AN ABSTRACT OF THE THESIS OF

Greg R. Wedd for the Master of Science Degree

in Biology presented on 14 May 1983

Title: Neosho River Larval Fish in Coffey County

Abstract approved: _Robert J Clarke_

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 fam-
ilies Catostomidae (48.5%) and Clupeidae (48.3%) dominated
the assemblage at Hartford whereas Clupeidae was solely dom-
inant at both John Redmond (98.0% diurnally and 95.2% noc-
turnally) and Burlington, although to a lesser degree at
Burlington (81.4%). Larval fish densities at Hartford
peaked at $1246.7/100m^3$ on 28 May while maximum densities for
both diurnal and nocturnal John Redmond collections peaked
at over $5000/100m^3$ on 13 June, and the maximum level at
Burlington occurred at $1766.4/100m^3$ on 19 June. No statis-
tically significant differences were found in mean daily
total concentrations or day/night John Redmond data. Morph-
ological data were compiled and are presented in tabular
form for 14 taxa. These data generally compare favorably
with published accounts, thereby supporting taxonomic
assignments made and documenting regional variation. The

<u>Pomoxis</u> larvae identified had eye-gas bladder distances (as % total length) from 13 to 19, although <u>Pomoxis</u> <u>annularis</u> was the sole representative of this genus in the study area.

NEOSHO RIVER LARVAL FISH

IN COFFEY COUNTY

A Thesis

Submitted to

The Division of Biological Sciences

Emporia State University

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

by

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May, 1983

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434955

ACKNOWLEDGEMENTS

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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 stages. 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 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). Pre-
liminary 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 methods of collection for lar-
val 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 zoo-
plankton 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 stages 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.

Throughout the infancy of fish early life history studies, a variety of classification systems for developmental stages 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.

UROSTYLE

MYOMERE

YOLK

AUDITORY
VESSICLE

GRW

MEDIAN
FINFOLD

VENT
(ANUS)

OIL
GLOBULE

CLEITHRUM
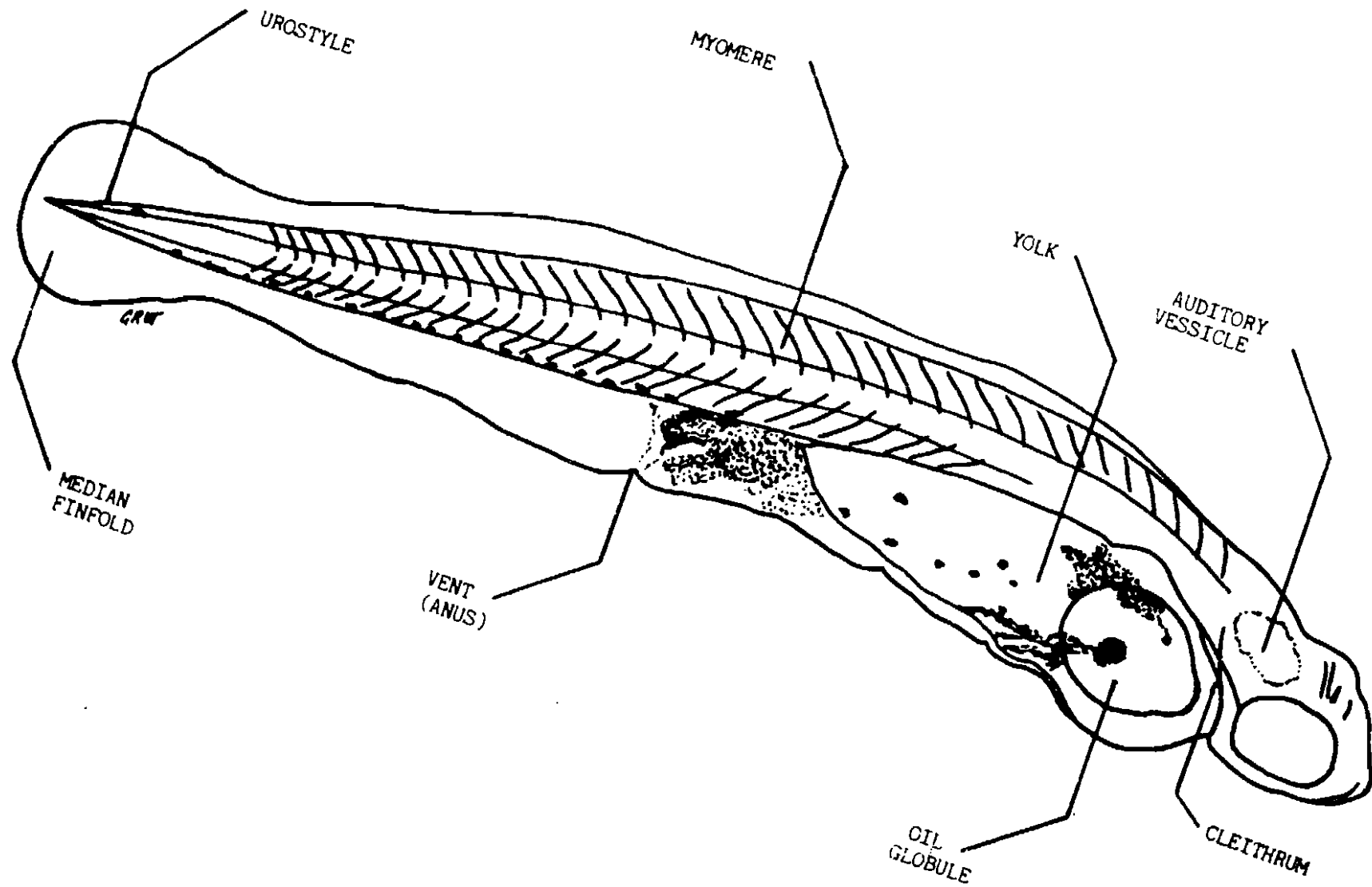
Not until the late seventies were attempts made to standardize terminology. Snyder (1976) proposed a system which minimized the importance of the presence of yolk material and classed larvae as protolarvae, mesolarvae, metalarvae or juveniles. With the advent of the most recent systems and efforts by 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 1979a; 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 (1979a), 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 h 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 (Figure 3). The river at this location varies in

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

Location 2

Neosho River

Hartford

Highway 75

New Strawn

John Redmond
Reservoir

Location 1

Scale
of Miles

1   0   1   2

Location 3

FAS 10

Burlington
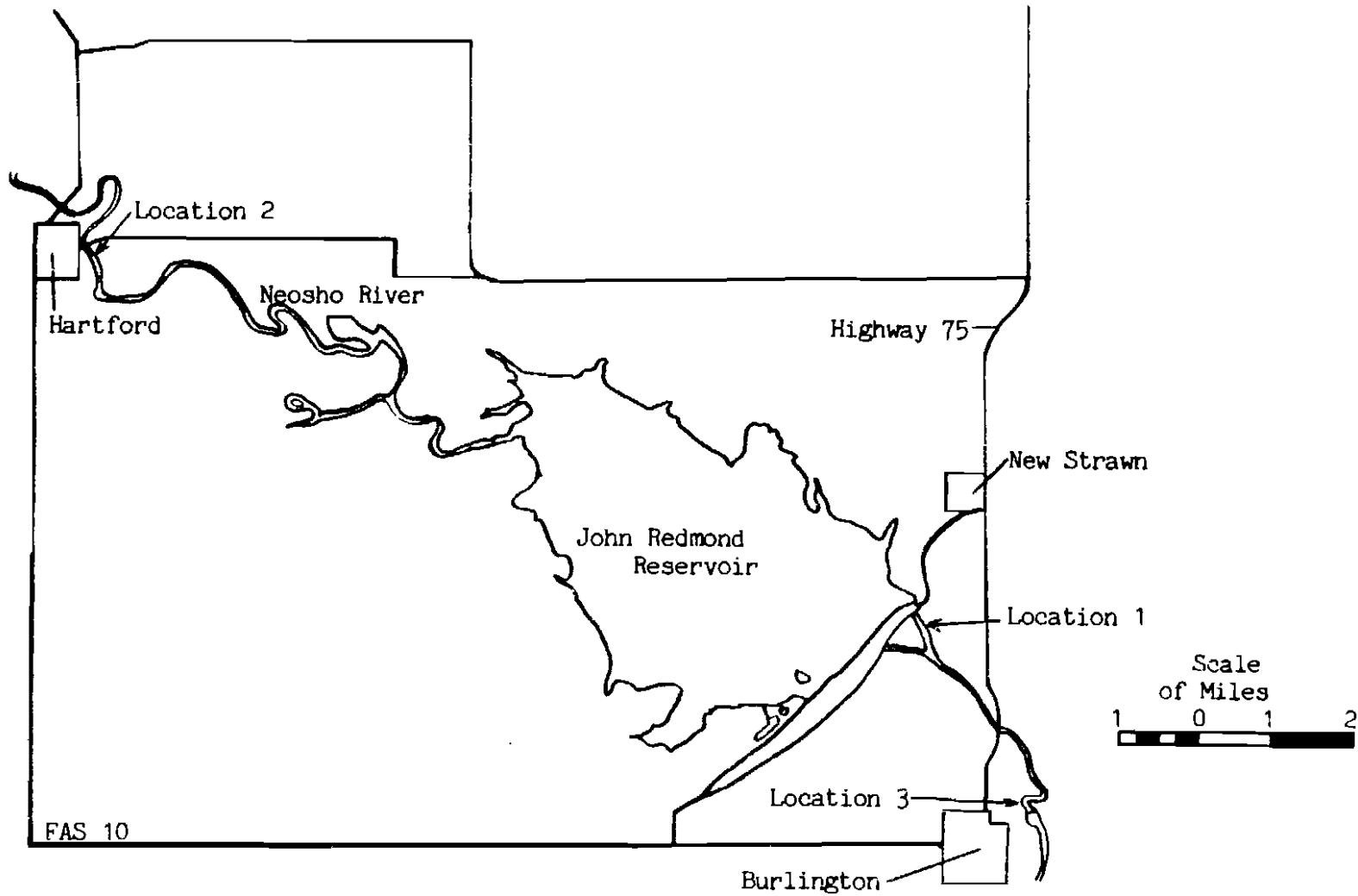
Figure 3. Location 2: Hartford looking upstream to the northwest.

