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Observations On Neosho River Larval Fish In Coffey County, Kansas

by
Greg R. Wedd*

ABSTRACT

The 1981 larval fish drift of the Neosho River upstream and downstream of John Redmond Reservoir in Coffey County, Kansas, was studied. Field data were collected from 25 April through 31 July. A total of 27,905 eggs, larvae, and juvenile fish, representing 11 families and 30 taxa, was collected from three sampling points. Members of the families Catostomidae (48.5%) and Clupeidae (48.3%) dominated the assemblage at Hartford whereas Clupeidae was solely dominant at both John Redmond (98.0% diurnally and 95.2% nocturnally) and Burlington, although to a lesser degree at Burlington (81.4%). Larval fish densities at Hartford peaked at 1246.7/100m³ on 28 May while maximum densities for both diurnal and nocturnal John Redmond collections peaked at over 5000/100m³ on 13 June, and the maximum level at Burlington occurred at 1766.4/100m³ on 19 June. No statistically significant differences were found in mean daily total concentrations or day/night John Redmond data. Morphological data were compiled and are presented in tabular form for 14 taxa. These data generally compared favorably with published accounts, thereby supporting the taxonomic assignments made and documenting regional variation. The *Pomoxis* larvae identified had eye-gas bladder distances (as % total length) from 13 to 19, although *Pomoxis annularis* was the sole representative of this genus in the study area.

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* This study originated as a master's thesis under the direction of Dr. Robert F. Clarke in the Division of Biological Sciences at Emporia State University. The author is currently employed by Kansas Gas & Electric Company in the Environmental Management group of Nuclear Services.

INTRODUCTION

The purpose of this research was to describe the 1981 larval fish drift above and below John Redmond Reservoir, a mainstream impoundment of the Neosho River in Coffey County, Kansas. Larval fish present in drift samples were identified, quantified, and characterizations made of their seasonal occurrence, diel patterns, and developmental phases. This study also presents morphological data for selected taxa, provides explanations of generic and species assignments made, and discusses evidences which support these assignments. Additionally, a discussion of the potential value of early life history data is provided.

The study was conducted because descriptions of the larval fish drift occurring in most Kansas rivers have not been accomplished. This is despite the fact that the period of time following spawning and extending through early life history stages is very important in the development of North American freshwater fish populations.

The importance of this period was realized by some early researchers and, as a result, attempts were made to provide identification guides to assist research in this field. Fish (1932) provided one of the earliest works of this nature with a regional descriptive morphological study covering 62 species. Later studies emphasized gross morphological features such as body shape, gut development, pigmentation, fin ray/spine development and counts (May and Gasaway 1967; Mansueti and Hardy 1967; Tabor 1969). Preliminary keys and guides were the results of these works. However, identification to species was still often precluded by close phylogenetic relationships and the lack of early life history descriptions for many species.

The lack of concise reference materials resulted in neglect in the study of fish early life histories by many fishery managers. As a result, the period of life following spawning to the appearance in seine or trawl collections of juvenile fish took on nearly mystical qualities in the minds of some managers. The lack of information concerning this stage in development for many fish populations reflects this attitude.

Several factors have contributed to this situation, the first being the difference in collection methods for larval fish. Collection techniques are more similar to those used by limnologists than by fishery managers. Sampling gear utilized consists of nets of the types used for zooplankton collections, however, these nets are typically larger in diameter and mesh size. The methods by which such gear are used have only been limited by the ingenuity of the

researcher. Nets used to collect larval fish have been manually positioned, mounted on bridge abutments (Potter et al. 1978), towed by boat (Hoyt et al. 1979), and boom-mounted on boats (Tarplee et al. 1979).

Techniques for larval fish identification also differ substantially from the methods used on adult fish. Many of the morphological features diagnostic for adult fish are absent during larval phases and other structures, invisible in adults, are prominent in larvae. Structures such as the cleithrum, auditory vesicle, yolk, myomeres and urostyle all are used in larval fish identification (Figure 1). Additionally, the counts, ratios, and proportions of various distances or enumerable structures, such as head length, preanal length, postanal length, preanal and postanal myomeres play an important role in the classification of larval fish.

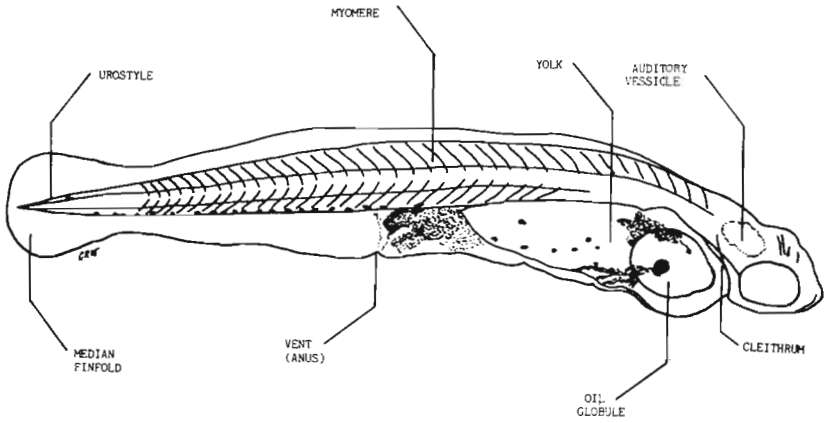


Figure 1. Features useful in the identification of larval fish.

Throughout the infancy of fish early life history studies, a variety of classification systems for developmental phases evolved. Titcomb (1910) developed one of the earliest systems which consisted of the simple differentiation of "fry, advanced fry and fingerlings." Later schemes emphasized the presence of yolk material but failed to define precise criteria for the separation of developmental stages (Hubbs 1943; May and Gasaway 1967; Mansueti and Hardy 1967). The controversy which resulted from the partisan use of the various schemes served to widen the gap between researchers and field personnel.

Not until the late seventies were attempts made to standardize terminology. Snyder (1976) proposed a system which minimized the importance of the presence of yolk material and classed larvae as protolarvae, mesolarvae, metalarvae and juveniles. With the advent of the most recent systems and efforts by the Early Life History Section of the American Fisheries Society, terminology reached a semblance of standardization (Snyder, 1981a). This terminology has achieved improved precision, practicality, and ease of use for field personnel. Additionally, there has been an increase in the comparability of published works since its inception (Fuiman 1979; Fuiman and Witman 1979; Conner et al. 1980; Yeager and Baker 1982).

Studies undertaken recently have been directed at detailed descriptions of closely related species. For example, Fuiman (1979), Fuiman and Witman (1979), Yeager and Baker (1982) and Snyder (1981b) have completed descriptions for members of the family Catostomidae. Meristics and fine morphological features have received special attention in these works. Certain recent studies define a few diagnostic characteristics which may be used to segregate closely related species (Conner 1979; Chatry and Conner 1980). The use of such data is now permitting expeditious identification of larval fish to low taxonomic levels.

The increasing utility of reference materials is also assisting the expansion of early life history studies from simple baseline cataloging to assessments of factors influencing year-class development. Studies performed by Kindschi et al. (1979), Cada and Hergenrader (1980), and Martin et al. (1981) explored the role which environmental factors, such as physical conditions and water levels, play in the development of year classes. The relationship of flow stages to the occurrence of various lotic species was explored by Gallagher and Conner (1980) through a detailed spatio-temporal study of Mississippi River larval fish.

Despite the expansion of early life history investigations and the completion of studies covering larval fish ecology for many areas, Kansas larval fish populations have not been studied. No studies of Kansas larval fish populations were found in the literature, with the exception of work completed as part of Kansas Gas and Electric Company environmental monitoring (Bliss 1978, 1979, 1980).

DESCRIPTION OF STUDY AREA

This study was conducted on river locations in the immediate vicinity of John Redmond Reservoir, a mainstream impoundment of the Neosho (Grand) River in Coffey County, Kansas. John Redmond Reservoir is a major flood control impoundment located northwest of Burlington. It has a surface area of 3,800 ha at conservation pool elevation of 316.7 m MSL. John Redmond Reservoir was formed by impoundment of the Neosho River, which has its headwaters in Morris County, Kansas. The Neosho flows in a southeasterly direction through southeast Kansas and northeastern Oklahoma. The total drainage of the Neosho is approximately 16,300 km^2, with the Kansas portion measuring roughly 15,000 km^2. Throughout its course, the Neosho follows a well defined channel with banks ranging from 4.5 to 9.0 m in height along its lower reaches.

Three river locations were utilized during this study (Figure 2). Location numbers utilized were established by previous studies performed as part of Kansas Gas and Electric Company monitoring. For ease of interpretation, the location descriptions start with Hartford and proceed downstream.

Location 2, Hartford (S.W. ¼ of Sec. 14, T. 20 S., R. 13 E.): This location was delineated at its upstream edge by the old Hartford river bridge and extended 300 m downstream. The river at this location varied in width from 30 to 40 m with a mud, gravel, and rubble bottom and steep mud banks. Location 2 was in the area where the Neosho transforms from a lotic to lentic environment by flood pool elevations of John Redmond Reservoir.

Location 1, John Redmond Reservoir tailwaters (W. ½ of N.W. ¼ of Sec. 10, T. 21 S., R. 15 E.): Location 1 was located immediately below John Redmond Reservoir in the spillway area. It began at a point approximately 70 m below where the two outlet channels merge and extended downstream along the south bank of the river for 300 m. Flow at this location was entirely dependent upon discharges from John Redmond Reservoir. The width of the river at this point was highly variable, ranging from 7 to 90 m. The river bottom consisted of bedrock and rubble with riprap and mud banks.

Location 3, Burlington (S.E. ¼ of N.W. ¼ Sec. 23, T. 21 S., R. 15 E.): This location consisted of a 300 m stretch of the Neosho bordered on its downstream edge by the Burlington City Dam. The river at this point pooled upstream of the dam and, during low flow, formed a small impoundment. Periods of high flow resulted

in complete overtopping of the dam and a corresponding loss of quiescent conditions. The bottom at this location was bedrock covered by thick mud.

Physical Conditions

The middle Neosho River drainage had experienced a moderate drought during the latter part of the year preceeding the study. The drought persisted in 1981, with the Neosho drainage receiving below average rainfall during the first 16 weeks of the year. The remainder of 1981 saw above average precipitation (Figure 3).

The flow pattern of the Neosho River in the study area was characterized by a four month period of reduced flows, followed by a three-five-fold increase in June which lasted through July, and normal to slightly below average flow for the remainder of the year.

The average daily inflows of the Neosho to John Redmond Reservoir (JRR) appear in Table 1. With the exception of four dates, inflow values did not exceed 200 cfs during the first 16 weeks of 1981. Inflows increased in the second half of May and peaked in July when the daily inflow averaged 2,632 cfs.

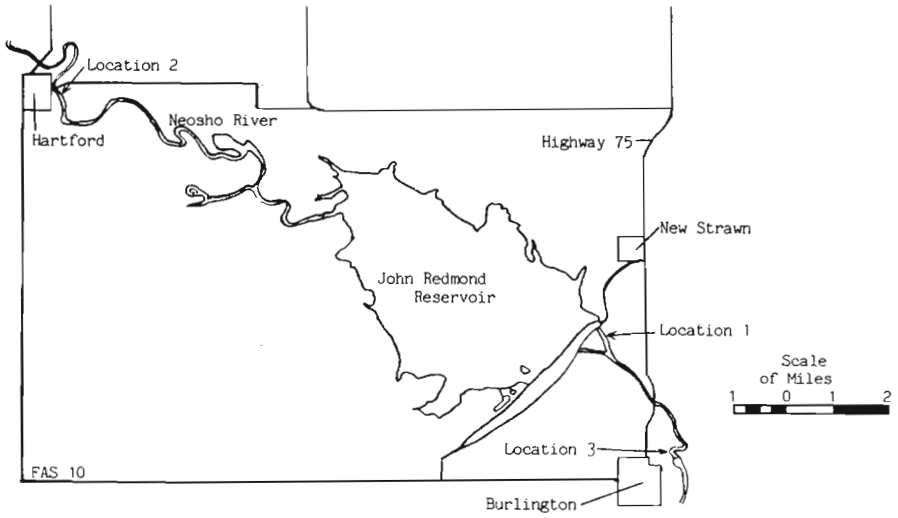


Figure 2. The Neosho River and John Redmond Reservoir area, showing sample collection points (Location 2: Hartford, Location 1: John Redmond Reservoir tailwaters, and Location 3: Burlington).

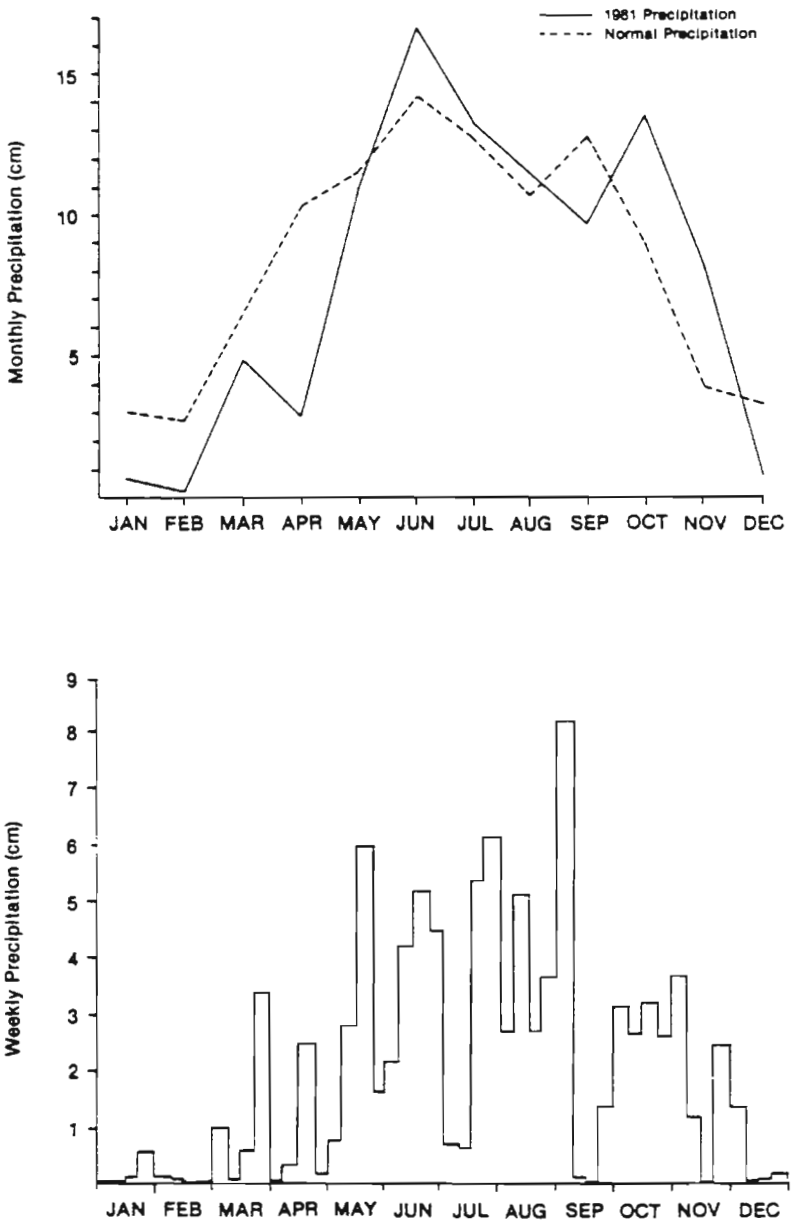


Figure 3. Precipitation at John Redmond Reservoir, January - December, 1981 (NOAA, 1981) (Redrawn from King, 1981).

