collections were made with towed nets.

37. Entrainment of eggs and larvae (Industrial Bio-Test Laboratories 1974, 1975; NALCO Environmental Sciences 1976, 1977; Hazleton Environmental Sciences 1978, 1979a,b)

The purpose of this long-term (1973-1979) investigation was to describe the drifting ichthyoplankton near the Commonwealth Edison Company Quad-Cities Generating Station and estimate the numbers of ichthyoplankters entrained in the condenser cooling system. In addition, an estimate of survival after entrainment was made in 1978. Sampling design varied little from year to year; stationary plankton nets were set weekly. In 1978, locations and assumptions of the study were reevaluated and it was determined that sampling in the discharge canal would provide the best estimate of entrainment.

Pool 16

38. Habitat use by young-of-the-year fish (Van Vooren 1982)

Samples were collected by the Iowa Conservation Commission to determine the species distribution of YOY fishes occurring in specific shallow-water habitats (backwater, side channel, main channel borders), and the relative use of these habitats by these fish. Five sites were sampled twice monthly (June to August 1980, and September 1981) with a seine (15 feet x 4 feet, 1/8-in. mesh) and a bag seine (50 feet x 6 feet, 1/4-in. mesh) hauls were made in a downstream direction parallel to shore.

Pool 18

39. Ichthyoplankton distribution (Van Vooren 1982)

Three sites were sampled on three consecutive days in September 1981 to determine sampling variance for the study conducted in Pool 16.

Pools 19, 26

40. Ichthyoplankton distribution (Jackson and Lubinski 1982)

This work was done in conjunction with a large-river, long-term, ecological research project entitled "Ecological structure and function of major rivers in Illinois." The objective was to test the hypothesis that larval fish density and diversity are greater in the more lentic channel border and backwater areas than in the lotic channel habitats because the available habitats are more diverse. Most of the sampling was done in Pool 19; however, limited quarterly sampling was conducted in Pool 26 and in the Illinois River. Drift collections were made with bongo set nets in at least one main channel, one border, and one backwater lake along each transect.

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