width from 30 to 40 m with a mud, gravel, and rubble bottom and steep mud banks. Location 2 is in the area where the Neosho is transformed 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 (Figure 4). 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 of 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 (Figure 5). The river at this point pools upstream of the dam and, during low flow, formed a small impoundment. Periods of high flow result in complete overtopping of the dam and a corresponding loss of quiescent conditions. The bottom at this location was bedrock covered by thick muck.

Physical Conditions

The middle Neosho River drainage had experienced a moderate drought during the latter part of the year preceeding

Figure 4. Location 1: John Redmond Reservoir tailwaters looking upstream to the north.

Figure 4. Location 1: John Redmond Reservoir tailwaters looking upstream to the north.
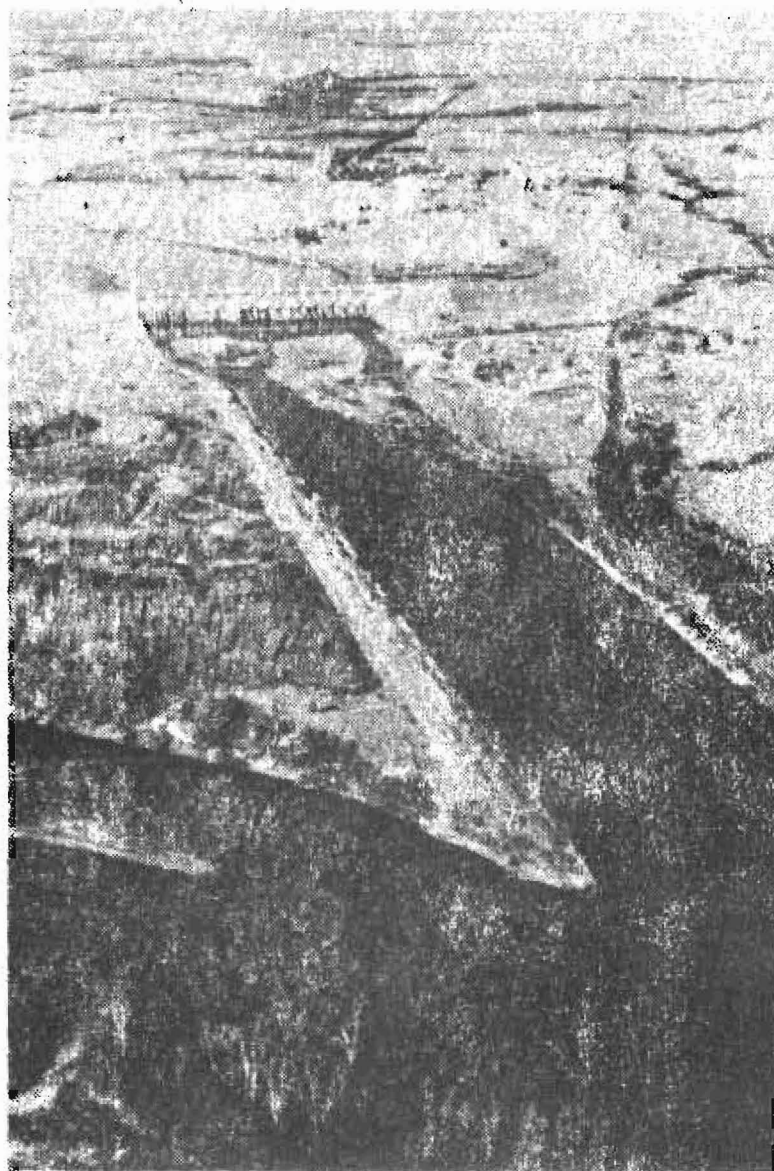
Figure 5. Location 3: Burlington city dam looking upstream to the north.

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 6).

The flow pattern of the Neosho River in the study area can be characterized as a four month period of reduced flows, followed by a three-five-fold flow increase in June which lasted through July, and normal to slightly above 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 30 cfs during the first 16 weeks of 1981. Inflows increased in the second half of May and peaked in July when the mean daily inflow was 2,632 cfs.

Table 2 gives the mean daily releases from JRR. Discharge flow rates generally mirror inflow values, although they 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 6. Precipitation at John Redmond Reservoir, January - December, 1981 (NOAA, 1981)

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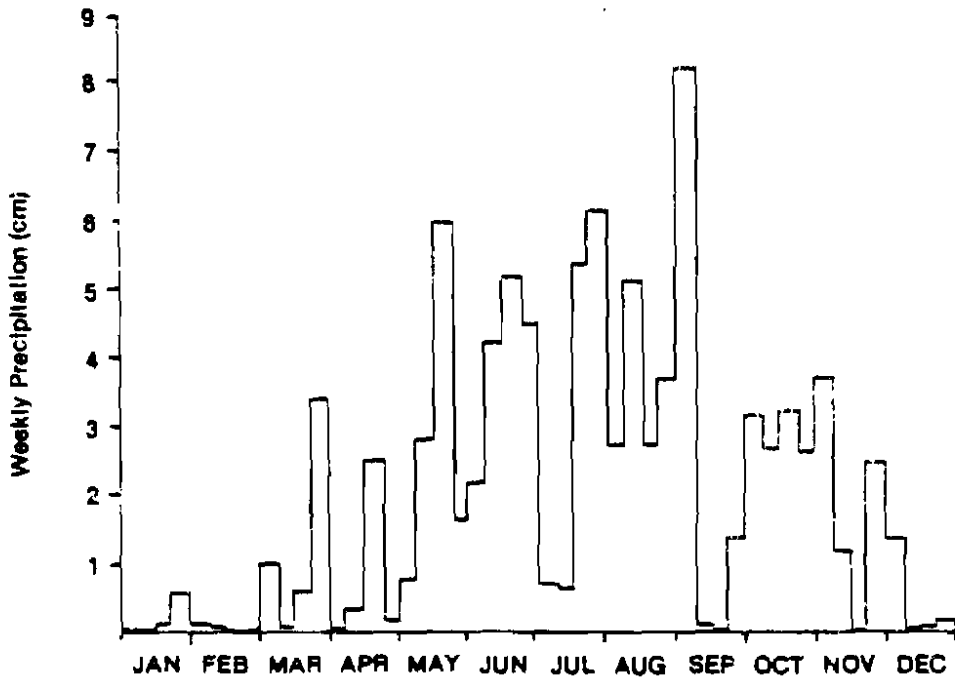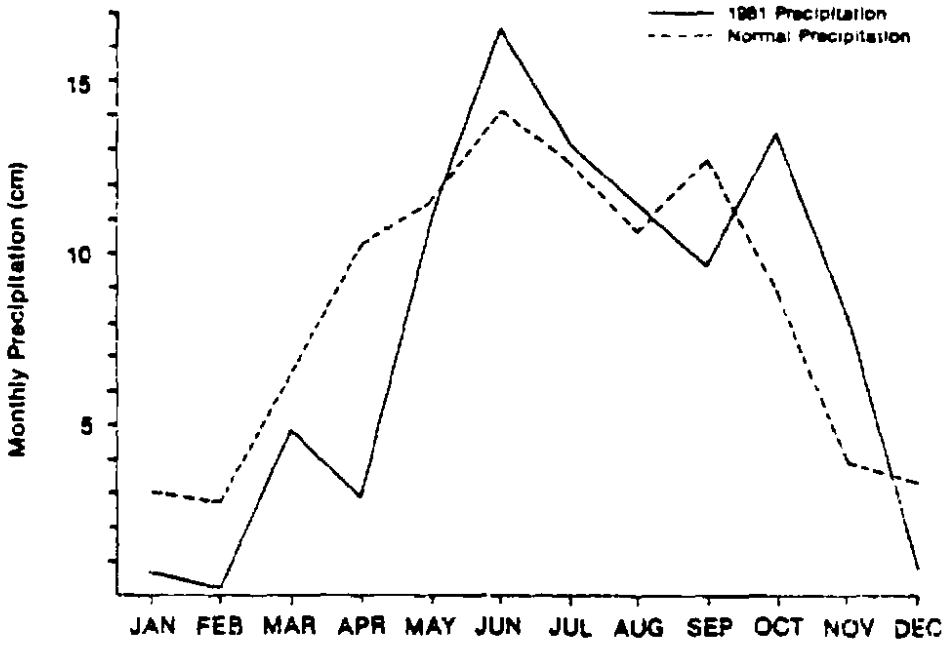
Table 1. Mean daily river inflow (cfs) of the Neosho River into the John Redmond Reservoir, 1981.