Table 1. Mean daily inflow (cfs) of the Neosho River into the John Redmond Reservoir, 1981.

DATE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	50	50	50	55	30	1,240	1,770	940	8,460	200	7,880	5,100
2	25	50	25	85	30	1,120	825	1,630	7,150	50	13,500	3,700
3	25	50	25	70	30	1,680	3,210	2,250	2,980	100	16,400	3,700
4	25	50	150	60	50	950	11,900	2,970	1,200	250	14,100	1,500
5	25	50	75	55	20	1,570	14,000	2,900	500	400	11,400	1,100
6	25	25	50	50	20	1,120	11,900	1,720	200	400	5,120	1,000
7	50	25	50	50	50	460	4,240	1,080	400	100	2,540	1,000
8	50	25	50	55	75	505	2,400	310	400	150	2,200	1,000
9	50	25	100	45	200	460	1,750	625	740	800	6,500	900
10	100	25	50	65	100	130	1,400	1,410	485	500	11,600	900
11	100	25	50	125	20	925	2,400	1,130	400	300	9,900	900
12	50	25	75	90	75	1,340	1,500	870	500	300	5,500	900
13	50	25	60	135	400	1,150	565	1,000	380	370	5,180	900
14	50	25	50	125	70	720	1,150	800	365	1,800	3,840	800
15	50	25	50	70	30	8,590	1,310	520	340	620	2,300	800
16	50	25	30	55	80	8,060	325	450	200	1,530	1,360	800
17	50	25	130	140	1,120	2,240	1,000	480	100	6,840	1,200	800
18	50	25	80	120	4,780	1,330	800	330	250	5,930	1,000	800
19	50	25	50	100	3,545	1,870	600	275	150	3,100	900	1,000
20	50	100	30	190	2,735	1,810	800	200	200	1,900	1,100	1,100
21	50	100	45	100	1,390	860	600	300	150	400	1,000	1,200
22	50	100	30	140	975	680	500	250	70	1,500	1,400	1,000
23	50	50	20	10	4,520	1,110	450	300	275	100	1,200	1,000
24	50	25	100	100	895	830	350	200	225	100	1,100	1,200
25	50	25	285	75	1,105	705	300	500	560	200	1,200	1,200
26	50	25	150	65	490	750	700	560	480	400	1,200	1,200
27	50	25	100	55	655	9,510	2,100	230	460	500	1,200	1,300
28	50	50	200	75	815	14,500	3,810	300	450	400	1,200	1,600
29	50	.	340	100	795	7,680	4,200	250	360	400	1,500	1,800
30	50	.	310	20	1,890	2,450	3,210	565	635	550	3,500	1,800
31	500	.	130	.	2,410	.	1,530	5,000	.	915	.	1,520
Mean	64	39	95	83	949	2,545	2,632	979	969	1,003	4,601	1,404

Table 2 gives the mean daily releases from JRR. Discharge flow rates generally mirrored inflow values, although they tended to lag behind one to two weeks. Reservoir releases also increased during late May and peaked in July when the mean outflow was 3,449 cfs.

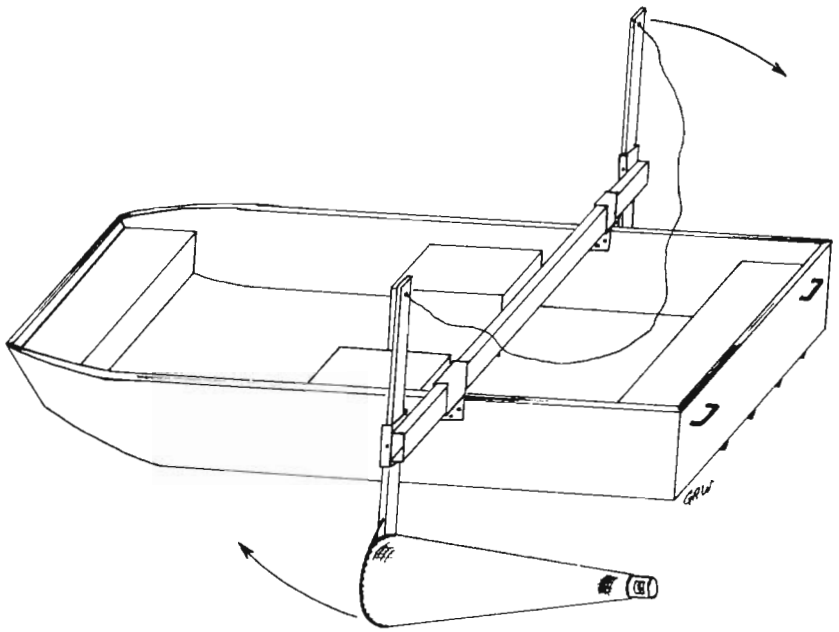


Figure 4. Twin push net assembly utilized throughout the study (patterned after Tarplee et al. 1979).

MATERIALS AND METHODS

Three collection locations in the Neosho River, one upstream and two downstream of John Redmond Reservoir (JRR) (Figure 2), were established for sampling on a weekly basis throughout the study period of 1 April through 31 July. Duplicate nocturnal samples were scheduled to be taken at all locations throughout the study with diurnal sampling also performed at Location 1. Diurnal collections at Location 1 were accomplished during the late afternoon. Nocturnal sampling was initiated at Location 2 (Hartford) no earlier than one-half hour after sunset, with Location 1 (JRR) collections following approximately one and one-half hours later, and Location 3 (Burlington) sampling initiated roughtly 40 minutes after boat recovery at JRR.

Table 2. Mean daily discharges (cfs) of John Redmond Reservoir into the Neosho River, 1981.

DATE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	19	135	145	61	32	1,442	5,928	2,112	267	220	240	3,730
2	19	117	145	29	34	2,010	7,280	2,100	1,873	220	2,100	5,282
3	19	86	145	29	34	2,010	6,942	2,079	4,290	220	7,252	4,196
4	19	86	145	29	34	2,010	6,977	2,088	4,208	220	9,640	1,701
5	19	86	145	29	34	2,010	7,350	2,112	4,048	220	10,270	1,080
6	19	86	145	29	34	2,010	7,688	2,113	3,900	220	10,270	1,080
7	19	86	145	29	34	2,010	7,688	1,718	3,770	220	9,765	776
8	19	86	145	29	34	1,170	7,408	1,078	2,749	220	7,905	540
9	19	43	145	29	34	440	7,093	1,058	1,139	220	7,508	540
10	19	19	145	29	34	440	5,476	1,060	430	220	9,563	540
11	19	19	145	27	34	440	3,773	1,065	378	220	10,125	753
12	19	19	145	29	34	355	3,713	1,065	430	220	9,925	1,080
13	19	19	145	29	34	250	2,536	1,065	430	220	7,080	1,080
14	54	19	145	29	34	250	1,725	1,065	307	220	3,920	1,333
15	99	19	145	29	34	250	1,856	1,058	240	240	3,902	1,620
16	98	19	145	29	34	1,483	1,780	1,038	240	240	3,258	1,283
17	94	131	145	29	34	2,500	1,755	424	240	250	2,160	1,080
18	94	184	145	29	35	2,486	1,735	75	240	270	1,496	1,070
19	148	175	145	29	36	2,452	1,700	75	240	1,122	1,080	1,055
20	180	132	145	29	37	2,446	1,247	75	240	2,000	1,080	1,050
21	157	132	145	29	142	2,404	420	75	229	2,776	1,080	1,613
22	145	132	145	29	230	2,367	674	75	220	3,920	1,080	2,070
23	145	132	145	28	245	2,317	840	75	220	2,329	1,080	2,050
24	145	132	145	29	250	2,296	669	163	220	679	1,080	2,030
25	145	139	117	29	250	2,258	420	240	220	675	1,080	2,010
26	145	145	96	29	718	1,744	420	240	220	502	1,080	1,990
27	145	145	96	29	1,130	1,167	788	240	220	228	1,080	1,970
28	155	145	96	29	1,130	1,303	2,197	240	220	230	1,080	2,524
29	161	·	96	29	1,130	2,841	3,030	240	220	230	1,080	2,840
30	130	·	96	29	1,130	4,453	3,070	240	220	230	1,721	2,787
31	135	·	96	·	1,130	·	2,746	248	·	230	·	2,092
Mean	84	95	134	30	263	1,720	3,449	858	1,062	620	4,332	1,769

Larval fish collections were accomplished through the use of a boat-mounted twin net assembly patterned after Tarplee et al. (1979). The push net apparatus (Figure 4) utilized twin 0.5 x 1.5 m conical nets made of 0.560 mm mesh Nytex bolting cloth. Each net terminated in a 16.8 x 32.4 cm flow-through bucket with 0.411 mm mesh stainless steel screen.

The means of collection consisted of positioning the boat in an area of adequate flow and maintaining this position with the nets lowered. If flow velocity was inadequate for proper control, the boat was advanced through the sample area with the nets in the down position. Upon completion of a collection, the nets were rotated to the up position and the collected material washed completely into the buckets. Bucket contents were then further strained through the use of a 0.600 mm brass sieve prior to preservation with ten percent buffered formalin acetate.

Volumes of 35 to 60 m^3 per sample were used throughout the study as target values. The quantity of water filtered was measured by calibrated General Oceanics flowmeters (Model 2030R) mounted in the mouth of each net. Boat velocity was also measured for all collections through the use of a calibrated General Oceanics remote read-out flowmeter (Model 2031). Boat velocity measurements provided a back-up for in-net flowmeters. Data on several physical parameters were also recorded at the time of collection including date, time, current velocity, and water temperature.

Preserved samples were transported to laboratory facilities, where sorting was accomplished with the aid of a viewer/magnifier. Each replicate was picked twice to assure complete sorting. Larval fish found were transferred to ten percent buffered formalin phosphate and stored in the dark.

Identification of larval fish was accomplished through the use of Fish (1932); Hogue et al. (1976); Mansueti and Hardy (1967); May and Gasaway (1967), as well as appropriate family, generic, or species descriptions. Determinations of larval fish developmental phases were made as defined by Snyder (1981b) (Figures 5 and 6) as follows:

> "Larval Period - The period of bony fish development characterized by obvious fin morphogenesis following hatching or parturition. Transition to the juvenile period is based on the following three criteria, each of which must be met: 1) finfold and atrophying fins, if any (very rare), must be absorbed beyond recognition; 2) the full adult complement of fin spines (actinotricha) and rays (lepidotrichia), including secondary rays, must be distinctly formed (visually well defined) in all fins; and 3) segmentation must

be evident in at least a few of the rays of each fin that is characterized by segmented rays in the adult.

Protolarval Phase - The larval phase of bony fish development characterized by the absence of distinct spines or rays associated with the future median fins (dorsal, anal or caudal fins). Transition to the mesolarval phase is based on the appearance of at least one distinct spine or ray in any of the median fins. Pectoral and pelvic fins or fin buds may be present.

Mesolarval Phase - The larval phase of bony fish development characterized by the morphogenesis of distinct principal rays in the median fins. Transition to the metalarval phase is based on the following two criteria, each of which must be met, except in species lacking pelvic fins: 1) the full adult complement of principal rays must be distinctly formed in the median fins; 2) the pelvic fins or fin buds must be evident.

Metalarval Phase - The larval phase of bony fish development characterized by the full adult complement of principal rays in the median fins and the presence of pelvic fins or fin buds (except in species lacking pelvic fins). Transition to the juvenile period is as specified in the definition for the larval period."

The definitions for developmental phase established by Snyder (1981b) were selected for use in this study due to the precision and reproducibility of determinations made through their use. Previous definitions based on retention of yolk material resulted in variable classification of families in relation to developmental advancement. The establishment of critera based on terminology unrelated to yolk retention permits increased consistency in relation to morphological features common to the majority of freshwater fish.

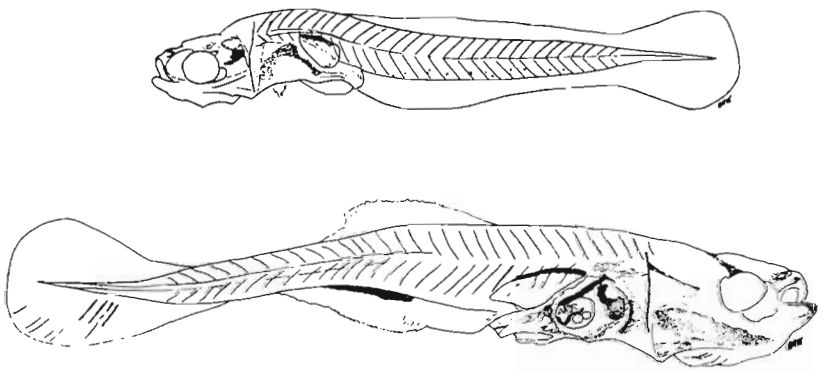


Figure 5. Representative protolarval and mesolarval phase fish (*Pomoxis annularis* shown).

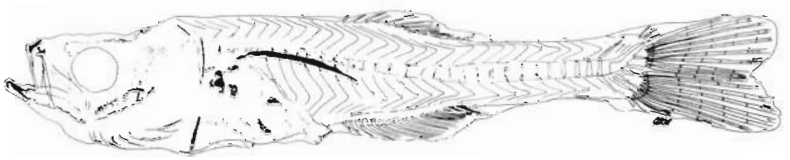


Figure 6. Representative metalarval phase fish (*Pomoxis annularis* shown).

Head, preanal, postanal, standard, and total lengths were measured on many of the sub-juvenile, non-clupeid larval fish identified (Figure 7). Head length was defined as the distance from the tip of the snout to the posterior margin of the cleithrum or the distance from the tip of the snout to the posterior margin of the operculum, if present. Other measurements, such as eye-gas bladder distance, head depth, etc., were recorded when necessary for identification.

Total preanal and postanal myomeres (Figure 7) were determined and recorded for the majority of sub-juvenile, non-clupeid larvae. Postanal myomeres were determined according to Siefert (1969) as follows:

"Postanal myomeres include all complete myomeres posterior to an imaginary vertical line drawn through the body at the posterior end of the anus... Remaining myomeres, including those bisected by the line, are considered preanal."

As discussed by Snyder (1981b), this technique produces myomere counts which nearly approximate the number of vertebrae to the bisecting line. All morphological determinations were recorded on the larval fish identification sheet. Measurements and meristics were documented through the use of an American Optics microscope with calibrated micrometer and polarizer or neutral density filter.

Raw data were compiled through the use of an Apple III computer. The Apple Visicalc III program was used for data processing including summation and mean, variance, and standard deviation determinations. The production of figures was accomplished through the use of an Apple LISA computer which utilized LISA file and LISA draw software. Mean daily larval fish concentrations for all locations, including JRR diurnal and nocturnal data, were tested through AOV for significant differences ($P_{0.05}$). Total mean diurnal and nocturnal concentrations were also analyzed for significant differences by the student's $t_{0.05}$ - test.

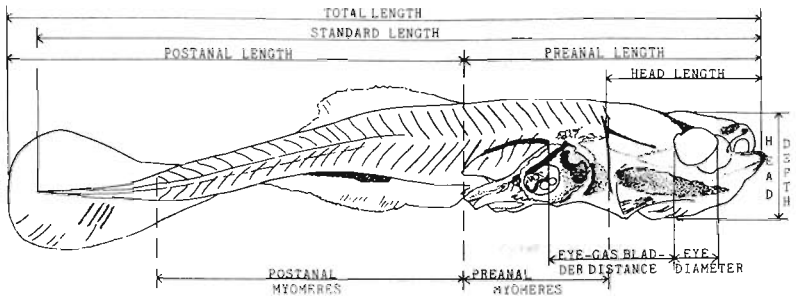


Figure 7. Selected anatomical and morphological distances and counts useful in the identification of larval fish.