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	665	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. Mean daily river 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	-	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

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 roughly 40 minutes after boat recovery at JRR.

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 7) 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

Figure 7. Twin push net assembly utilized throughout the study (patterned after Tarplee

et al. 1979).
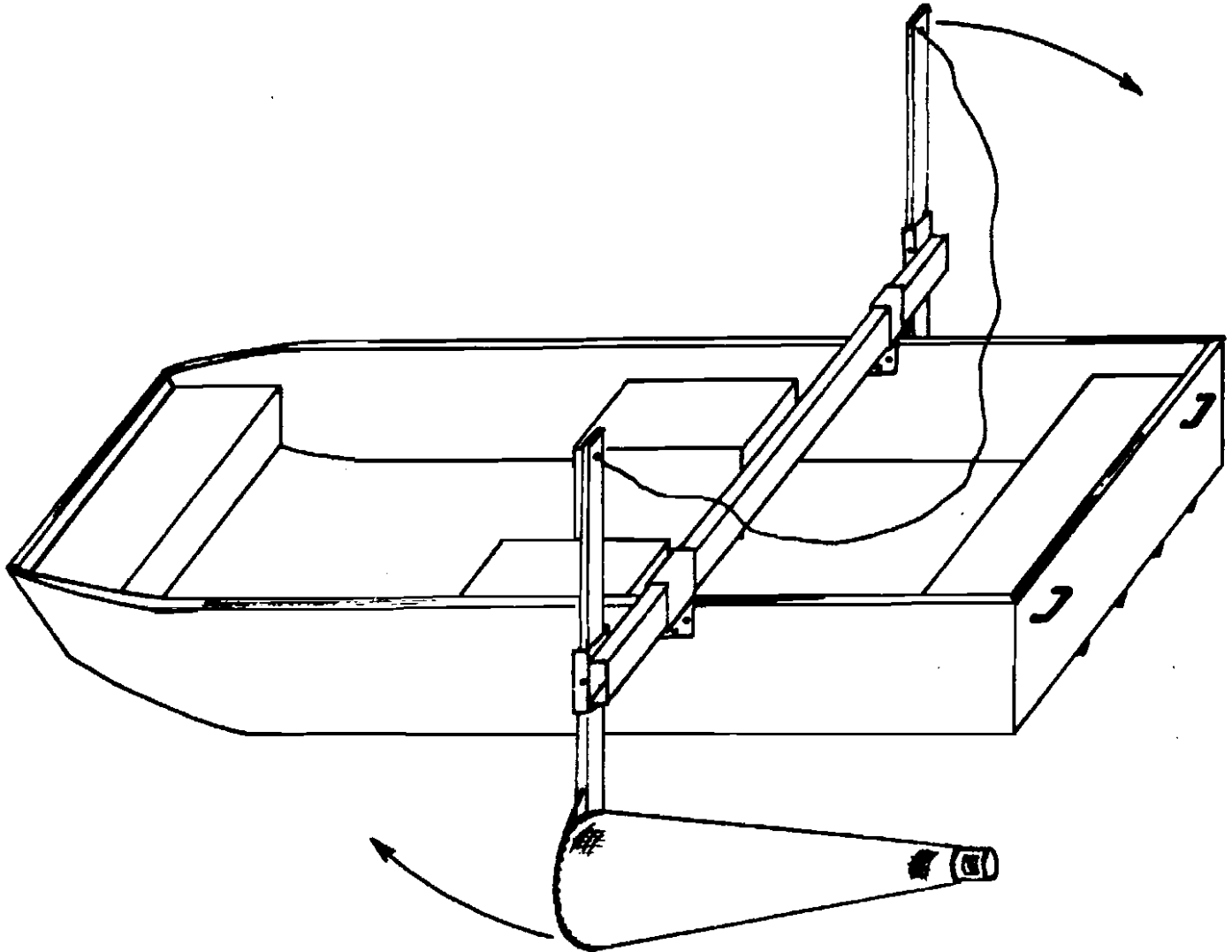
a collection, the nets were rotated to the up position and the collected material washed completely into the buckets. Bucket contents were then further strained through the use of a 0.600 mm brass seive prior to preservation with ten percent buffered formalin acetate.

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 (Figure 8).

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 (1967), as well as appropriate family, generic, or species descriptions. Determinations of larval fish developmental stages were made as defined by Snyder (1981b) (Figures 9 and 10) as follows:

Figure 8. Fish egg and larvae sampling gear summary sheet.

FORM KSF-REB REV 9 82

KANSAS GAS AND ELECTRIC COMPANY
WOLF CREEK GENERATING STATION

No. 8__ - ____

Reviewed _____

FISH EGG AND LARVAE SAMPLING:
___GEAR SUMMARY SHEET___

Collector _____   Mo. ____ Day ____ Yr. ____

Collector _____   Station _____

Project _____

A
(left)   Net No. _____
         Flowmeter No. _____   **Day/Dark**

B
(right) Net No. _____   Time _____

         Flowmeter No. _____   Fishing Temp. _____ °F C

Thermometer _____   Duration _____ min.

Net Diameter _____   Boat Velocity _____ m/sec.

Cod Mesh _____   Current Velocity _____ m/sec.

Current Meter _____

Net Rep. _____

	OUT	IN	NUMBER OF REVS.
A (a)			
(b)			
B (a)			
(b)			

Notes:

Figure 9. Representative protolarval and mesolarval stage fish (Pomoxis annularis shown).
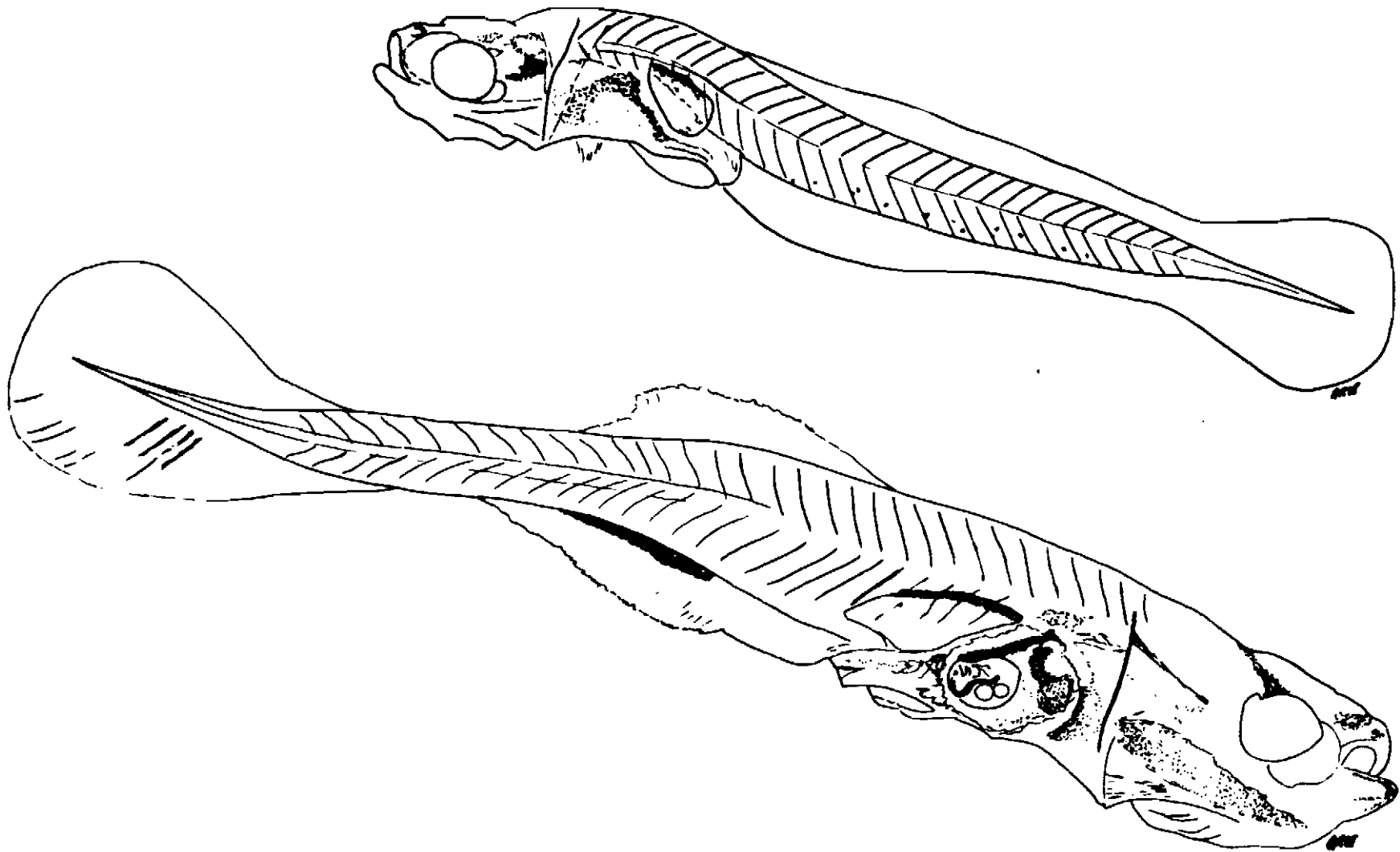
Figure 10. Representative metalarval stage fish (<u>Pomoxis</u> annularis shown).
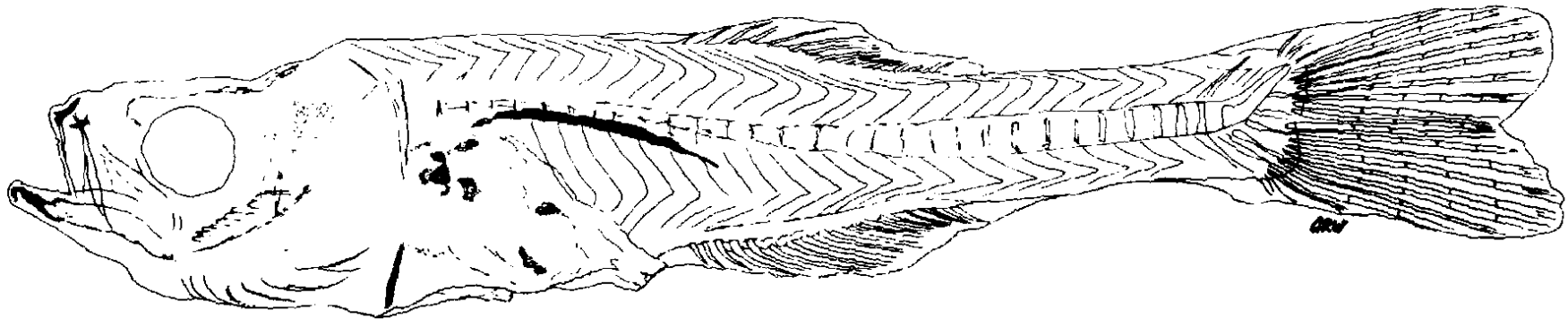
"Larval Period - The period of bony fish develop-
ment characterized by obvious fin morphogenesis
following hatching or parturition. Transition to
the juvenile period is based on the following
three criteria, each of which must be met: 1)
finfold and atrophying fins, if any (very rare),
must be absorbed 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 dis-
tinct spines or rays associated with the future
median fins (dorsal, anal or caudal fins). Tran-
sition 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; and 2) the
pelvic fins or fin buds must be evident.

Metalarval Phase - The larval phase of bony fish
development characterized by the full adult com-
plement 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 stages 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 criteria based on terminology unrelated to yolk retention permits increased consistency in relation to morphological features common to the majority of freshwater fish.

Head, preanal, postanal, standard, and total lengths were measured on many of the sub-juvenile, non-clupeid larval fish identified (Figure 11). 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 11) 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 (Figure 12). Measurements and meristics were documented through
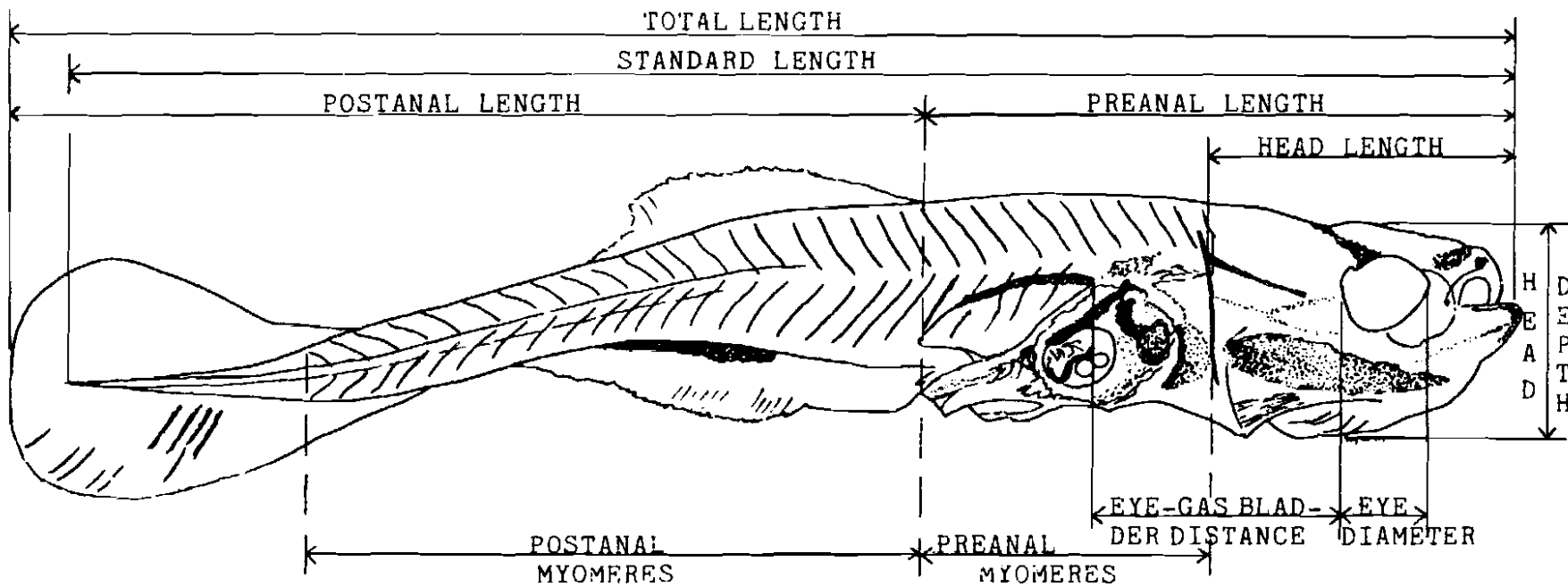
LARVAL FISH IDENTIFICATION SHEET

No. 8__ - ____

Page ____ of ____

Collection Date _____   Replicate _____   Identified _____   1st Picking _____ Larvae? _____

Collection Time _____   Collector(s) ____/____   Investigator _____   2nd Picking _____ Larvae? _____

Location _____   Water Temp _____

Species	Devel Stage	Head Length	Prean Length	Postan Length	Stnd Length	Total Length	Prean Myomere	Postan Myomere	Total Myomere				Comments
1.													
2.													
3.													
4.													
5.													
6.													
7.													
8.													
9.													
10.													
11.													
12.													
13.													
14.													
15.													

Developmental Stages: E = Egg   PRL = Prolarvae   PL = Postlarvae   EPL = Early Postlarvae   LPL = Late Postlarvae   J = Juvenile
(PRTL = Protolarvae   MSL = Mesolarvae   MTL = Metalarvae)

the use of an American Optics trinocular 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, calculational, mean, variance, and standard deviation determinations. The production of figures was accomplished through the use of the Apple Graphics III program. 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.

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 de-
scribed 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 situa-
tions, Location 3 was sampled only nine times, while Loca-
tion 1 (nocturnal) collections were made 13 times, Loca-
tion 2, 14 times, and Location 1 (diurnal) collections were
made on all 15 dates. A total of 51 samples, each consist-
ing 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 measurements 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 stages were 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 stages. 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 13). 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 14).

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		25	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	-b	2130	2120	2120
WATER TEMPERATURE (C)		17.8	20.0	19.5	17.0	15.5	21.5	21.5	24.5	22.0	26.0	25.5	-c	28.5	24.0	
CURRENT VELOCITY (M/SEC)		-a	-a	-a	-a	0.65	0.20	0.85	0.40	0.70	-a	0.40	-	0.20	-a	0.55
SAMPLE VOLUME (m³) (sum of both replicates)		79.1	95.4	107.5	92.4	115.7	116.7	94.2	106.0	94.2	117.8	94.2	-	139.6	124.9	122.6
Egg							1698.1		322.6		12.7	169.8				
Unknown, PRTL									4.7					2.2	0.8	
Unknown, MSL									0.3							
Lepisosteidae																
Lepisosteus sp. MSL									0.9							
MTL											0.8					
Clupeidae																
Dorosoma cepedianum PRTL		5.15	4.2	31.1	9.6		904.9		3.9		5.1	2.1				
MSL			4.1	1.9												
Cyprinidae																
Cyprinus carpio PRTL							4.3	9.6	2.9	1.1		7.4				
MSL								3.2								
Unknown Cyprinid PRTL										1.1				0.8	2.6	
MSL														0.8		
Notropis sp. PRTL									2.4							
(Th. Deliciosus) PRTL		2.5														
MSL		10.1														
(Th. Pimephales) PRTL												2.1				
Catostomidae																
Unknown Catostomid PRTL									1.9							
Ictaluridae																
(Th. Carpiodes carpio) PRTL											0.8	93.9		14.4	23.0	
(Th. Ictiobus) PRTL							137.5	435.4		14.9	121.9					
MSL									33.4		7.6					
Ictiobus (Th. Niger) MSL															0.8	
Ictiobus (Th. Cyprinellus) (J)												1.1				
Ictaluridae																
Ictalurus punctatus MTL																1.1
Noturus sp. MTL																1.6
(J)																1.6
Centrarchidae																
Lepomis sp. PRTL									6.6							
(J)										1.1						
Lepomis (Th. cyanellus) MTL										1.1						
(J)																1.6
Lepomis macrochirus (J)																0.8
Percidae																
Percina sp. MSL			1.1													
TOTAL EGGS (#/100 m³)		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 m³)		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 m³)		17.7	9.4	33.0	9.6	0.0	1246.7	468.2	34.8	19.2	138.2	95.5	-	16.6	23.2	5.8
TOTAL COLLECTED (#/100 m³)		17.7	9.4	33.0	9.6	0.0e	2944.8	468.2	357.4	19.3	150.9	266.4	-	16.6	23.2	9.5

a = Below Detection Limit
b = Samples Not Collected Due to Equipment Malfunction
c = Not Measured
d = All Values Represent the Mean of Two Replicates
e = No Fish Collected

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

Figure 13.   Annual relative abundance of larval fish collected at Location 2, Hartford.