RESULTS

Larval fish sampling on the Neosho River in 1981 was not initiated in early April as originally planned due to delays in equipment fabrication. The initial collection occurred on 25 April and sampling continued on a weekly basis through 31 July. Ichthyoplankton collections were accomplished on a total of 15 dates.

A combination of two problems resulted in incomplete sampling of all locations on some of the 15 dates. The first problem was high flow at Location 3 which, as described in the study plan, created hazardous conditions, precluding collections on four occasions. The second was a recurring bearing problem on the boat trailer which resulted in incomplete circuits on some dates. Due to these situations, Location 3 was sampled only nine times, while Location 1 (nocturnal) collections were made 13 times, Location 2, 14 times, and Location 1 (diurnal) collections were made on all 15 dates. A total of 51 samples, each consisting of two replicates, was collected despite the existence of these problems.

Physical Parameters

Measurement of field parameters was accomplished on all dates as planned, with the exception of 18 July when water temperatures were not recorded.

The General Oceanic flowmeters used from the beginning of the study for in-net measurement of water volumes filtered were removed for scheduled calibration on 13 July. They were found to be out-of-calibration at that time and were replaced. The replacement flowmeters served throughout the remainder of the study and were in-calibration after termination of sampling.

A comparison of in-net flow values provided by the out-of-calibration meters and boat speeds provided by the in-calibration back-up remote flowmeter was performed. Analysis of these data permitted the determination that the in-net flowmeters failed on or after the 5 June collections. Based on this determination, flow measurments made during the first six collection efforts were used for water volume calculations while boat speeds, as measured by the remote meter, were used for the 5 June through 10 July computations.

Spatial and Temporal Variations in Abundance and Species

In this study, larval fish were collected at all locations on all dates except for the 15 May John Redmond Reservoir (JRR) diurnal and 21 May Hartford nocturnal samples. A total of 27,905 fish of all phases was collected in 1981. This total consisted of 23,194 larvae, 2,501 eggs, and 2,210 juveniles. Excluding unidentified eggs, protolarvae, and mesolarvae, a total of 30 taxa representing 11 families was identified from the larvae collected. Tables follow which detail collection dates, times, water temperatures, current velocities, taxa collected, densities, and seasonal composition for larvae from all locations. A brief summary of the information in these tables is provided by location as follows.

Location 2: Hartford

Larval fish were collected at this location on all sampling dates except for 21 May. Efforts at Hartford resulted in a total collection of 4,837 fish of all phases. This total was comprised of 2,499 eggs, 2,330 larvae, and eight juvenile fish.

Eighteen taxa, excluding unidentified eggs, protolarvae, and mesolarvae, representing seven families were found to occur at this location (Table 3). Members of the families Clupeidae and Catostomidae dominated the larval fish complement; each comprising approximately 48% of all larvae (Figure 8). No other family except Cyprinidae, comprised more than 0.3% of the catch at Hartford.

Location 2 larval fish concentrations were variable throughout the study, ranging from a minimum of 9.4/100m^3 to a maximum of 1,246.7/100m^3. The total concentration of larval fish at Hartford exhibited a primary peak on 28 May which was roughly nine times higher than a secondary peak which occurred on 26 June (Figure 9).

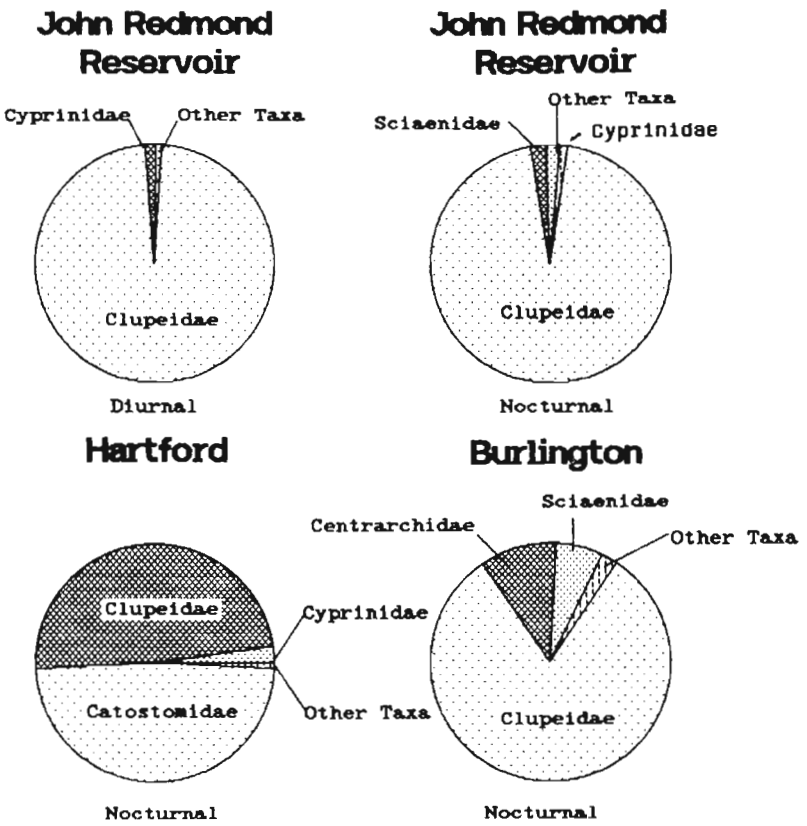


Figure 8. Annual relative abundance of larval fish collected at all locations in 1981.

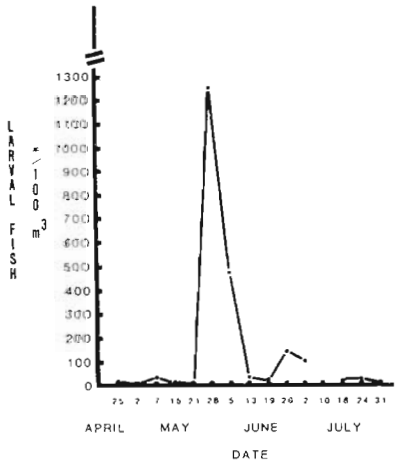


Figure 9. Total concentrations of larval fish collected in 1981 at Location 2, Hartford.

Table 3. Density of eggs, protolarvae, mesolarvae, metalarvae, and juvenile fish collected at Location 2, Hartford in 1981: nocturnal samples.

MONTH		APRIL			MAY			JUNE				JULY			
DATE		29	02	07	15	21	28	05	13	19	26	02	10	18	24	31
TIME (MILITARY)		2000	2100	2110	2110	2120	2120	2120	2135	2125	2135	2125	-do-	2130	2120	2120
WATER TEMPERATURE (C)		17.0	20.0	19.0	17.0	15.5	21.5	21.5	24.5	22.0	26.0	25.5	-	-c-	20.5	24.0
CURRENT VELOCITY (M/SEC)		-a	-a	-a	-a	0.69	0.20	0.89	0.40	0.70	-a	0.40	-	0.20	-a	0.39
SAMPLE VOLUME (M^3) (sum of both replicates)		79.1	95.4	107.8	92.4	119.7	116.7	94.2	106.0	94.2	117.8	94.2	-	139.6	124.8	122.6
Eggs							1698.1		322.6		12.7	169.8				
Unknown PRTL									4.7					2.2	0.8	
Unknown MSL									0.9							
Lepisosteidae																
Lepisosteus sp.	MSL								0.9							
	MTL										0.8					
Clupeidae																
Dorosoma cepedianum	PRTL	5.1d	4.2	31.1	9.6		904.9		3.8		5.1	2.1				
	MSL		4.1	1.9												
Cyprinidae																
Cyprinus carpio	PRTL						4.1	9.6	2.8	1.1		7.4				
	MSL							3.2								
Unknown Cyprinid	PRTL									1.1					0.8	2.5
	MSL														0.8	
Notropis sp.	PRTL								2.8							
(Th. Phenacobius)	PRTL	2.5														
	MSL	10.1														
(Th. Pimephales)	PRTL											2.1				
Catostomidae																
Unknown Catostomid	PRTL								1.9							
Ictiobinae																
(Th. Carpiodes carpio)	PRTL										0.8	83.9		14.4	20.0	
(Th. Ictiobus)	PRTL						337.5	455.4		14.9	121.9					
	MSL								10.4		7.6					
Ictiobus (Th. bubalus)	MSL														0.8	
Ictiobus (Th. cyprinellus)	(J)											1.1				
Ictaluridae																
Ictalurus punctatus	MTL															1.7
Noturus sp.	MTL															1.6
	(J)															1.6
Centrarchidae																
Lepomis sp.	PRTL								6.6							
	(J)									1.1						
Lepomis (Th. cyanellus)	MTL									1.1						1.6
	(J)															
Lepomis macrochirus	(J)															0.8
Percidae																
Percina sp.	MSL		1.1													
TOTAL Eggs (#/100 M^3)		0.0	0.0	0.0	0.0	0.0	1698.1	0.0	322.6	0.0	12.7	169.8	-b-	0.0	0.0	0.0
TOTAL Juveniles (#/100 M^3)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	1.1	-	0.0	0.0	4.0
Total Larvae (#/100 M^3)		17.7	9.4	31.0	9.6	0.0	1246.7	468.2	34.8	38.2	138.2	95.5	-	16.6	23.2	5.8
Total Collected (#/100 M^3)		17.7	9.4	31.0	9.6	0.0	2944.8	468.2	357.4	39.3	150.9	266.4	-	16.6	23.2	9.8

a = Below Detection Limit
b = Samples Not Collected Due to Equipment Malfunction
c = Not Measured
d = All Values Approximate Due to Net Malfunction
e = No Fish Collected

PRTL = Protolarvae
MSL = Mesolarvae
MTL = Metalarvae
(J) = Juvenile
Th. = Thought to be (See Discussion)

Location 1: John Redmond Reservoir Tailwaters

With the exception of 15 May, larval fish were collected on all dates at Location 1. A total of 19,950 fish of all phases was collected at JRR as a result of diurnal and nocturnal collections. This total consisted of 7,969 diurnally collected and 11,981 nocturnally collected fish. The diurnal collection total included 1 egg, 6,773 larvae, and 1,195 juvenile fish while 1 egg, 11,566 larvae, and 414 juvenile fish comprised the nocturnal catch.

A total of 21 taxa, representing ten families, occurred at JRR, excluding unidentified eggs and protolarvae (Tables 4 and 5). Not all 21 taxa appeared both diurnally and nocturnally, however. Only 13 taxa occurred diurnally while 19 were present nocturnally. Taxa present in daylight samples but not present in collections made after dark were unknown cyprinid, Cyprinidae (thought to be *Pimephales*), *Ictiobus* sp., *Ictalurus punctatus*, Cyprinodontidae

(thought to be *Fundulus notatus*), unknown centrarchid, *Percina* sp., and Percidae (thought to be *Stizostedion*). Conversely, unknown catostomid and *Labidesthes sicculus* were the only two nocturnally collected taxa not found in diurnal samples.

In addition to variability in the taxa present, larval fish also occurred in variable numbers diurnally and nocturnally. Table 6 presents the day/night (D/N) ratio of JRR larval fish.

Table 4. Density of eggs, protolarvae, mesolarvae, metalarvae, and juvenile fish collected at Location 1, John Redmond Reservoir spillway in 1981: diurnal samples.

MONTH		APRIL			MAY			JUNE				JULY				
DATE		25	02	07	15	21	28	05	13	19	26	02	10	18	24	31
TIME (MILITARY)		1730	1830	1820	1725	1735	1725	1820	1650	1825	1720	1750	1800	1645	1715	1705
WATER TEMPERATURE (C)		19.5	21.5	18.0	18.5	17.0	20.5	21.5	25.5	22.0	25.0	25.0	28.5	-b	27.0	25.0
CURRENT VELOCITY (M/SEC)		-a	-a	-a	-a	-a	0.65	0.95	-a	0.90	0.40	1.25	0.85	0.90	0.30	0.70
SAMPLE VOLUME (M^3) (sum of both replicates)		104.7	113.3	126.3	140.5	104.1	87.0	108.0	94.2	106.0	104.0	106.8	106.0	127.2	120.2	136.3
Egg							1.2									
Unknown PRTL		1.0c	0.9													
Clupeidae																
Dorosoma cepedianum	PRTL	5.7	73.3	64.3		3.8	96.4	110.0	46.0	0.9			7.9			
	MSL			11.1		3.8	8.0	37.0	2853.7	47.2			1.9		29.1	37.1
	MTL								1795.7	529.8	76.4	0.9	13.9			4.1
	(J)									6.6	657.6	14.2	386.8	1.6	10.8	5.1
Cyprinidae																
Cyprinus carpio	PRTL					0.9	4.7	2.0					0.9			
	MSL															
	MTL															
	(J)									0.9	0.9	2.8				
Unknown Cyprinid	PRTL															
	MSL															
Notropis sp.	PRTL								3.4							
	MSL								12.7							
	MTL								1.1		0.9		0.9			
	(J)										0.9		0.9			
Notropis (Th. buchanani)	PRTL												11.3			
	MSL												11.3	2.4	10.8	
	MTL												0.9	3.2	1.7	11.2
	(J)												0.9		3.1	0.9
(Th. Pimephales)	PRTL															
Catostomidae																
Unknown Catostomid	PRTL												0.9			
Ictaluridae																
(Th. Ictalurus)	PRTL															
	MSL								2.1							
	MTL															
	(J)															
Ictalurus sp.	MTL															
	(J)															
Ictalurus (Th. cyprinellus)	(J)											7.6				
Ictaluridae																
Ictalurus punctatus	MSL															
	(J)															
Cyprinodontidae																
(Th. Fundulus notatus)	PRTL															
Atherinidae																
Labidesthes sicculus	PRTL						1.1									
Percichthyidae																
Morone chrysops	PRTL						19.7									
	MSL							3.0								
	MTL															
	(J)									1.9	2.8	6.6				0.8
Centrarchidae																
Unknown Centrarchid	PRTL															
Lepomis sp.	PRTL								6.4							
	MSL												0.9			
Pomoxis sp.	PRTL					0.9										
	MTL									0.9						
Pomoxis annularis	PRTL							5.0								
	MSL							2.0								0.8
	MTL															
	(J)									0.9	0.9	4.7				
Percidae																
Percina sp.	PRTL			0.8				5.0								
(Th. Stizostedion)	MSL							2.0								0.8
Sciaenidae																
Aplodinotus grunniens	PRTL															
	MSL															
	MTL															
	(J)									0.9	0.9	4.7				
TOTAL EGGS (#/100 M^3)		0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL JUVENILES (#/100 M^3)		0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.5	10.3	66.9	36.8	388.6	1.6	14.1	6.8
TOTAL LARVAE (#/100 M^3)		6.7	74.2	80.2	0.0	9.4	129.9	634.0	5274.9	569.6	77.3	0.9	49.8	5.6	41.6	93.4
TOTAL COLLECTED (#/100 M^3)		6.7	74.2	80.2	0.0	9.4	131.1	634.0	5274.9	580.1	743.2	37.7	438.4	7.2	55.7	100.2

a = Below Detection Limit
b = Not Measured
c = All Values Represent the Mean of Two Replicates
d = No Fish Collected

PRTL = Protolarvae
MSL = Mesolarvae
MTL = Metalarvae
(J) = Juvenile
Th. = Thought to be (See Discussion)

Table 5. Density of eggs, protolarvae, mesolarvae, metalarvae, and juvenile fish collected at Location 1, John Redmond Reservoir spillway in 1981: nocturnal samples.

MONTH		APRIL			MAY			JUNE				JULY				
DATE		25	02	07	15	21	28	05	13	19	26	02	10	18	24	31
TIME (MILITARY)		2125	2245	2240	2235	2250	2240	2249	2236	2240	-b	2309	-b	2259	2225	2245
WATER TEMPERATURE (C)		18.0	19.0	18.0	15.5	15.0	20.0	23.5	25.0	22.0	-	25.0	-	-c	26.0	24.0
CURRENT VELOCITY (M/SEC)		-a	-a	-a	-a	-a	0.60	0.99	0.10	0.95	-	1.50	-	0.75	0.25	0.80
SAMPLE VOLUME (M^3) (sum of both replicates)		84.2	106.7	111.0	113.6	105.2	114.9	106.8	112.0	112.0	-	106.0	-	118.8	127.5	104.9
Egg																
Unknown PRTL							0.9									
Clupeidae																
Dorosoma cepedianum	PRTL	22.8d	24.4	18.9		2.9	140.1	146.2	53.6						1.6	
	MSL		0.9	0.9	0.9		29.6	3701.9	4007.1	6.2				2.5	13.2	22.0
	MTL							1.9	1241.1	597.3						6.6
	(J)									271.4		7.6		12.7	8.6	7.6
Cyprinidae																
Cyprinus carpio	PRTL	24.0	12.2		0.9	2.9	11.4									
	MSL		0.9					42.4								
	MTL									0.9						
	(J)											1.9				
Unknown Cyprinid	PRTL			0.9				0.9	1.8							
	MSL								9.8							
Notropis sp.	PRTL								1.8							
	MSL								6.2	0.9						
	MTL								0.9							
	(J)															
Notropis (Th. buchanani)	PRTL															
	MSL														3.1	1.0
	MTL													0.8	3.9	4.7
	(J)															1.0
(Th. Pimephales)	PRTL								10.7							
Catostomidae																
Unknown Catostomid	PRTL															
Ictaluridae																
(Th. Ictalurus)	PRTL							11.3								
	MSL							4.7	11.6	2.7						
	MTL									0.9						
	(J)															
Ictalurus sp.	MTL								1.8							
	(J)								1.8							
Ictalurus (Th. Cyprinellus)	(J)											5.7				
Ictaluridae																
Ictalurus punctatus	MSL											0.9				0.9
	(J)									0.9		2.8			0.8	0.9
Cyprinodontidae																
(Th. Fundulus notatus)	PRTL								0.9							
Atherinidae																
Labidesthes sicculus	PRTL															
Percichthyidae																
Morone chrysops	PRTL		3.8				95.2	0.9								
	MSL							2.8		0.9						
	MTL								0.9							
	(J)								1.8	6.2		1.9				
Centrarchidae																
Unknown Centrarchid	PRTL								0.9							
Lepomis sp.	PRTL						0.9	0.9	7.1							
	MSL															
Pomoxis sp.	PRTL				0.9											
	MTL								0.9							
Pomoxis annularis	PRTL					1.9	2.6									
	MSL						1.7	0.9								
	MTL							0.9								
	(J)															
Percidae																
Percina sp.	PRTL		0.9	0.9					6.2							
(Th. Stizostedion)	MSL			0.9												
Sciaenidae																
Aplodinotus grunniens	PRTL							39.6	12.5	2.7				3.3	2.4	
	MSL							42.4	42.0	16.1				6.7	6.4	2.8
	MTL								1.8	5.4		1.9			0.8	4.7
	(J)									8.0		27.4		0.8		1.0
TOTAL EGGS (#/100 M^3)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-b	0.0	-b	0.0	0.0	0.0
TOTAL JUVENILES (#/100 M^3)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.6	286.5	-	47.3	-	13.5	9.4	10.5
TOTAL LARVAE (#/100 M^3)		46.8	43.1	22.5	2.7	7.6	282.4	3998.0	5419.6	634.0	-	2.8	-	13.3	31.4	42.7
TOTAL COLLECTED (#/100 M^3)		46.8	43.1	22.5	2.7	7.6	282.4	3998.0	5423.2	920.5	-	50.1	-	26.8	40.8	53.2

a = Below Detection Limit
b = Samples Not Collected Due to Equipment Malfunction
c = Not Measured
d = All Values Represent the Mean of Two Replicates

PRTL = Protolarvae
MSL = Mesolarvae
MTL = Metalarvae
(J) = Juvenile
Th. = Thought to be (See Discussion)

Dorosoma cepedianum, the sole member of the family Clupeidae, dominated the diurnal JRR larval fish complement, comprising 98.0% of all larvae (Figure 8). Although they comprised only 1.2% of the catch, members of the family Cyprinidae were the next most common diurnally collected larvae. No other family present diurnally consisted of more than 0.3% of the total catch.

Table 6. Diurnal/nocturnal ratios of larval fish collected in 1981 at John Redmond Reservoir.

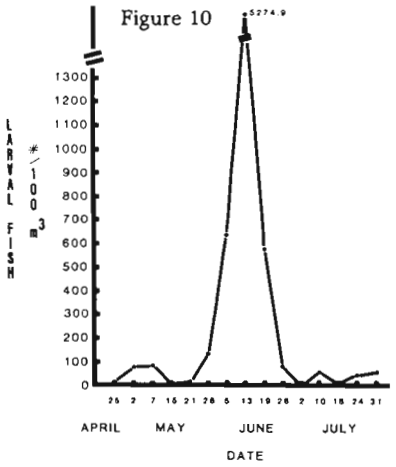
MONTH	APRIL			MAY			JUNE				JULY			
DATE	25	02	07	15	21	28	05	13	19	26	02	10	18	24	31
TAXA															
Unknown PREL	1/0a	1/0													
Clupeidae															
Dorosoma cepedianum	6/19	83/27	45/11	0/1	8/3	91/195	617/4081	4941/5938	603/676	81/-	1/0	24/-	0/3	35/19	24/15
Cyprinidae															
Cyprinus carpio	0/20	0/14		0/1	1/3	4/13	2/45		0/1			1/-			
Unknown Cyprinid			0/1				0/1	0/13							
Morone sp.								2/1	0/1	1/-		1/-			
Morone (Th. huchanani)												25/-	7/1	15/9	13/6
(Th. Pleuphales)								0/12							
Catostomidae															
Unknown Catostomid												1/-			
Ictiobinae															
(Th. Ictiobus)							0/17	2/13	0/4						
Ictiobus sp.								0/5							
Ictaluridae															
Ictalurus punctatus											0/2				0/1
Cyprinodontidae															
(Th. Fundulus notatus)								0/1							
Atherinidae															
Labidesthes sicculus						1/0									
Percichthyidae															
Morone chrysops		0/4				17/109	3/4	0/3	0/1						
Centrarchidae															
Unknown Centrarchid								0/1							
Lepomis sp.						0/1	0/1	3/4				1/-			
Pomoxis sp.				0/1	1/0				0/1						
Pomoxis annularis					0/2	0/5	1/2	0/1							
Percidae															
Percina sp.		0/1	0/1					0/7							
(Th. Stizostedion)			0/1												
Sciaenidae															
Aplodinotus grunniens			1/0				7/87	0/63	0/27		0/2		0/12	0/12	1/8

a = All Values Expressed as Ratios Reduced to Lowest Common Denominator
Th. = Thought to be (See Discussion)

In nocturnal samples *D. cepedianum* also was dominant, representing 95.2% (Figure 8). No other taxa comprised more than 2.0% of the total catch, although members of Cyprinidae, Percichthyidae, and Sciaenidae exhibited total annual relative abundances of 1.2, 1.0, and 2.0%, respectively.

Both diurnal and nocturnal larval fish densities reached maximum levels near 5,000/100m³ in 1981 at JRR. The patterns of occurrence were similar, with both diurnal and nocturnal larvae exhibiting a catch curve similar to a Gaussian distribution.

The maximum diurnal larval fish density occurred on 13 June at 5,274.9/100m³ and was flanked by two periods of densities below 10.0/100m³ (Figure 10). These periods of diminished larval fish occurrence were preceded and followed by periods when ichthyoplankton achieved densities between 50 and 100/100m³. The minimum diurnal concentration occurred on 15 May when no larvae were collected.



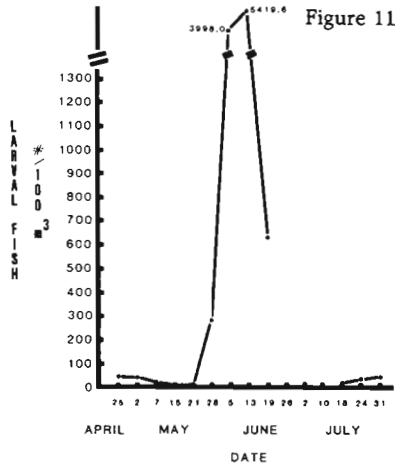


Figure 10. Total concentrations of larval fish collected in 1981 at Location 1, John Redmond Reservoir tailwaters: diurnal samples.

Figure 11. Total concentrations of larval fish collected in 1981 at Location 1, John Redmond Reservoir tailwaters: nocturnal samples.

Maximum nocturnal densities at JRR were achieved during the first two June sampling dates. Larval fish densities on these dates, 5 and 13 June, were 3,998.0 and 5,419.6/100m³; roughly six to eight times higher than the next highest concentration (Figure 11). A value of 2.7/100m³ on 15 May was the minimum larval fish concentration nocturnally at JRR.

Location 3: Burlington

Larval fish were found at Burlington on all nights that sampling was performed. A total of 3,118 fish of all phases appeared in 0.5 m nets at this location. This total consisted of 2,525 larvae, no eggs, and 593 juvenile fish. Excluding unidentified protolarvae, 14 taxa, representing seven families, were identified from Location 3 larvae (Table 7). *Dorosoma cepedianum* also dominated the annual relative abundance at Burlington, but to a lesser degree than at JRR, comprising 81.4% of all larvae. Other important families included Centrarchidae at 10.1%, Sciaenidae at 6.4%, and Cyprinidae at 1.1%. No other family comprised more than 1.0% of the Location 3 catch (Figure 8).

Larval fish concentrations varied from 6.3/100m³ on 18 July to a maximum of 1,766.4/100m³ on 19 June. The graph of densities at

Table 7. Density of eggs, protolarvae, mesolarvae, metalarvae, and juvenile fish collected at Location 3, Burlington in 1981: nocturnal samples.

MONTH		APRIL			MAY			JUNE				JULY			
DATE		25	02	07	15	21	28	05	13	19	26	02	10	18	24	31
TIME (MILITARY)		2300	2350	2330	2350	2350	2345	-b	-c	2325	-c	-b	-c	2350	2325	-b
WATER TEMPERATURE (C)		18.5	19.5	19.5	17.0	15.5	20.0	-	-	22.0	-	-	-	-d	21.0	-
CURRENT VELOCITY (M/SEC)		-a	-a	-a	-a	-a	0.15	-	-	0.40	-	-	-	-a	-a	-
SAMPLE VOLUME (M^3) (sum of both replicates)		92.7	111.3	92.9	105.5	139.1	121.2	-	-	117.8	-	-	-	126.8	130.1	-
Unknown PRTL							0.8									
Clupeidae																
Dorosoma cepedianum	PRTL		5.4	15.0	23.7	5.0	58.6									
	MSL		1.8		0.9					404.1				0.8	0.8	
	MTL									1232.6						
	(J)									436.3						
Cyprinidae																
Cyprinus carpio	PRTL	1.1e	8.1				7.4									
	MSL									0.8						
Unknown Cyprinid	MSL									0.8						
	MTL														0.8	
(Th. Notemigonus crysoleucas)	PRTL		0.9													
Notropis sp.	(J)														1.6	
Notropis (Th. hachwanai)	MSL														1.6	
	MTL														2.4	
	(J)													1.5	0.8	
Ictaluridae																
Ictalurus punctatus	MTL														3.1	
	(J)														36.0	
Atherinidae																
Labidesthes sicculus	PRTL				3.8											
	(J)													1.7	0.8	
Percichthyidae																
Morone chrysops	PRTL						10.7									
	MSL	2.1														
	MTL									0.8						
	(J)									1.4						
Centrarchidae																
Lepomis sp.	MTL													0.8		
Micropterus sp.	MTL						0.8									
Pomoxis sp.	PRTL	3.3		5.4	44.4	13.7	1.6									
	MSL									0.8						
Pomoxis annularis	PRTL	51.7	22.5	21.7	52.2	12.9	1.6									
	MSL		1.6	2.2		0.7										
	(J)									1.7						
Sciaenidae																
Aplodinotus grunniens	PRTL													0.7		
	MSL									95.9				4.0		
	MTL									30.6					2.3	
	(J)						1.3			15.1						
TOTAL EGGS (#/100 M^3)		0.0	0.0	0.0	0.0	0.0	0.0	-b	-c	0.0	-c	-b	-c	0.0	0.0	-b
TOTAL JUVENILES (#/100 M^3)		0.0	0.0	0.0	0.0	0.0	1.3	-	-	456.7	-	-	-	3.2	39.2	-
TOTAL LARVAE (#/100 M^3)		58.2	42.3	44.3	125.0	32.3	81.5	-	-	1766.4	-	-	-	6.3	11.0	-
TOTAL COLLECTED (#/100 M^3)		58.2	42.3	44.3	125.0	32.3	84.8	-	-	2223.1	-	-	-	9.5	50.2	-

a = Below Detection Limit
b = Samples Not Collected Due to High Flow
c = Samples Not Collected Due to Equipment Malfunction
d = Not Measured
e = All Values Represent the Mean of Two Replicates

PRTL = Protolarvae
MSL = Mesolarvae
MTL = Metalarvae
(J) = Juvenile
Th. = Thought to be (See Discussion)

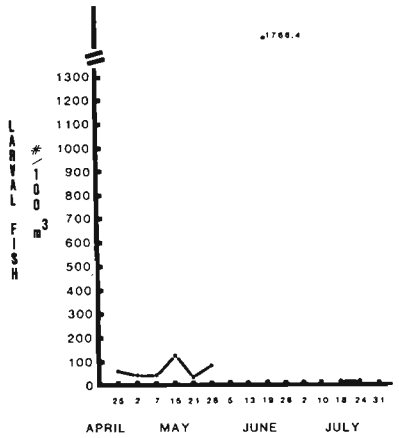


Figure 12. Total concentrations of larval fish collected in 1981 at Location 3, Burlington.

this location also appeared to exhibit a Gaussian distribution, although data gaps make the curve less distinct (Figure 12).

Morphometrical Data

Certain morphological data necessary for identification of larval fish were collected throughout the identification process. These data consisted of measurements and counts for diagnostic features. The morphometrical features quantified were not identical for all taxa, although a limited number were common to all.

With three exceptions, morphometrical data are presented in tabular form for those taxa occurring in sufficient numbers to permit meaningful interpretation. *Dorosoma cepedianum, Morone chrysops,* and *Aplodinotus grunniens* were the three taxa not included in the morphometrical tables. Data for these species were not presented on the basis that they present distinctive morphological characteristics which have been extensively studied. Table 8 provides definitions for the abbreviations used in the following tables. Tables 9 through 22 present morphometrical data for the 14 taxa determined to represent worthwhile information.

Table 8. Definitions of morphometrical abbreviations.

Abbreviation	Definition
TL	Total Length
SL	Standard Length
Ptnl L	Postanal Length
Prnl L	Preanal Length
Egb D	Eye-gas Bladder Distance
PFL	Pectoral Fin Length
Ed	Eye Diameter
HD	Head Depth
HL	Head Length
N/A	Not Applicable

Table 9. Means, ranges, and standard deviations for morphometrical data on Cyprinidae: *Cyprinus carpio*.