CATOSTOMIDAE   CLUPEIDAE

CYPRINIDAE   OTHER TAXA
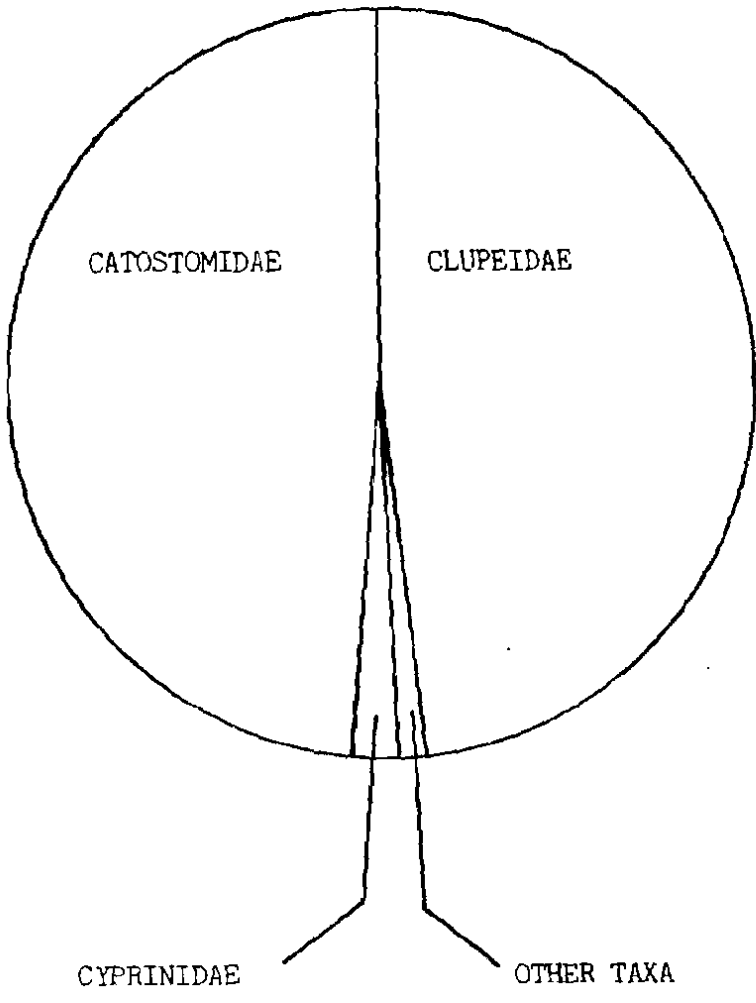
Figure 14.   Total concentrations of larval fish collected in 1981 at Location 2, Hartford.
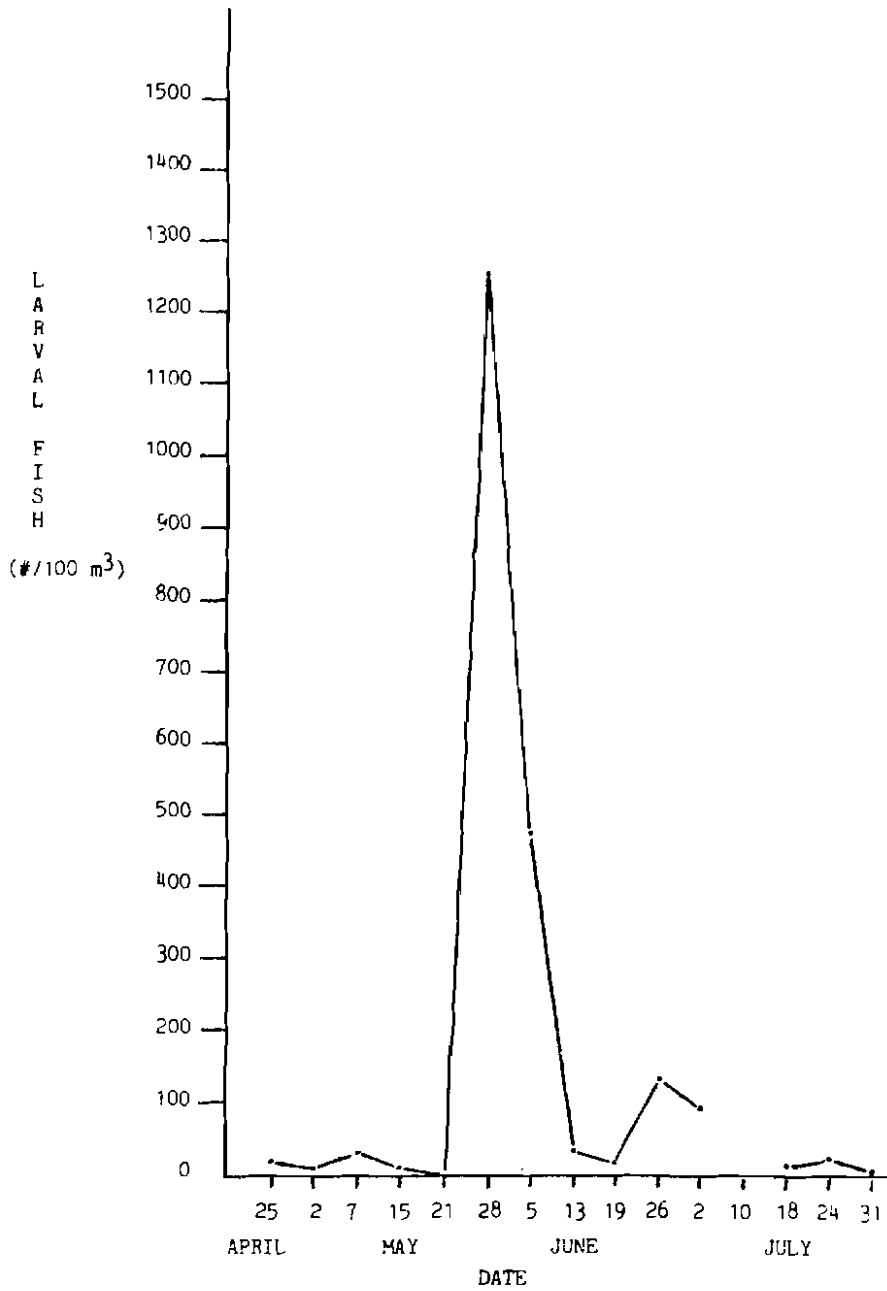
Location 1:   John Redmond Reservoir Tailwaters

With the exception of 15 May, larval fish were collect-
ed on all dates at Location 1.   A total of 19,950 fish of
all stages was collected at JRR as a result of diurnal and
nocturnal collections.   This total consisted of 7,969 diurn-
ally 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 sam-
ples 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, un-
known 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 noc-
turnally.   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	15	1725	1830	1650	1825	1720	1730	1800	1845	1715	1745
WATER TEMPERATURE (C)		19.5	21.5	18.0	18.5	.7.0	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 (m³) (sum of both replicates)		104.7	113.1	126.3	140.5	104.1	87.0	100.0	94.2	106.0	106.0	106.0	106.0	121.2	120.2	126.3
Egg							1.2									
Unknown, PRTL		1.0c	0.9													
Clupeidae																
Dorosoma cepedianum	PRTL	5.7	73.3	68.3		3.8	96.4	110.0	86.0	0.9			3.8		29.1	37.1
	MSL			11.1		3.8	8.0	507.0	3853.5	47.2			5.7			
	MTL								1305.7	520.8	76.4	0.9	11.2			4.3
	(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								7.4							
	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		1.1	0.9
(Th. Pimephales)	PRTL															
Catostomidae																
Unknown Catostomid	PRTL												0.9			
Ictiobus																
(Th. Ictiobus)	PRTL															
	MSL								2.1							
	MTL															
	(J)															
Ictiobus sp.	MTL															
	(J)															
Ictiobus (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									1.9	2.8	6.6				0.8
	(J)															
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															
	MTL															
	(J)											2.8	0.9			
Percidae																
Percina sp.	PRTL															
(Th. Stizostedion)	MSL															
Sciaenidae																
Aplodinotus grunniens	PRTL			0.8					5.0							
	MSL								2.0							
	MTL															0.8
	(J)											0.4	0.9	4.7		
TOTAL EGGS (#/100 m³)		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 m³)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.3	665.9	36.8	388.6	1.6	24.1	6.8
TOTAL LARVAE (#/100 m³)		6.7	74.2	80.2	0.0	9.4	129.9	634.0	5274.9	569.8	77.3	0.9	49.8	5.6	41.6	53.4
TOTAL COLLECTED (#/100 m³)		6.7	74.2	80.2	0.04	9.4	131.1	634.0	5274.9	580.1	743.2	37.7	438.4	7.2	55.7	60.2