	PROTOLARVAE			MESOLARVAE			METALARVAE			JUVENILES		
	MEAN ± SD	RANGE	N	MEAN ± SD	RANGE	N	MEAN ± SD	RANGE	N	MEAN ± SD	RANGE	N
SIZE - DISTANCE (mm)												
TL	6.9 ± 0.6	5.2 - 8.1	86	12.3 ± 2.2	7.5 - 15.4	22	N/A	19.1	1	25.3 ± 2.8	21.4 - 28.2	4
SL	6.6 ± 0.5	5.0 - 7.7	83	10.8 ± 1.6	7.0 - 13.2	22	N/A	15.2	1	19.4 ± 2.4	16.5 - 22.0	4
Ptnl L	2.2 ± 0.2	1.5 - 2.6	85	4.1 ± 0.8	2.4 - 5.2	22	N/A	7.5	1	9.9 ± 1.2	8.6 - 11.5	4
Prnl L	4.7 ± 0.4	3.2 - 5.5	85	8.1 ± 1.4	5.1 - 10.2	22	N/A	11.6	1	14.9 ± 1.8	12.8 - 16.7	4
HL	1.5 ± 0.2	1.0 - 1.8	81	3.1 ± 0.7	2.0 - 4.0	22	N/A	7.0	1	6.8 ± 1.0	5.9 - 8.1	4
LENGTHS (%TL)												
HL	21.0 ± 2.0	15.0 - 25.0	81	25.0 ± 2.0	21.0 - 27.0	22	N/A	37.0	1	27.0 ± 2.0	24.0 - 29.0	4
Prnl L	68.0 ± 3.0	58.0 - 75.0	85	66.0 ± 1.0	65.0 - 69.0	22	N/A	61.0	1	59.0 ± 3.0	55.0 - 62.0	4
RELATIONSHIPS												
Prnl L/HL (#)	3.2 ± 0.3	2.8 - 4.4	81	2.7 ± 0.2	2.4 - 3.0	22	N/A	1.7	1	2.2 ± 0.3	2.0 - 2.6	4
Prnl L/Ptnl L (#)	2.1 ± 0.2	1.4 - 2.9	85	2.0 ± 0.1	1.8 - 2.2	22	N/A	1.6	1	1.5 ± 0.1	1.4 - 1.6	4
MYOMERES												
Preanal	25.0 ± 1.0	23.0 - 27.0	80	26.0 ± 1.0	24.0 - 28.0	22		-				
Postanal	12.0 ± 1.0	9.0 - 14.0	80	11.0 ± 1.0	9.0 - 14.0	22		-		12.0 ± 1.0	12.0 - 13.0	4
Total	37.0 ± 1.0	34.0 - 40.0	80	37.0 ± 1.0	35.0 - 39.0	22		-				

Table 10. Means, ranges, and standard deviations for morphometrical data on Cyprinidae: *Notropis* sp.

	PROTOLARVAE			MESOLARVAE			METALARVAE			JUVENILES		
	MEAN ± SD	RANGE	N	MEAN ± SD	RANGE	N	MEAN ± SD	RANGE	N	MEAN ± SD	RANGE	N
SIZE - DISTANCE (mm)												
TL	6.0 ± 0.5	5.6 - 7.0	12	8.2 ± 0.7	7.1 - 9.6	16	11.3 ± 0.8	10.4 - 12.0	4	12.5 ± 1.0	11.8 - 13.2	2
SL	5.7 ± 0.4	5.2 - 6.6	12	7.5 ± 0.5	6.6 - 8.4	16	9.3 ± 0.6	8.8 - 9.8	4	10.2 ± 0.8	9.6 - 10.8	2
Ptnl L	2.2 ± 0.3	1.6 - 2.6	12	3.2 ± 0.3	2.6 - 3.8	16	5.2 ± 0.6	4.5 - 5.9	4	5.8 ± 0.6	5.4 - 6.3	2
Prnl L	3.9 ± 0.3	3.4 - 4.5	12	5.1 ± 0.4	4.6 - 5.8	16	6.1 ± 0.4	5.9 - 6.6	4	6.6 ± 0.4	6.4 - 6.9	2
HL	1.2 ± 0.3	0.9 - 1.6	12	1.5 ± 0.2	1.0 - 1.8	16	2.2 ± 0.2	2.0 - 2.4	4	2.6 ± 0.1	2.5 - 2.6	2
LENGTHS (%TL)												
HL	20.0 ± 5.0	15.0 - 29.0	12	18.0 ± 2.0	12.0 - 20.0	16	20.0 ± 1.0	18.0 - 21.0	4	20.0 ± 1.0	20.0 - 21.0	2
Prnl L	64.0 ± 4.0	61.0 - 71.0	12	62.0 ± 1.0	60.0 - 64.0	16	54.0 ± 2.0	51.0 - 57.0	4	53.0 ± 1.0	52.0 - 54.0	2
RELATIONSHIPS												
Prnl L/HL (#)	3.4 ± 0.8	2.1 - 4.4	12	3.5 ± 0.5	3.2 - 5.2	16	2.8 ± 0.2	2.5 - 3.0	4	2.6 ± 0.0	2.6	2
Prnl L/Ptnl L (#)	1.8 ± 0.3	1.5 - 2.5	12	1.6 ± 0.1	1.5 - 1.8	16	1.2 ± 0.1	1.0 - 1.3	4	1.1 ± 0.1	1.1 - 1.2	2
MYOMERES												
Preanal	23.0 ± 1.0	22.0 - 24.0	12	23.0 ± 1.0	21.0 - 24.0	16	21.0 ± 1.0	19.0 - 22.0	4	20.0 ± 0.0	20.0	2
Postanal	12.0 ± 1.0	9.0 - 14.0	12	12.0 ± 1.0	11.0 - 13.0	16	12.0 ± 1.0	11.0 - 14.0	4	12.0 ± 1.0	12.0 - 13.0	2
Total	35.0 ± 2.0	31.0 - 37.0	12	35.0 ± 1.0	33.0 - 36.0	16	34.0 ± 2.0	31.0 - 36.0	4	32.0 ± 1.0	32.0 - 33.0	2

Table 11. Means, ranges, and standard deviations for morphometrical data on Cyprinidae: *Notropis* sp. (Thought to be *buchanani*).

	PROTOLARVAE MEAN ± SD	PROTOLARVAE RANGE	N	MESOLARVAE MEAN ± SD	MESOLARVAE RANGE	N	METALARVAE MEAN ± SD	METALARVAE RANGE	N	JUVENILES MEAN ± SD	JUVENILES RANGE	N
SIZE - DISTANCE (mm)												
TL	5.8 ± 0.7	4.8 - 7.1	12	8.7 ± 1.0	6.8 - 10.6	35	11.5 ± 1.2	9.6 - 14.4	28	14.8 ± 2.7	11.0 - 17.7	9
SL	5.5 ± 0.7	4.4 - 6.9	12	7.6 ± 0.7	6.3 - 9.0	35	9.5 ± 0.8	8.0 - 11.2	28	12.1 ± 2.5	8.6 - 16.4	9
Ptnl L	2.1 ± 0.2	1.8 - 2.4	12	3.6 ± 0.5	2.6 - 4.8	35	5.3 ± 0.8	4.1 - 7.2	27	7.4 ± 1.8	4.8 - 9.4	9
Prnl L	3.6 ± 0.6	3.0 - 5.0	12	5.1 ± 0.5	4.2 - 5.8	35	6.2 ± 0.6	5.5 - 8.5	27	7.4 ± 0.9	6.2 - 8.4	9
HL	1.0 ± 0.2	0.8 - 1.4	12	1.6 ± 0.2	1.2 - 2.2	35	2.3 ± 0.3	1.9 - 2.8	28	3.0 ± 0.5	2.2 - 3.6	9
LENGTHS (%TL)												
HL	17.0 ± 2.0	15.0 - 20.0	12	19.0 ± 1.0	17.0 - 21.0	35	20.0 ± 1.0	19.0 - 22.0	28	20.0 ± 1.0	20.0 - 21.0	9
Prnl L	63.0 ± 3.0	61.0 - 70.0	12	59.0 ± 2.0	55.0 - 62.0	35	54.0 ± 3.0	49.0 - 66.0	27	51.0 ± 4.0	47.0 - 56.0	9
RELATIONSHIPS												
Prnl L/HL (#)	3.8 ± 0.4	3.4 - 4.8	12	3.1 ± 0.2	2.6 - 3.6	35	2.6 ± 0.6	2.3 - 3.3	28	2.5 ± 0.2	2.3 - 2.8	9
Prnl L/Ptnl L (#)	1.7 ± 0.2	1.6 - 2.4	12	1.4 ± 0.1	1.2 - 1.6	35	1.2 ± 0.2	0.9 - 2.0	27	1.0 ± 0.2	0.9 - 1.3	9
MYOMERES												
Preanal	22.0 ± 1.0	21.0 - 23.0	11	22.0 ± 1.0	20.0 - 24.0	35	20.0 ± 1.0	19.0 - 22.0	25	20.0 ± 1.0	18.0 - 21.0	9
Postanal	13.0 ± 1.0	11.0 - 14.0	11	12.0 ± 1.0	10.0 - 14.0	35	11.0 ± 1.0	10.0 - 14.0	25	13.0 ± 1.0	11.0 - 14.0	9
Total	35.0 ± 1.0	34.0 - 36.0	11	33.0 ± 1.0	31.0 - 36.0	35	32.0 ± 1.0	30.0 - 34.0	25	32.0 ± 1.0	31.0 - 34.0	9

Table 12. Means, ranges, and standard deviations for morphometrical data on Cyprinidae: (Thought to be *Phenacobius*).

	PROTOLARVAE MEAN ± SD	PROTOLARVAE RANGE	N	MESOLARVAE MEAN ± SD	MESOLARVAE RANGE	N	METALARVAE MEAN ± SD	METALARVAE RANGE	N	JUVENILES MEAN ± SD	JUVENILES RANGE	N
SIZE - DISTANCE (mm)												
TL	8.0 ± 0.1	8.0 - 8.1	2	9.7 ± 0.8	8.7 - 11.4	8	None Identified			None Identified		
SL	7.6 ± 0.1	7.5 - 7.6	2	9.0 ± 0.6	8.2 - 10.1	8						
Ptnl L	2.9 ± 0.1	2.9 - 3.0	2	3.6 ± 0.4	3.2 - 4.3	8						
Prnl L	5.1 ± 0.0	5.1	2	6.1 ± 0.5	5.5 - 7.1	8						
PFL	N/A	1.3	1	N/A	1.3	1						
HL	1.4 ± 0.4	1.1 - 1.6	2	2.0 ± 0.2	1.7 - 2.4	8						
LENGTHS (%TL)												
HL	17.0 ± 5.0	14.0 - 20.0	2	21.0 ± 1.0	20.0 - 22.0	8						
Prnl L	63.0 ± 1.0	63.0 - 64.0	2	63.0 ± 1.0	61.0 - 65.0	8						
RELATIONSHIPS												
Prnl L/HL (#)	3.9 ± 1.0	3.2 - 4.6	2	3.0 ± 0.1	2.8 - 3.2	8						
Prnl L/Ptnl L (#)	1.7 ± 0.1	1.7 - 1.8	2	1.7 ± 0.1	1.6 - 1.8	8						
TL/PFL	N/A	7.4	1	N/A	6.2	1						
MYOMERES												
Preanal	25.0 ± 1.0	24.0 - 26.0	2	25.0 ± 1.0	24.0 - 26.0	8						
Postanal	11.0 ± 1.0	11.0 - 12.0	2	12.0 ± 1.0	9.0 - 13.0	8						
Total	36.0 ± 2.0	35.0 - 38.0	2	37.0 ± 1.0	35.0 - 38.0	8						

Table .13 Means, ranges, and standard deviations for morphometrical data on Cyprinidae: (Thought to be *Pimephales*).

	PROTOLARVAE MEAN ± SD	RANGE	N	MESOLARVAE MEAN ± SD	RANGE	N	METALARVAE MEAN ± SD	RANGE	N	JUVENILES MEAN ± SD	RANGE	N
SIZE - DISTANCE (mm)												
TL	4.5 ± 0.4	4.0 - 5.9	14	None Identified			None Identified			None Identified		
SL	4.2 ± 0.4	3.8 - 5.6	14									
Ptnl L	1.8 ± 0.2	1.6 - 2.3	14									
Prnl L	2.7 ± 0.3	2.3 - 3.6	14									
HL	0.9 ± 0.1	0.8 - 1.2	14									
LENGTHS (%TL)												
HL	19.0 ± 2.0	17.0 - 23.0	14									
Prnl L	59.0 ± 2.0	54.0 - 62.0	14									
RELATIONSHIPS												
Prnl L/HL (#)	3.1 ± 0.3	2.6 - 3.4	14									
Prnl L/Ptnl L (#)	1.5 ± 0.1	1.4 - 1.6	14									
MYOMERES												
Preanal	20.0 ± 1.0	19.0 - 22.0	14									
Postanal	12.0 ± 1.0	11.0 - 14.0	14									
Total	33.0 ± 1.0	31.0 - 35.0	14									

Table 14. Means, ranges and standard deviations for morphometrical data on Catostomidae: Ictiobinae; (Thought to be *Carpiodes carpio*).

	PROTOLARVAE MEAN ± SD	RANGE	N	MESOLARVAE MEAN ± SD	RANGE	N	METALARVAE MEAN ± SD	RANGE	N	JUVENILES MEAN ± SD	RANGE	N
SIZE - DISTANCE (mm)												
TL	6.6 ± 0.5	5.4 - 7.7	57	None Identified			None Identified			None Identified		
SL	6.3 ± 0.5	5.1 - 7.3	57									
Ptnl L	1.8 ± 0.2	1.4 - 2.1	57									
Prnl L	4.8 ± 0.4	3.9 - 5.7	57									
PFL	N/A	0.8	1									
HD	0.7 ± 0.1	0.6 - 0.8	11									
HL	1.2 ± 0.1	1.0 - 1.6	56									
LENGTHS (%TL)												
HL	19.0 ± 1.0	16.0 - 27.0	56									
Prnl L	73.0 ± 2.0	70.0 - 78.0	57									
DEPTHS (%TL)												
HD	11.0 ± 1.0	10.0 - 12.0	11									
RELATIONSHIPS												
HD/HL (%)	61.0 ± 3.0	56.0 - 64.0	11									
Prnl L/HL (#)	3.9 ± 0.3	2.6 - 4.5	56									
Prnl L/Ptnl L (#)	2.7 ± 0.2	2.3 - 3.5	57									
TL/PFL (#)	N/A	8.9	1									
MYOMERES												
Preanal	28.0 ± 1.0	26.0 - 30.0	52									
Postanal	8.0 ± 1.0	5.0 - 12.0	53									
Total	36.0 ± 1.0	32.0 - 41.0	52									

Table 15. Means, ranges, and standard deviations for morphometrical data on Catostomidae: Ictiobinae; (Thought to be *Ictiobus*).

	PROTOLARVAE MEAN ± SD	PROTOLARVAE RANGE	PROTOLARVAE N	MESOLARVAE MEAN ± SD	MESOLARVAE RANGE	MESOLARVAE N	METALARVAE MEAN ± SD	METALARVAE RANGE	METALARVAE N	JUVENILES MEAN ± SD	JUVENILES RANGE	JUVENILES N
SIZE - DISTANCE (mm)												
TL	7.1 ± 0.6	5.3 - 8.8	151	11.3 ± 2.2	8.4 - 16.5	40	N/A			N/A		
SL	6.7 ± 0.6	5.0 - 8.6	153	10.3 ± 1.3	8.2 - 13.0	40						
Ptnl L	1.9 ± 0.3	1.1 - 2.5	152	3.6 ± 1.1	2.3 - 6.2	40						
Prnl L	5.2 ± 0.4	4.1 - 6.6	152	8.1 ± 1.2	6.3 - 10.7	40						
PFL	0.8 ± 0.1	0.8 - 0.9	5	-	-	-						
HD	0.8 ± 0.0	0.8	3	-	-	-						
ED	0.5 ± 0.1	0.4 - 0.5	37	-	-	-						
HL	1.4 ± 0.2	1.0 - 1.8	118	2.5 ± 0.6	1.7 - 4.1	40						
LENGTHS (%TL)												
HL	19.0 ± 1.0	16.0 - 24.0	120	21.0 ± 1.0	19.0 - 27.0	40						
Prnl L	73.0 ± 2.0	70.0 - 81.0	152	70.0 ± 3.0	62.0 - 74.0	40						
DEPTHS (%TL)												
HD	11.0 ± 0.0	11.0	3	-	-	-						
RELATIONSHIPS												
ED/TL (%)	7.0 ± 1.0	6.0 - 8.0	37	-	-	-						
HD/HL (%)	62.0 ± 1.0	62.0 - 63.0	3	-	-	-						
Prnl L/HL (#)	3.9 ± 0.3	3.1 - 4.6	119	3.3 ± 0.3	2.7 - 3.8	40						
Prnl L/Ptnl L (#)	2.7 ± 0.3	2.3 - 4.4	152	2.4 ± 0.3	1.6 - 2.8	40						
TL/PFL (#)	8.6 ± 0.5	8.1 - 9.3	5	-	-	-						
MYOMERES												
Preanal	28.0 ± 1.0	27.0 - 30.0	149	28.0 ± 1.0	27.0 - 30.0	40						
Postanal	8.0 ± 1.0	5.0 - 10.0	149	7.0 ± 1.0	6.0 - 9.0	40						
Total	36.0 ± 2.0	33.0 - 38.0	150	36.0 ± 1.0	33.0 - 38.0	40						

Table 16. Means, ranges, and standard deviations for morphometrical data on Catostomidae: Ictiobinae; *Ictiobus* sp.

	PROTOLARVAE MEAN ± SD	PROTOLARVAE RANGE	PROTOLARVAE N	MESOLARVAE MEAN ± SD	MESOLARVAE RANGE	MESOLARVAE N	METALARVAE MEAN ± SD	METALARVAE RANGE	METALARVAE N	JUVENILES MEAN ± SD	JUVENILES RANGE	JUVENILES N
SIZE - DISTANCE (mm)												
TL	N/A			N/A			19.7 ± 2.1	18.0 - 22.0	3	27.3 ± 5.3	18.4 - 35.5	7
SL							15.3 ± 1.7	14.0 - 17.2	3	20.3 ± 3.8	14.2 - 26.2	7
Ptnl L							7.2 ± 0.5	6.6 - 7.6	3	11.1 ± 2.4	6.6 - 14.4	7
Prnl L							12.5 ± 1.7	11.4 - 14.4	3	16.2 ± 2.9	11.8 - 21.1	7
HL							4.5 ± 0.3	4.2 - 4.8	3	7.1 ± 1.8	4.8 - 10.0	6
LENGTHS (%TL)												
HL							23.0 ± 1.0	22.0 - 24.0	3	26.0 ± 1.0	25.0 - 28.0	6
Prnl L							63.0 ± 2.0	61.0 - 65.0	3	60.0 ± 2.0	59.0 - 64.0	7
RELATIONSHIPS												
Prnl L/HL (#)							2.8 ± 0.2	2.5 - 3.0	3	2.3 ± 0.1	2.1 - 2.5	6
Prnl L/Ptnl L (#)							1.7 ± 0.2	1.6 - 1.9	3	1.5 ± 0.1	1.4 - 1.8	7
MYOMERES												
Preanal							26.0 ± 1.0	25.0 - 27.0	3	29.0 ± 1.0	28.0 - 30.0	3
Postanal							7.0 ± 2.0	5.0 - 9.0	3	7.0 ± 1.0	6.0 - 8.0	6
Total							34.0 ± 1.0	33.0 - 34.0	3	35.0 ± 1.0	35.0 - 36.0	3

Table 17. Means, ranges, and standard deviations for morphometrical data on Atherinidae: *Labidesthes sicculus*.

	PROTOLARVAE MEAN ± SD	RANGE	N	MESOLARVAE MEAN ± SD	RANGE	N	METALARVAE MEAN ± SD	RANGE	N	JUVENILES MEAN ± SD	RANGE	N
SIZE - DISTANCE (mm)												
TL	6.5 ± 1.5	4.0 - 7.7	5	None Identified			None Identified			28.2 ± 6.8	23.4 - 33.0	2
SL	6.6 ± 0.6	6.0 - 7.2	4							23.4 ± 5.9	19.2 - 27.6	2
Ptnl L	4.6 ± 1.2	2.7 - 5.6	5							16.0 ± 3.6	13.4 - 18.5	2
Prnl L	1.8 ± 0.3	1.8 - 2.1	5							12.2 ± 3.2	10.0 - 14.5	2
HL	1.2 ± 0.1	1.0 - 1.3	4							5.5 ± 1.4	4.5 - 6.5	2
LENGTHS (%TL)												
HL	17.0 ± 1.0	15.0 - 19.0	5							20.0 ± 0.0	20.0	2
Prnl L	29.0 ± 2.0	27.0 - 33.0	5							43.0 ± 1.0	43.0 - 44.0	2
RELATIONSHIPS												
Prnl L/HL (#)	1.7 ± 0.2	1.5 - 1.9	4							2.2 ± 0.0	2.2	2
Prnl L/Ptnl L (#)	0.4 ± 0.1	0.4 - 0.5	5							0.8 ± 0.0	0.8	2
MYOMERES												
Preanal	8.0 ± 1.0	7.0 - 9.0	5							-	-	-
Postanal	31.0 ± 2.0	28.0 - 33.0	5							-	-	-
Total	39.0 ± 2.0	35.0 - 40.0	5							-	-	-

Table 18. Means, ranges, and standard deviations for morphometrical data on Centrarchidae: *Lepomis* sp.

	PROTOLARVAE MEAN ± SD	RANGE	N	MESOLARVAE MEAN ± SD	RANGE	N	METALARVAE MEAN ± SD	RANGE	N	JUVENILES MEAN ± SD	RANGE	N
SIZE - DISTANCE (mm)												
TL	5.3 ± 0.6	4.6 - 7.4	18	N/A	7.9	1	N/A	9.2	1	N/A	17.0	1
SL	5.1 ± 0.6	4.4 - 7.2	18	N/A	6.9	1	N/A	7.8	1	N/A	13.6	1
Ptnl L	2.9 ± 0.6	2.4 - 5.2	18	N/A	4.2	1	N/A	4.9	1	N/A	10.1	1
Prnl L	2.4 ± 0.2	2.2 - 2.7	18	N/A	3.7	1	N/A	4.3	1	N/A	6.9	1
HD	0.7 ± 0.1	0.6 - 0.8	11	N/A	1.2	1	N/A	1.5	1	-	-	1
HL	0.9 ± 0.2	0.8 - 1.9	18	N/A	1.6	1	N/A	2.0	1	N/A	4.0	1
LENGTHS (%TL)												
HL	18.0 ± 6.0	11.0 - 39.0	18	N/A	20.0	1	N/A	22.0	1	N/A	24.0	1
Prnl L	45.0 ± 4.0	30.0 - 48.0	18	N/A	47.0	1	N/A	47.0	1	N/A	41.0	1
DEPTHS (%TL)												
HD	13.0 ± 2.0	8.0 - 16.0	11	N/A	15.0	1	N/A	16.0	1	-	-	-
RELATIONSHIPS												
HD/HL (%)	74.0 ± 12.0	67.0 - 88.0	11	N/A	7.5	1	-	-	-	-	-	-
Prnl L/HL (#)	2.6 ± 0.4	1.2 - 3.0	18	N/A	2.3	1	N/A	2.2	1	N/A	1.7	1
Prnl L/Ptnl L (#)	0.8 ± 0.1	0.4 - 0.9	18	N/A	0.9	1	N/A	0.9	1	N/A	0.7	1
MYOMERES												
Preanal	13.0 ± 1.0	12.0 - 14.0	18	N/A	13.0	1	N/A	13.0	1	-	-	-
Postanal	16.0 ± 1.0	13.0 - 17.0	18	N/A	14.0	1	N/A	14.0	1	N/A	14.0	1
Total	29.0 ± 1.0	27.0 - 31.0	18	N/A	27.0	1	N/A	27.0	1	-	-	-

Table 19. Means, ranges, and standard deviations for morphometrical data on Centrarchidae: *Lepomis macrochirus.*

	PROTOLARVAE MEAN ± SD	RANGE	N	MESOLARVAE MEAN ± SD	RANGE	N	METALARVAE MEAN ± SD	RANGE	N	JUVENILES MEAN ± SD	RANGE	N
SIZE - DISTANCE (mm)												
TL	5.0 ± 0.5	4.4 - 5.4	3	None Identified			None Identified			N/A		
SL	4.8 ± 0.5	4.2 - 5.2	3									
Ptnl L	2.8 ± 0.5	2.3 - 3.2	3									
Prnl L	2.1 ± 0.1	2.1 - 2.2	3									
HD	0.7 ± 0.1	0.6 - 0.8	3									
HL	0.9 ± 0.1	0.8 - 1.0	3									
LENGTHS (%TL)												
HL	19.0 ± 1.0	18.0 - 20.0	3									
Prnl L	43.0 ± 4.0	41.0 - 48.0	3									
DEPTHS (%TL)												
HD	14.0 ± 1.0	14.0 - 15.0	3									
RELATIONSHIPS (%)												
HD/HL (%)	75.0 ± 5.0	70.0 - 80.0	3									
Prnl L/HL (%)	2.3 ± 0.3	2.1 - 2.6	3									
Prnl L/Ptnl L (%)	0.8 ± 0.1	0.6 - 0.9	3									
MYOMERES												
Preanal	12.0 ± 1.0	12.0 - 13.0	3									
Postanal	15.0 ± 0.0	15.0	3									
Total	27.0 ± 1.0	27.0 - 28.0	3									

Table 20. Means, ranges, and standard deviations for morphometrical data on Centrarchidae: *Promoxis* sp.

	PROTOLARVAE MEAN ± SD	RANGE	N	MESOLARVAE MEAN ± SD	RANGE	N	METALARVAE MEAN ± SD	RANGE	N	JUVENILES MEAN ± SD	RANGE	N
SIZE - DISTANCE (mm)												
TL	4.8 ± 0.4	4.4 - 6.2	32	12.7 ± 0.4	12.4 - 13.0	2	N/A			None Identified		
SL	4.6 ± 0.4	4.2 - 6.0	32	10.4 ± 0.3	10.2 - 10.6	2						
Ptnl L	2.8 ± 0.2	2.6 - 3.5	29	7.5 ± 0.4	7.2 - 7.8	2						
Prnl L	1.8 ± 0.1	1.6 - 2.1	29	N/A	5.2	2						
Egb D	0.7 ± 0.1	0.6 - 0.8	26	1.6 ± 0.3	1.4 - 1.8	2						
HL	0.9 ± 0.1	0.8 - 1.1	27	N/A	3.2	2						
LENGTHS (%TL)												
HL	19.0 ± 1.0	17.0 - 20.0	27	25.0 ± 1.0	25.0 - 26.0	2						
Egb D	14.0 ± 1.0	13.0 - 15.0	26	13.0 ± 1.0	11.0 - 14.0	2						
Prnl L	39.0 ± 1.0	36.0 - 43.0	29	41.0 ± 1.0	40.0 - 42.0	2						
RELATIONSHIPS												
Prnl L/HL (%)	2.1 ± 0.1	1.9 - 2.4	27	N/A	1.6	2						
Prnl L/Ptnl L (%)	0.6 ± 0.1	0.6 - 0.8	29	0.7 ± 0.0	0.7	2						
MYOMERES												
Preanal	11.0 ± 1.0	8.0 - 13.0	29	12.0 ± 1.0	11.0 - 13.0	2						
Postanal	20.0 ± 1.0	18.0 - 22.0	28	18.0 ± 1.0	18.0 - 19.0	2						
Total	32.0 ± 1.0	26.0 - 33.0	28	30.0 ± 2.0	29.0 - 32.0	2						

Table 21. Means, ranges and standard deviations for morphometrical data on Centrarchidae: *Pomoxis annularis*.

	PROTOLARVAE MEAN ± SD	RANGE	N	MESOLARVAE MEAN ± SD	RANGE	N	METALARVAE MEAN ± SD	RANGE	N	JUVENILES MEAN ± SD	RANGE	N
SIZE - DISTANCE (mm)												
TL	5.5 ± 0.9	4.4 - 8.0	91	9.0 ± 1.8	8.0 - 13.6	9	N/A	12.1	1	21.6 ± 3.6	18.4 - 26.8	6
SL	5.2 ± 0.8	4.0 - 7.3	87	8.4 ± 1.3	7.6 - 11.6	9	N/A	9.8	1	17.0 ± 2.5	14.8 - 20.5	6
Ptnl L	3.3 ± 0.5	2.1 - 4.6	86	5.5 ± 1.1	4.8 - 8.2	9	N/A	6.1	1	12.8 ± 2.4	10.4 - 16.2	6
Prnl L	2.1 ± 0.3	1.6 - 3.0	86	3.5 ± 0.7	3.1 - 5.4	9	N/A	6.0	1	8.8 ± 1.4	7.4 - 10.6	6
Egb D	0.9 ± 0.2	0.7 - 1.3	69	1.5 ± 0.4	1.0 - 2.4	9	N/A	2.4	1	-	-	
HL	1.0 ± 0.2	0.8 - 1.5	82	1.8 ± 0.5	1.5 - 3.2	9	N/A	3.8	1	5.8 ± 0.8	4.9 - 7.1	6
LENGTHS (%TL)												
HL	17.0 ± 6.0	16.0 - 29.0	91	20.0 ± 2.0	17.0 - 24.0	9	N/A	31.0	1	27.0 ± 2.0	24.0 - 30.0	6
Egb D	16.0 ± 1.0	15.0 - 19.0	91	17.0 ± 2.0	13.0 - 19.0	9	N/A	20.0	1	-	-	
Prnl L	39.0 ± 2.0	35.0 - 57.0	86	39.0 ± 2.0	36.0 - 42.0	9	N/A	50.0	1	41.0 ± 2.0	39.0 - 45.0	6
RELATIONSHIPS												
Prnl L/HL (#)	2.1 ± 0.1	1.6 - 2.4	82	1.9 ± 0.1	1.7 - 2.1	9	N/A	1.6	1	1.5 ± 0.1	1.5 - 1.7	6
Prnl L/Ptnl L (#)	0.7 ± 0.1	0.6 - 1.3	-	0.6 ± 0.0	0.6 - 0.7	9	N/A	1.0	1	0.7 ± 0.1	0.6 - 0.8	6
MYOMERES												
Preanal	12.0 ± 1.0	9.0 - 13.0	83	12.0 ± 0.0	11.0 - 12.0	9	N/A	11.0	1	13.0 ± 1.0	12.0 - 14.0	3
Postanal	20.0 ± 1.0	18.0 - 22.0	82	20.0 ± 1.0	19.0 - 22.0	9	N/A	19.0	1	19.0 ± 1.0	18.0 - 21.0	6
Total	31.0 ± 1.0	29.0 - 34.0	82	32.0 ± 1.0	30.0 - 34.0	9	N/A	30.0	1	32.0 ± 2.0	31.0 - 34.0	3

Table 22. Means, ranges, and standard deviations for morphometrical data on Percidae: *Percina* sp.