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	2240	2230	2240	-b	2300	-b	2250	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	0.90	0.10	0.95	-	1.50	-	0.75	0.25	0.80
SAMPLE VOLUME (M3) (sum of both replicates)		66.2	106.7	111.0	113.6	105.2	114.9	106.0	112.0	112.0	-	106.0	-	118.8	127.5	204.9
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				7.5	13.2	22.0
	MTL							1.9	1241.1	597.1						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. Pimphales)	PRTL								10.7							
Catostomidae																
Unknown Catostomid	PRTL															
Ictiobinae																
(Th. Ictiobus)	PRTL							11.3								
	MSL							4.7	11.6	2.7						
	MTL									0.9						
	(J)															
Ictiobus sp.	MTL								1.8							
	(J)								1.8							
Ictiobus (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								
	MTL								0.9	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					1.8	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 M3)		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 M3)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	286.5	-	47.3	-	13.5	9.4	10.5
TOTAL LARVAE (#/100 M3)		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 M3)		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)

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 PROL	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							
Notropis sp.								2/1	0/1	1/-		1/-			
Notropis (Th. buchanani)												25/-	7/1	15/9	13/6
(Th. Pimephales)								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					0/1							
(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)

Dorosoma cepedianum, the sole member of the family Clupeidae, dominated the diurnal JRR larval fish complement, comprising 98.0% of all larvae (Figure 15). 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.

In noturnal samples D. cepedianum also was dominant, representing 95.2% (Figure 16). 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 $5,000/100m^3$ 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 $5,274.9/100m^3$ and was flanked by two periods of densities below $10.0/100m^3$ (Figure 17). These periods of diminished larval fish occurrence were preceded and followed by periods when ichthyoplankton achieved densities between 50 and $100/100m^3$. The minimum diurnal concentration occurred on 15 May when no larvae were collected.

Maximum nocturnal densities at JRR were achieved during the first two June sampling dates. Larval fish densities on

Figure 15. Annual relative abundance of larval fish collected diurnally at Location 1, John Redmond Reservoir tailwaters.

CLUPEIDAE

OTHER TAXA   CYPRINIDAE
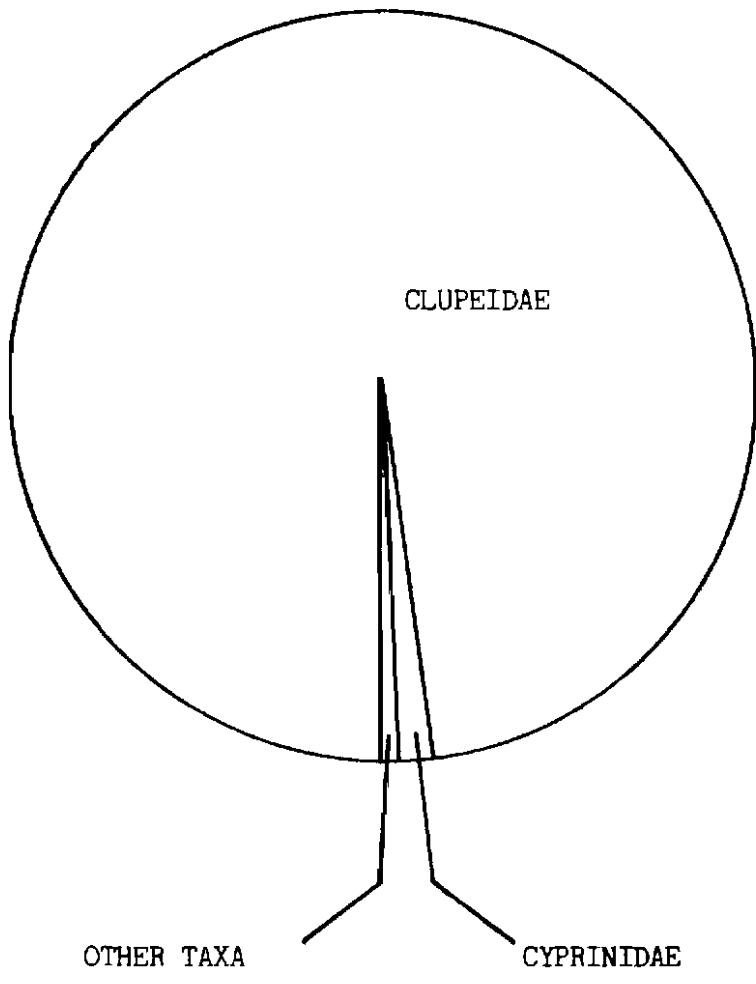
Figure 16. Annual relative abundance of larval fish collected nocturnally at Location 1, John Redmond Reservoir tailwaters.

Figure 17. Total concentrations of larval fish collected in 1981 at Location 1,
John Redmond Reservoir tailwaters: diurnal samples.
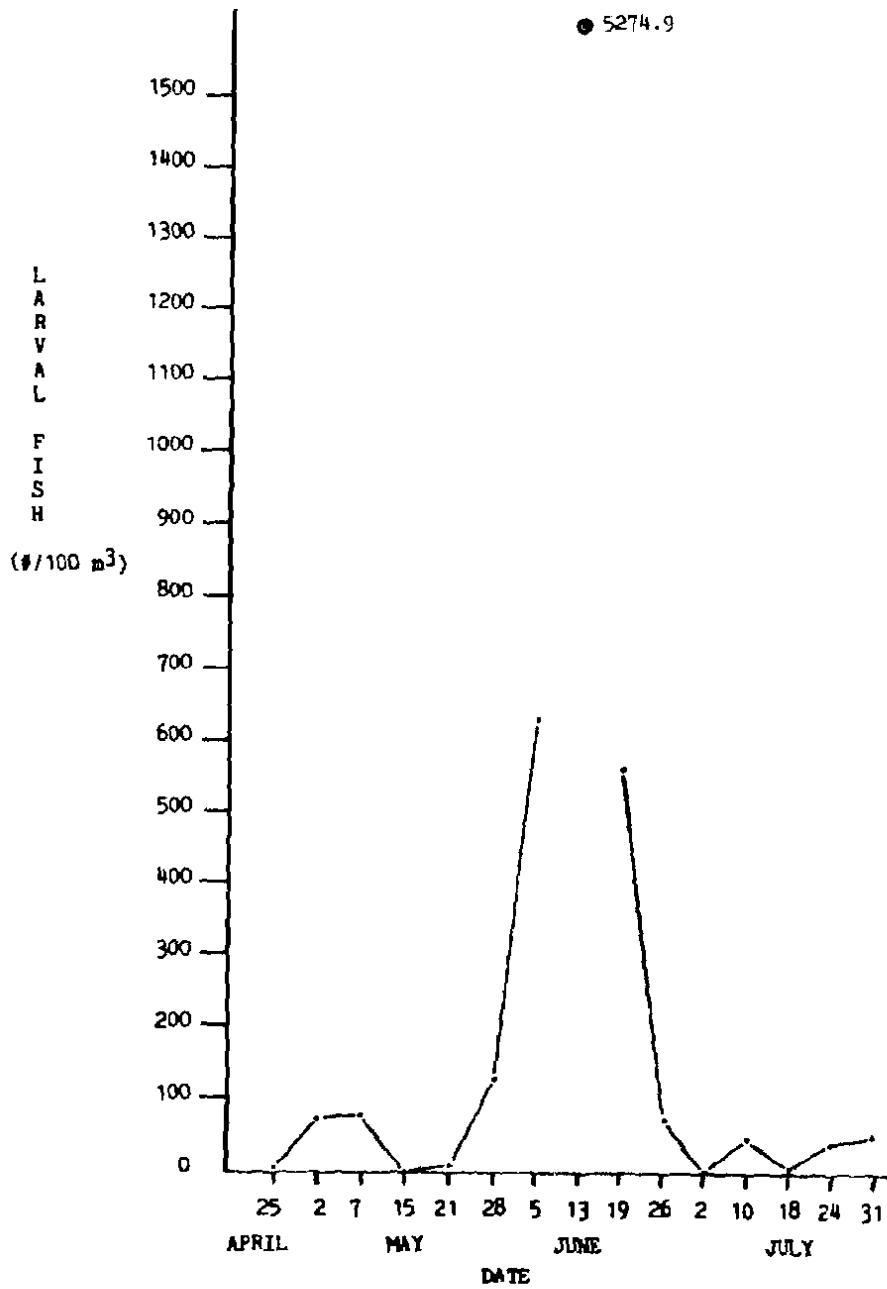
these dates, 5 and 13 June, were 3,998.0 and 5,419.6/ $100m^3$; roughly six to eight times higher than the next highest concentration (Figure 18). A value of 2.7/$100m^3$ on 15 May was the minimum larval fish concentration nocturnally at JRR.