	PROTOLARVAE MEAN ± SD	RANGE	N	MESOLARVAE MEAN ± SD	RANGE	N	METALARVAE MEAN ± SD	RANGE	N	JUVENILES MEAN ± SD	RANGE	N
SIZE - DISTANCE (mm)												
TL	5.7 ± 0.2	5.6 - 6.2	9	N/A	11.4	1	None Identified			None Identified		
SL	5.5 ± 0.2	5.4 - 6.0	9	N/A	10.6	1						
Ptnl L	2.5 ± 0.1	2.4 - 2.8	9	N/A	4.9	1						
Prnl L	3.2 ± 0.1	3.0 - 3.4	9	N/A	6.5	1						
HL	0.8 ± 0.1	0.8 - 1.0	9	N/A	2.4	1						
LENGTHS (%TL)												
HL	15.0 ± 1.0	14.0 - 16.0	9	N/A	21.0	1						
Prnl L	56.0 ± 1.0	55.0 - 58.0	9	N/A	57.0	1						
RELATIONSHIPS (%)												
Prnl L/HL	3.8 ± 0.2	3.4 - 4.1	9	N/A	2.7	1						
Prnl L/Ptnl L	1.3 ± 0.1	1.2 - 1.4	9	N/A	1.3	1						
MYOMERES												
Preanal	21.0 ± 1.0	20.0 - 23.0	9	N/A	23.0	1						
Postanal	19.0 ± 2.0	17.0 - 22.0	9	N/A	16.0	1						
Total	40.0 ± 2.0	38.0 - 45.0	9	N/A	39.0	1						

DISCUSSION

Studies investigating the larval fish assemblages for lotic and reservoir/riverine systems of a large size, such as the Missouri Rivers, have been reported (Walberg 1971; Gallagher and Conner 1980). These studies were complicated; however, by extra-riverine inputs to these large systems. The present study characterized an annual middle Neosho River larval fish population, relatively free from extra-riverine inputs, in a comprehensive manner. Larval fish patterns observed in this study permit separation of larvae produced above, originating in, and produced downstream of John Redmond Reservoir (JRR).

Although no significant difference was found through AOV testing between the total mean larval fish concentrations at the three locations (including JRR diurnal and nocturnal data), some statements about the Neosho River/JRR larval fish populations can be made.

The larval fish complement of the Neosho River/JRR system was characterized as one which was dominated by *Dorosoma cepedianum,* except at Location 2 where *D. cepedianum* and Catostomidae larvae were co-dominants. A limited number of other families were noteworthy, although of diminished importance compared to shad and suckers, including the Location 2 Cyprinidae, Location 1 Sciaenidae and Centrarchidae, and Sciaenidae at Location 3. More detailed discussions of Neosho River/JRR larval fish are provided by location as follows:

Location 2: Hartford

The larval fish data from this location characterized the allochthonous input to JRR from the Neosho River. The larval drift at Location 2 was dominated nearly equally by Catostomidae and Clupeidae. The only other family represented at levels above 0.3% of absolute abundance was Cyprinidae at 2.1%.

The Catostomidae component of the assemblage was dominated by the *Ictiobus* taxa which occurred in numbers on five dates. Larvae of these *Ictiobus* taxa comprised a source of individuals for recruitment in this commercially important genus. Ictiobinae larvae, thought to be *Carpiodes carpio,* were present in lower concentrations for a four week period. These larvae also represented a source of potentially recruitable individuals, although in this case for river carpsucker, an undesirable rough fish. The Catostomidae drift was also of interest due to the lack of *Moxostoma* and *Cycleptus* larvae. Delayed initiation of sampling

possibly explained the absence of *Cycleptus* larvae but the lack of *Moxostoma* in the drift was not explained by study methodology.

Gizzard shad were an early and continuing component of the Hartford drift. Shad larvae were also eligible for recruitment but these fish were entering a lake which JRR release data indicated already had a population. Low shad concentrations leaving JRR (20-25/100m^3), however, might indicate river spawning shad were giving their young an edge over lake spawned larvae which increased two weeks later.

Cyprinidae larvae were represented primarily by *Cyprinus carpio* which occurred from late May though early July. Common carp entering JRR represent an undesirable input of recruitable rough fish. Cyprinidae larvae, thought to be *Phenacobius,* was the only other minnow present in numbers.

The game fish component was comprised solely of *Ictalurus punctatus,* which was present on only one date. No other gamefish were collected at Hartford, although both *Morone chrysops* and *Pomoxis annularis* were expected. No explanation for the lack of larvae of these two species was offered, since the young of both should have been present during the collection period.

Location 1: John Redmond Reservoir Tailwaters

The composition of Location 1 larval fish data was representative of ichthyoplankton losses from JRR and production in the immediate tailwaters area. The diurnal larval fish drift at this location was dominated by shad originating in JRR. Also occurring were Cyprinidae larvae, principally *Notropis* sp. thought to be *buchanani,* which probably were produced in the tailwaters. The gamefish portion of the diurnal larval fish population was represented by *Morone chrysops,* which occurred in low numbers, and two *Pomoxis* taxa which were present sporadically in low numbers. *Dorosoma cepedianum* was also the main component of the nocturnal complement, although Sciaenidae and Cyprinidae occurred in low percentages. The nocturnal gamefish drift was limted to four varieties, *Ictalurus punctatus, M. chrysops, Pomoxis* taxa, and Percidae thought to be *Stizostedion,* which all occurred in low concentrations.

No significant difference was found between total mean daily diurnal and nocturnal concentrations when the student $t_{0.05}$ test was performed. However, variability in diurnal/nocturnal numbers did occur. For the majority of JRR taxa, diurnally collected larvae were fewer in number than those nocturnally collected. The relationship of higher nocturnal numbers was most apparent for *D.*

cepedianum, Cyprinus carpio, Ictiobinae thought to be *Ictiobus, M. chyrsops,* and *Aplodinotus grunniens.* Only *Notropis* sp. and *Notropis* sp. (thought to be *buchanani*) exhibited distinctly higher diurnal numbers than nocturnal values.

The large numbers of shad entering the Neosho River at this point was of interest due to the lack of habitat available to this population. The limited size of the Neosho and the limited duration of survival for early life stage fish under stress conditions certainly resulted in high mortality of discharged shad larvae.

The Catostomidae taxa collected at Location 1 included those found at Location 2 except for Ictiobinae thought to be *Carpiodes carpio.* The lack of river carpsucker larvae was not expected, since this species is a common component of the adult fish population at this location (Bliss 1978, 1979, 1980). The presence of three other taxa was also noteworthy. Cyprinodontidae thought to be *Fundulus notatus, Labidesthes sicculus,* and Percidae thought to be *Stizostedion,* were taxa collected which had not been previously identified in Neosho River larval fish studies (Bliss 1978, 1979, 1980).

Location 3: Burlington

The larval fish complement of this location was reflective of both JRR releases and riverine reproduction. The generally similar concentrations and catch periods for most taxa to JRR data was supportive of this position. Although *Dorosoma cepedianum* was still the dominant taxa at this location, it dominated less than at Location 1. Centrarchidae and Sciaenidae were other important families at this location.

Centrarchidae larvae collected included *Lepomis* sp., *Micropterus* sp., and *Pomoxis* taxa. The two *Pomoxis* taxa, *Pomoxis* sp. and *Pomoxis annularis* were the second most abundant larvae at this location. However, *Pomoxis* taxa exhibited an earlier occurrence and higher densities than at JRR. These two factors would indicate *Pomoxis* production in the Neosho downstream of Location 1 in the "lake" formed by the Burlington city dam. The existence of production from this area provided a source of recruitable individuals to bolster the downstream and JRR tailwaters fisheries. Production in this area would probably be most beneficial during periods of low flow when *Pomoxis* losses from JRR were minimal. This position was supported by catches of *Notropis* sp., *Notropis* sp. thought to be *buchanani,* and *Morone chrysops* which present evidence that this area was an effective nursery.

The lack of Catostomidae larvae was somewhat contradictory to the previous discussion until the life history of the suckers was considered. Catostomidae larvae, as a group, tend to move to backwaters, oxbows, and tributaries during middle development stages.

Morphological Basis for Identification

Identifications for larval fish are contingent on ratios, percentages, and numbers of certain features. Although the relationships of these structures are diagnostic, questions can still persist due to regional variations (Conner 1979). Fourteen of the 30 taxa identified in this study were morphometrically analyzed in sufficient numbers to permit statistical analysis or represented information useful enough to warrant inclusion. The presentation of these 14 tables (Tables 9 through 22) of morphological data serves to document regional variations and/or demonstrates areas requiring additional study for the taxa included.

As noted earlier in this paper, data for *Dorosoma cepedianum, Morone chrysops,* and *Aplodinotus grunniens* were not included in tabular form because of the distinctive, well documented morphologies of these species. Several other taxa occurred in insufficient numbers for presentation in tabular form and these taxa were discussed in the text. The relationship of data collected in this study with data in the literature, along with the rationale for assignments made, was provided for most taxa by family in the following discussion.

Lepisosteidae

Collections of this family were limited to two individuals, both from Location 2. Both presented distinctive morphologies which simplified identification, including heterocercal tail, elongated snout, and narrow head. Hogue et al. (1976) identified *Lepisosteus* sp. as possessing 39-44 preanal myomeres and 11-16 postanal myomeres. The single individual which could be meristically counted possessed 15 postanal myomeres.

Clupeidae

Gizzard shad was the sole representative of this family in the study area and was the most commonly collected taxa in this study. Morphological data were not collected for this species because of its distinctive appearance (Hogue et al. 1976).

Cyprinidae

Cyprinus carpio

Common carp larvae presented a distinctive appearance in the form of a "Y" of melanophores running laterally to the area anterior to the gill arches. Hogue et al. (1976) and Snyder (1981b) presented morphometrical descriptions of this species. The data collected in this study (Table 9) compared favorably with Snyder (1981b) except for a slightly larger range for some features. The *C. carpio* data in Table 9 also compared favorably to Hogue et al. (1976) and Conner et al. (1980).

Notemigonus crysoleucas

This species was represented by a single individual collected at Burlington. Identification was based on the unique double row of ventral melanophores (Faber 1980 and Buynak and Mohr 1980).

Notropis sp.

The larvae assigned to this taxon fell into the *Notropis* genus by general characteristics. Head length (HL) and Prnl L (% TL) exhibited wider ranges but were generally close to *Notropis lutrensis* data provided by Snyder (1981b). Myomere counts for this taxa from this study (Table 10) were also nearly identical to Snyder's *N. lutrensis* data. While it might be reasonable to place the *N. lutrensis* label on these fish based on this comparison, the *Notropis* sp. was retained due to possible intermixing of other species and lack of specific references. These other species, particularly *N. stramineus* possibly present at Hartford, accounted for the wider ranges observed for some features.

Notropis sp. thought to be *buchanani*

Hogue et al. (1976) identified a Cyprinidae group c which contained "postlarvae" having 19-20 preanal myomeres and 13-14 postanal myomeres. Pigmentation in this group was sparse, restricted dorsally to a few melanophores on the head and the bases of dorsal and caudal fins, as well as a single ventral row of melanophores extending posterior behind the anus on either side of the anal fin, then merging to a single row continuing to the caudal fin. The eye was round in group c and the anal fin had eight rays. Hogue identified *N. volucellus* and *N. buchanani* as possible members of this group.

Protolarval and mesolarval preanal myomere data in this taxon were higher than cited by Hogue; however, metalarval and juvenile

preanal myomere counts matched very closely (Table 11). Postanal myomere counts compared favorably with Hogue group c data, although slightly lower, and total myomere data were similar, although somewhat higher.

Despite some variability in the meristical data *Notropis* sp. were placed in this taxon based on three main points. Larvae in this taxon had round eyes, exhibited the distinctive pigmentation pattern described by Hogue, and possessed eight anal rays in later stages. The common occurrence of *N. buchanani* at Location 1 (Bliss 1978, 1979, 1980), the lack of *N. volucellus,* and the distinctly different morphology from *Notropis* sp. also supported the assignment of this label to these larvae.

Cyprinidae thought to be *Phenacobius*

Larvae of this taxon were identified from Hartford on only one date. The appearance of these larvae bore a striking resemblance to Hogue unidentified Cyprinidae group a, except the postanal myomere count was slightly low (Table 12). Group a was thought by Hogue to contain the stargazing minnows *(Phenacobius uranops).*

The assignment of these larvae to this taxon was based on the elliptical eyes, sub-terminal mouth, and a double row of pigment ventrally. Although *P. uranops,* did not occur in the study area, the group a description was thought adequate for the taxon assignment made based on similarities within other genera cited in the literature.

Cyprinidae thought to be *Pimephales*

The assignment of *Pimephales* to larvae in this group was based on the similarity of these fish to Hogue Cyprinidae group b, including club shaped yolk, elliptical eye, and pigmented yolk. Also, meristics data (Table 13) were very similar to the values cited by Hogue for *P. promelas.*

Catostomidae

Ictiobinae thought to be *Carpiodes carpio* and Ictiobinae thought to be *Ictiobus*

The assignment of the subfamily Ictiobinae to the Catostomidae larvae of the above taxa was made with confidence. As summarized by Fuiman (1979), the family Catostomidae consists of three subfamilies described by Miller (1958); Cycleptinae; Ictiobinae, and Catostominae. Cycleptinae was represented as a

naturally occurring species by only *Cycleptus elongatus*. This taxon exhibits a distinctive morphology (Conner et al. 1980), and was not collected in 1981. The subfamily Catostominae was represented by three or four *Moxostoma* species in the study area. The preanal myomere counts for all *Moxostoma* sp. (Fuiman 1979, Fuiman and Whitman 1979, and Snyder 1979) exceed the mean values for both Ictiobinae taxa described in this study. The assignment of the subfamily Ictiobinae was therefore made.

The differentiation of *Carpiodes carpio* and *Ictiobus* early phases were not made as confidently, though. All morphometrical data were essentially identical (Tables 14 and 15); however, differentiation of these two taxa was made through the identification features described by Yaeger and Baker (1982). These features included the complete overlap of myomere counts, elliptical eye and flattening of the head in *C. carpio* larvae (>8.0 mm), and the typically more diffuse midlateral line of melanophores on early protolarvae *C. carpio* larvae (<8.0 mm).

Ictiobus sp.

This taxon was identifiable with certainty only in metalarval and juvenile fish (Table 16) and was defined by characteristics of Yaeger and Baker (1981).

Ictiobus thought to be *bubalus*

This taxon was represented by a single individual. The assignment was tentative, as described by Yaeger and Baker (1982), but was made based on the complete formation of the hypural complex at 10.5 mm TL. In *Ictiobus cyprinellus,* the hypural complex was only evident at 10.5 mm TL and completely formed at 13.0 mm TL.

Ictiobus thought to be *cyprinellus*

A single juvenile buffalofish was the sole representative of this taxon. Assignment to this taxon was made by features prominent at 28.9 mm TL, particularly the terminal mouth.

Ictaluridae

Ictalurus punctatus

This species was present as readily identifiable individuals due to the distinctive notched caudal fin. No morphometrical data were compiled for this taxon.

Noturus sp.

Two individuals in poor condition represented this taxon at Location 2 on 31 July. These individuals were a metalarva and a juvenile which exhibited the overhung snout and slightly notched adipose fin of the *Noturus* genus. The poor condition of these fish precluded identification to species but they were not believed to be *N. placidus,* and were possibly *N. flavus.*

Cyprinodontidae

Fundulus notatus

This family was represented by a single larva, thought to be *Fundulus notatus.* Assignment to this taxon was based on the description of Jones and Tabery (1980) for *Fundulus diaphanus.* Data collected on this fish closely compared with morphometrical values provided for *F. diaphanus.*

Atherinidae

Labidesthes sicculus

Larvae of this species presented a unique morphology not easily confused with any other taxon found in the study area. Morophometrical data for this taxon (Table 17) compared favorably with values cited by Rassmussen (1980) for this species in Florida.

Percichthyidae

Morone chrysops

Although this species was a common component of the larval assemblage in the study area, morphometrical data for it were not compiled.

Centrarchidae

Lepomis sp.

Larval fish were assigned to this genus primarily by postanal myomere counts in the range of 14-18 (Conner 1979). Secondarily, larvae assigned here did not have head depth (HD % TL) values which clearly fell into one of the Conner (1979) types (Table 18). The lack of additional segregation within this taxon was to be expected since as stated by Conner "many traditional characters that have been used to diagnose sunfish larvae are very environmental-

ly plastic." Further differentiation of *Lepomis* sp. larvae would require extensive study to verify the validity of data presented for the various "types" in relation to Kansas populations.

Lepomis sp. thought to be *cyanellus*

Only two individuals were assigned to this taxon. In both cases the individuals were collected from Hartford and had HD (% TL) values clearly within the range cited by Conner (1979) for *Lepomis cyanellus*. These assignments must be qualified in view of factors affecting sunfish identification, as previously mentioned.

Lepomis macrochirus

The three larvae classified as bluegill exhibited HD (% TL) values which clearly fell within Conner (1979) bluegill type (Table 19). The qualifications cited above also applied to this taxon.

Micropterus sp.

The single metalarva in this taxon clearly fits the *Micropterus* description of Conner (1979). A postanal myomere count of ≤ 17 and the dark mid-lateral band of pigment provided conclusive identification.

Pomoxis sp. and *Pomoxis annularis*

The assignment of larvae to the genus *Pomoxis* was made per Conner (1979) by a postanal myomere count of >19 and the morphological similarity of two fish which had a count of 18. Conner cited the inclusion of individuals having 18 postanal myomeres in *Pomoxis* by Hogue et al. (1976), as causing misidentification of *Lepomis* larvae. However, no *Lepomis* larvae enumerated in this study had >17 postanal myomeres and the sole *Micropterus* had a count of 16. These data indicated that *Pomoxis* protolarvae and mesolarvae within the study area occassionally included individuals with 18 postanal myomeres (Tables 20 and 21) contrary to Conner (1979) which stated only mesolarvae through juvenile *Pomoxis* had 18.

Chatry and Conner (1980) identified the EgbD (% TL) as the method of segregating *P. annularis* from *P. nigromaculatus* larval fish. Specifically, EgbD (% TL) of $<15.0\%$ in larvae <13.0 mm TL was cited for *P. nigromaculatus* larvae while values $>15.0\%$ were given as diagnostic for *P. annularis* (Figures 9 and 10).

The differentiation of *Pomoxis* sp. versus *Pomoxis annularis* was made in the lab at the time of identification through the use of a hand calculator. Differences in hand calculational rounding off and computer calculations resulted in larvae with eye-gas bladder distance (Egbd % TL) values of 15% falling in both *Pomoxis* sp. and *Pomoxis annularis* (Tables 20 and 21).

This situation created confusion in relation to the proper label for *Pomoxis* larvae and was further complicated by the fact that *P. nigromaculatus* adults were not collected in the Neosho River in 1981 (King 1981) and also were not collected in the three years previous to 1981 (Bliss 1978, 1979, 1980).

Although *P. nigromaculatus* occurred in the Neosho and was occasionally caught by anglers, evidence would indicate that all 1981 *Pomoxis* larvae were *P. annularis*. Given this conclusion, the 15% value found by Chatry and Conner (1980) for segregation of these two species should be used with caution in the study area.

Percidae

Percina sp.

Percina larvae identified in this study fit both the general description of Hogue et al. (1976) group b, which included *Percina caprodes*, and the *Percina caprodes* data presented by Cooper (1978). These *Percina* larvae did not fit the general *Estheostoma blennioides* description of Baker (1979).

Diagnostic features for these larvae included an overall slender appearance, prominent anterior oil globule, and small head (Figure 1). The small head was particularly useful in the separation of *Percina* from *Etheostoma* and *Stizostedion* larvae.

Percidae thought to be *Stizostedion*

One individual Percidae larva was collected early in the study which did not fit the *Percina* description of Cooper (1978), the Percidae group b of Hogue et al. (1976), or the Baker (1979) *Etheostoma blennioides* description. The large size at collection, HL/TL ratio of <3.0, and large head placed this larva in Percidae thought to be *Stizostedion*.

Sciaenidae

Aplodinotus grunniens

Data on the morphological features of the freshwater drum were not collated due to the distinctive characteristics of this species.

SUMMARY

The 1981 larval fish assemblage of the Neosho River, above and below John Redmond Reservoir (JRR), in Coffey County was described. Morphometrical data were compiled for selected taxa and were compared to published accounts.

1. A total of 27,905 eggs, larvae, and juvenile fish representing 11 families and 30 taxa was collected from the three locations sampled.

2. Nocturnal efforts at Location 2: Hartford resulted in the collection of 2,499 eggs, 2,330 larvae, and eight juvenile fish from seven families and 18 taxa. Members of the families Catostomidae and Clupeidae dominated the larval fish drift at this location. Larval fish densities ranged from a minimum of none on 21 May to a maximum of 1246.7/100mm^3 on 28 May.

3. Diurnal and nocturnal efforts at Location 1: JRR tailwaters resulted in the collection of one egg, 6,773 larvae, and 1,195 juvenile fish representing 21 taxa from ten families. Thirteen taxa were collected diurnally, while 19 were present nocturnally. Most taxa were collected in higher densities nocturnally, except for the *Notropis* taxa of the family Cyprinidae. *Dorosoma cepedianum* dominated the drift of both collection periods, comprising 98.0% and 95.2% of the annual relative abundance respectively. Both diurnal and nocturnal densities reached peak levels near 5,000/100m^3 on 13 June.

4. Larval fish were collected at Location 3: Burlington on all sampling dates. No eggs, 2,525 larvae, and 593 juvenile fish from 14 taxa representing seven families were collected at this location. *Dorosoma cepedianum* also dominated the annual relative abundance at Burlington, comprising 81.4%, but other important families included Centrarchidae at 10.1% and Sciaenidae at 6.4%. Larval fish concentrations varied from 6.3/100m^3 on 18 July to 1766.4/100m^3 on 19 June.

5. The larval fish populations identified represent the allochthonus input into JRR at Hartford; at JRR tailwaters they generally characterized those fish released from the reservoir, and at Burlington these data represented both releases from JRR and production in the area below the impoundment.

6. Morphometrical data were presented in tabular form for 14 taxa. These data generally compared favorably with published taxon accounts thereby supporting taxonomic assignments made.

Literature Cited

Baker, J.M. 1979. Larval development of the greenside darter, *Etheostoma blennioides newmanii*. Pages 70-91. *in* R.D. Hoyt (Editor). Proceedings of the third symposium on larval fish. West. Kent. Univ. Dept. of Biol. p. 236.

Bliss, Q.P. 1978. Fisheries study. Pages 139-167. *in* Final report of construction environmental monitoring program, Wolf Creek Generating Station. March, 1977-February, 1978. Report by Nalco Environmental Sciences for Kansas Gas and Electric Company, Wichita, KS.

Bliss, Q.P. 1979. Fisheries study. Pages 132-164. *in* Final report of construction environmental monitoring program, Wolf Creek Generating Station. March, 1978-February, 1979. Report by Hazleton Environmental Sciences for Kansas Gas and Electric Company, Wichita, KS.

Bliss, Q.P. 1980. Fisheries study. Pages 116-147. *in* Final report of construction environmental monitoring program, Wolf Creek Generating Station. March, 1979-February, 1980. Report by Hazleton Environmental Sciences for Kansas Gas and Electric Company, Wichita, KS.

Buynak, G.L. and H.W. Mohr, Jr. 1980. Larval development of golden shiner and comely shiner from northeastern Pennsylvania. Prog. Fish-Cult. 42(4):206-211.

Cada, G.F. and G.L. Hergenrader. 1980. Natural mortality rates of freshwater drum larvae in the Missouri River. Trans. Amer. Fish Soc. 109:479-483.

Chatry, M.F. and J.V. Conner. 1980. Comparative developmental morphology of the crappies, *Pomoxis annularis* and *Pomoxis nigromaculatus*. Pages 45-47. *in* L.A. Fuiman (Editor). Proceedings of the fourth annual larval fish conference. U.S. Fish Wildl. Serv. FWS/OBS 80/43. Wash. D.C. p. 179.

Conner, J.V. 1979. Identification of larval sunfishes (Centrarchidae, Elassomatidae) from southern Louisiana. Pages 17-52. *in* R.D. Hoyt (Editor). Proceedings of the third symposium on larval fish. West. Kent. Univ. Dept. of Biol. p. 236.

Conner, J.V., R.P. Gallagher, and M.F. Chatry. 1980. Larval evidence for natural reproduction of the grass carp *(Ctenopharyngodon idella)* in the lower Mississippi River. Pages 1-19. *in* L.A. Fuiman (Editor). Proceedings of the fourth annual larval fish conference. U.S. Fish Wildl. Serv., FWS/OBS-80/43. Wash. D.C. p. 179.

Cooper, J.E. 1978. Eggs and larvae of the logperch, *Percina caprodes* (Rafinesque). Amer. Midl. Nat. 99(2):257-269.

Faber, D.J. 1980. Observations on the early life of the golden shiner, *Notemigonus crysoleucas* (Mitchell), in Lac Heney, Quebec. Pages 69-78. *in* L.A. Fuiman (Editor). Proceedings of the fourth annual larval fish conference. U.S. Fish Wild. Serv., FWS/OBS-80/43. Wash. D.C. p. 179.

Fish, M.P. 1932. Contributions to the early life histories of sixty-two species of fishes from Lake Erie and its tributary waters. U.S. Bur. Fish., Bull. 47:293-398.

Fuiman, L.A. 1979. Descriptions and comparisons of catostomid fish larvae: Northern Atlantic drainage species. Tans. Amer. Fish. Soc. 108:560-603.

Fuiman, L.A. and D.C. Witman. 1979. Descriptions and comparisons of catostomid fish larvae: *Catostomus catostomus* and *Moxostoma erythrurum*. Trans. Amer. Fish. Soc. 108:604-619.

Gallagher, R.P. and J.V. Conner. 1980. Spatio-temporal distribution of ichthyoplankton in the lower Mississippi River. Pages 101-115. *in* L.A. Fuiman (Editor). Proceedings of the fourth annual larval fish conference. U.S. Fish Wild. Ser. FWS/OBS-80/43. Wash. D.C. p. 179.

Hogue, J.J., Jr., R. Wallus, and L.K. Kay. 1976. Preliminary guide to the identification of larval fishes in the Tennessee River. Tech. Note B19, Tenn. Valley Auth., Norris, Tenn. p. 67.

Hoyt, R.D., G.J. Overmann, and G.A. Kindschi. 1979. Observations on the larval ecology of the smallmouth buffalo. Pages 1-16. *in* R.D. Hoyt (Editor). Proceedings of the third symposium on larval fish. West. Kent. Univ. Dept. Biol. p. 236.

Hubbs, C.L. 1943. Terminology of early stages of fishes. Copeia 1943(4):260.

Jones, G.G. and M.A. Tabery. 1980. Larval development of the banded killifish *(Fundulus diaphanus)* with notes on the distribution in the Hudson River estuary. Pages 25-35. *in* L.A. Fuiman (Editor). Proceedings of the fourth annual larval fish conference. U.S. Fish Wildl. Serv., FWS/OBS-80/43. Wash. D.C. p. 179.

Kindschi, G.A., R.D. Hoyt, and G.J. Overmann. 1979. Some aspects of the ecology of larval fishes in Rough River Lake, Kentucky. Pages 139-168. *in* R.D. Hoyt (Editor). Proceedings of the third symposium on larval fish. West. Kent. Univ. Dept. of Biol. p. 236.

King, R.G. 1981. Fisheries Study. Pages 7.1-7.34. *in* Final report of construction environmental monitoring program, Wolf Creek Generating Station. March 1980-February 1981. Report by Ecological Analysts, Inc. for Kansas Gas and Electric Company, Wichita, KS.

Mansueti, A.J. and J.D. Hardy, Jr. 1967. Development of the fishes of the Chesapeake Bay region, an atlas of egg, larval, and juvenile stages. Part 1. Univ. of Maryland, Nat. Resour. Inst. p. 202.

Martin, D.B., L.J. Mangel, J.F. Novotry, and C.H. Walburg. 1981. Spring and summer water levels in a Missouri River reservoir: effects on age-0 fish and zooplankton. Trans. Amer. Fish. Soc. 110:370-381.

May, E.B. and C.R. Gasaway. 1967. A preliminary key to the identification of larval fishes of Oklahoma, with particular reference to Canton Reservoir, including a selected bibliography. Okla. Fish. Res. Lab. Bull. No. 5. p. 42.

Miller, R.R. 1958. Origin and affinities of the freshwater fish fauna of western North America. Pages 187-222 *in* C.L. Hubbs (Editor). Zoogeography. Amer. Assoc. for the Advancement of Sci. Publ. 51.

Potter, W.A., K.L. Dickson, and L.A. Nielson. 1978. Larval sport fish drift in the New River. Pages 672-679. *in* R.W. Dimmick (Editor), Proceedings of the thirty-second annual conference southeastern association of fish and wildlife agencies. p. 854.

Rassmussen, R.P. 1980. Egg and larva development of brook silversides from Peace River, Florida. Trans. Amer. Fish. Soc. 109:407-416.

Siefert, R.E. 1969. Characteristics for separation of white and black crappie larvae. Trans. Amer. Fish. Soc. 98:326-328.

Snyder, D.E. 1976. Terminologies for intervals of larval fish development. Pages 41-60. *in* J. Boreman (Editor). Great lakes fish egg and larvae identification. Proceedings of a workshop. U.S. Fish Wildl. Serv., Natl. Power Plant Team, Ann Arbor, Mich. FWS/OBS-76/23. p. 220.

Snyder, D.E. 1979. Myomere and vertebrae counts of the North American cyprinids and catostomids. Pages 53-69. *in* R.D. Hoyt (Editor). Proceedings of the third symposium on larval fish. West. Kent. Univ. Dept. of Biol. p. 236.

Snyder, D.E. 1981a. Early life history terminology: Snyder terminology clarified. Amer. Fish. Soc. Early Life Hist. Sect. Newsletter. 2(1):11-14.

Snyder, D.E. 1981b. Contributions to a guide to the cypriniform fish larvae of the Upper Colorado River system in Colorado. Biol. Series 3. U.S. Bur. of Land Mgt. p. 81.

Tabor, C.A. 1969. The distribution and identification of larval fishes in the Buncombe Creek arm of Lake Texoma, with observations on spawning habitats and relative abundance. Unpubl. Ph.D. Thesis, Univ. Okla. Norman. p. 120.

Tarplee, W.H., Jr., W.T. Bronson, and R.G. Sherfinshi. 1979. Portable push-net apparatus for sampling ichthyoplankton. Prog. Fish-Cult. 41(4):213-215.

Titcomb, J.W. 1910. Fish-cultural practices in the United States. Bureau of Fisheries. Bull. U.S. Bur. Fish. 28(2):697-757.

Walberg, C.H. 1971. Loss of young fish in reservoir discharge and year-class survival, Lewis and Clark Lake, Missouri River. Pages 441-448 *in* G.E. Hall (Editor). Reservoir Fisheries and Limnology. Amer. Fish. Soc. Spec. Publ. 8.

Yeager, B.L. and J.M. Baker. 1982. Early development of the genus *Ictiobus* (Catostomidae). Pages 63-69. *in* C.F. Bryan, J.V. Conner, and J.M. Truesdale (Editors). The fifth annual larval fish conference. La. Coop. Fish. Res. Unit and Sch. of For. Wildl. Mgt. p. 86.