Location 3: Burlington

Larval fish were found at Burlington on all nights that sampling was performed. A total of 3,118 fish of all stages appeared in 0.5 m nets at this location. This total con-sisted 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 impor-tant 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 19).

Larval fish concentrations varied from 6.3/$100m^3$ on 18 July to a maximum of 1,766.4/$100m^3$ on 19 June. The graph of densities at this location also appears to exhibit a Gaus-sian distribution, although data gaps make the curve less distinct (Figure 20).

Figure 18. Total concentrations of larval fish collected in 1981 at Location 1,
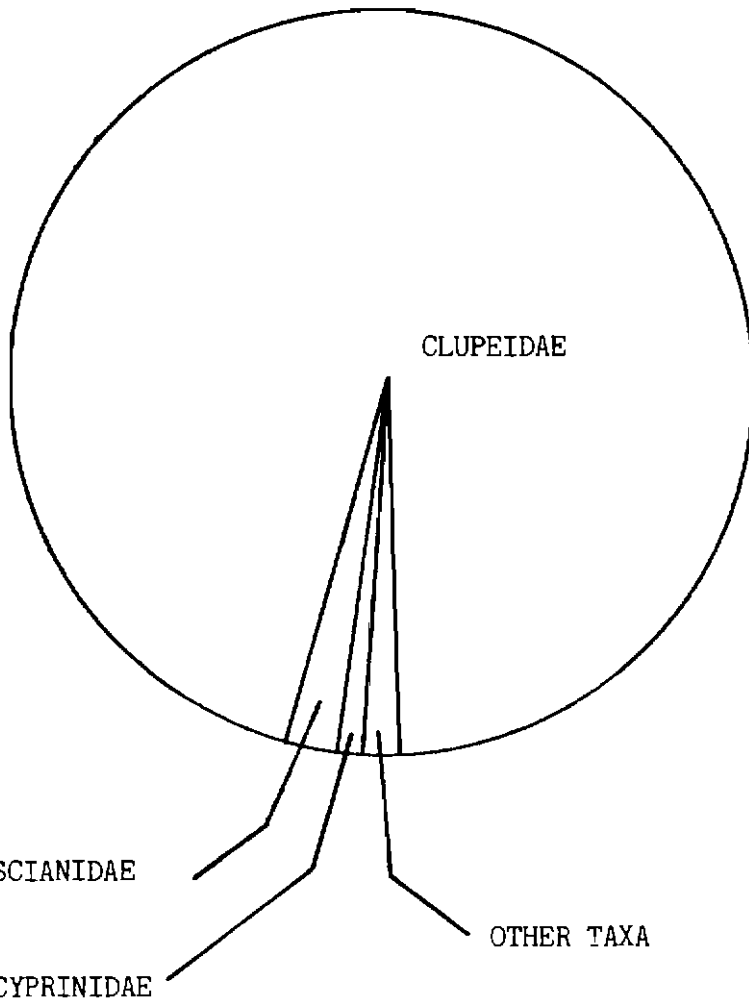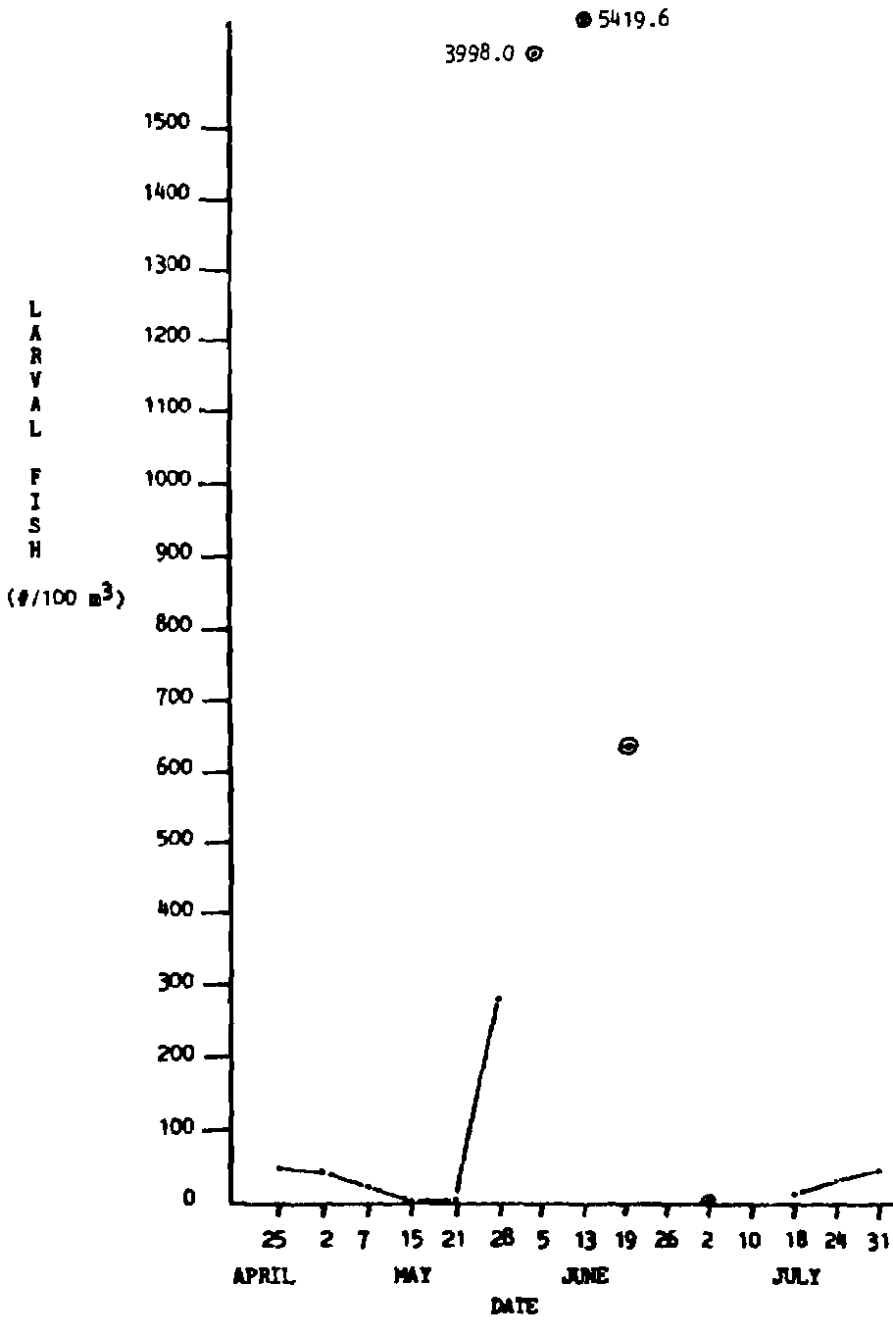John Redmond Reservoir tailwaters: nocturnal samples.

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	11
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 (M³)		92.7	111.3	92.9	105.5	139.1	121.2	-	-	117.8	-	-	-	126.8	130.1	-
(sum of both replicates)																
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						
	PRTL														0.8	
(Th. Notemigonus crysoleucas)																
	PRTL		0.8													
Notropis sp.	(J)														1.6	
Notropis (Th. buchanani)	MSL														1.6	
	MTL														2.4	
	(J)													1.5	0.8	
Ictaluridae																
Ictalurus punctatus	MTL														3.1	
	(J)														16.0	
Atherinidae																
Labidesthes sicculus	PRTL					3.8										
	(J)													1.7	0.8	
Percichthyidae																
Morone chrysops	PRTL						10.7									
	MSL	2.1														
	MTL									0.8						
	(J)									3.4						
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		3.6	2.2		0.7										
	(J)									1.7						
Sciaenidae																
Aplodinotus grunniens	PRTL													0.7		
	MSL									96.9				4.0		
	MTL									10.6					2.3	
	(J)						1.3			15.3						
TOTAL EGGS (#/100 M³)		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 M³)		0.0	0.0	0.0	0.0	0.0	3.3	-	-	456.7	-	-	-	3.2	19.2	-
TOTAL LARVAE (#/100 M³)		58.2	42.3	44.3	125.0	32.3	81.5	-	-	1766.4	-	-	-	6.3	31.0	-
TOTAL COLLECTED (#/100 M³)		58.2	42.3	44.3	125.0	32.3	84.8	-	-	2227.1	-	-	-	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 19.   Annual relative abundance of larval fish collected at Location 3, Burlington.

CLUPEIDAE

CENTRARCHIDAE

OTHER TAXA

SCIAENIDAE
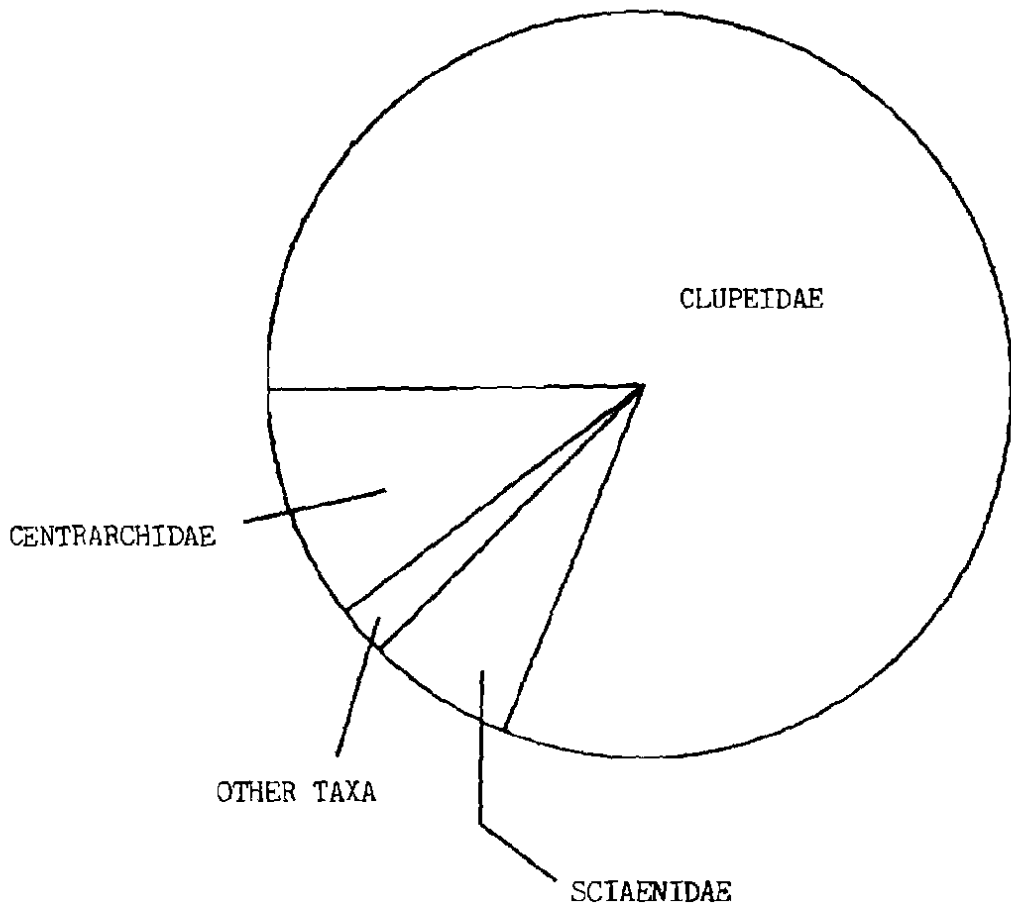
Figure 20. Total concentrations of larval fish collected in 1981 at Location 3, Burlington.
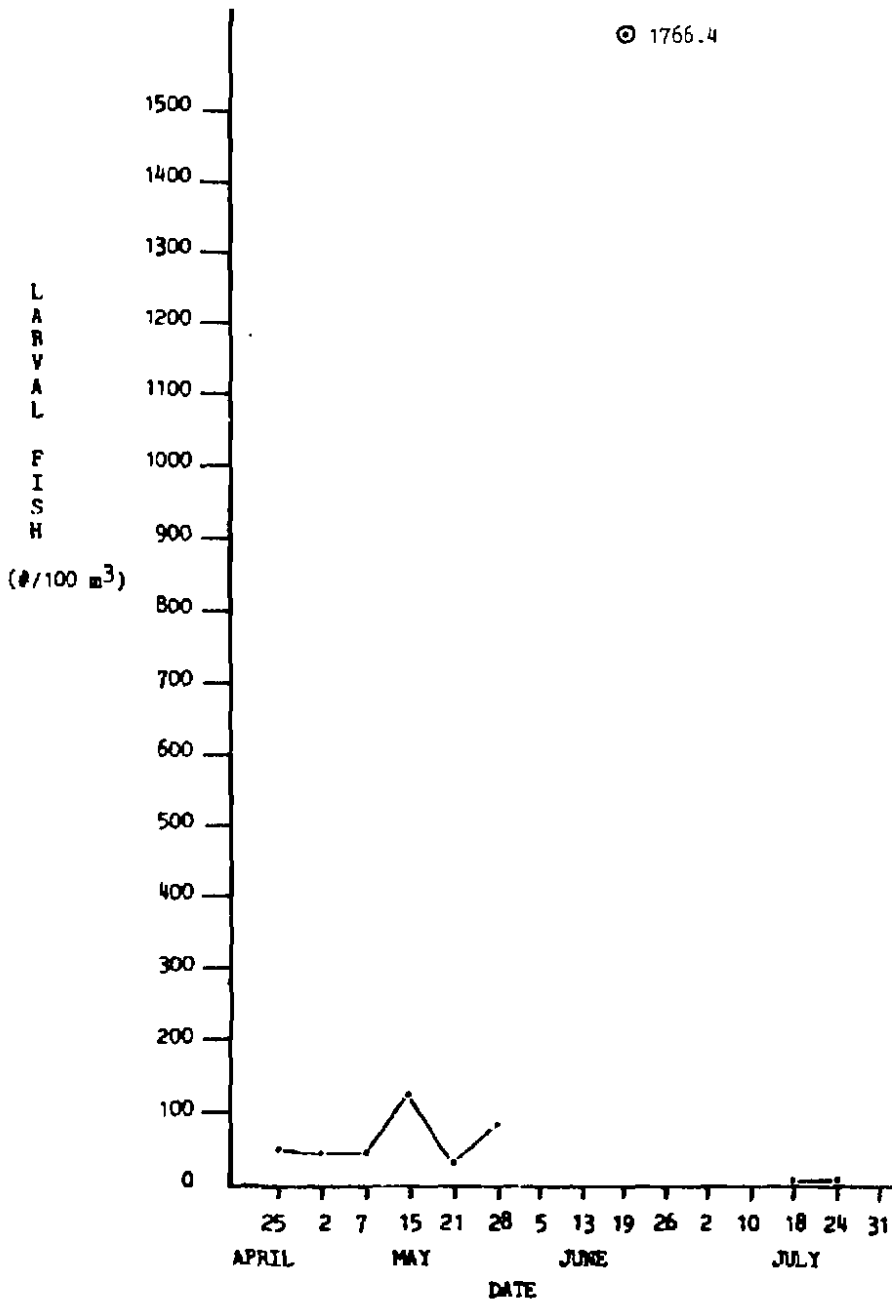
Morphometrical Data

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 are 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.

Definitions of Abbreviations Used in Morphometrical Tables

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

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

Lepomis 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	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	19.0 ± 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			MESOLARVAE			METALARVAE			JUVENILES		
	MEAN ± SD	RANGE	N	MEAN ± SD	RANGE	N	MEAN ± SD	RANGE	N	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
Ptnl 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: Pomoxis 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	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			MESOLARVAE			METALARVAE			JUVENILES		
	MEAN ± SD	RANGE	N	MEAN ± SD	RANGE	N	MEAN ± SD	RANGE	N	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												
Ptnl 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			MESOLARVAE			METALARVAE			JUVENILES		
	MEAN ± SD	RANGE	N	MEAN ± SD	RANGE	N	MEAN ± SD	RANGE	N	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 and the Mississippi 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 population can be made.

The larval fish complement of the Neosho River/JRR system can be 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 characterizes 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 number on five dates. Larvae of these _Ictiobus_ taxa comprise a source of individuals for recruitment in this commercially important genus. Ictiobinae, thought to be _Carpiodes carpio_, larvae were present in lower concentrations for a four week period. These larvae also represent 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 could possibly explain the absence of _Cycleptus_ larvae but the lack of _Moxostoma_ in the drift could not be 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 <u>Cyprinus</u> <u>carpio</u> which occurred from late May through early July. Common carp entering JRR represent an undesirable input of recruitable rough fish. Cyprinidae, thought to be <u>Phenacobius</u>, larvae was the only other minnow present in numbers.

The game fish component was composed solely of <u>Ictalurus</u> <u>punctatus</u>, which was present on only one date. No other gamefish were collected at Hartford, although both <u>Morone</u> <u>chrysops</u> and <u>Pomoxis</u> <u>annularis</u> were expected. No explanation for the lack of larvae of these two species can be 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 is 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 <u>Notropis</u> sp. thought to be <u>buchanani</u>, which probably were produced in the tailwaters. The gamefish portion of the diurnal larval fish population was represented by <u>Morone</u> <u>chrysops</u>, which occurred in low numbers, and two <u>Pomoxis</u>

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 limited 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. Variability in diurnal/nocturnal numbers did occur however. For the majority of JRR taxa diurnally collected larvae were fewer in number than those nocturnally collected. The relationship of higher nocturnal numbers were 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 is 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 must result 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 is 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 at this location is reflective of both JRR releases and riverine reproduction. The generally similar concentrations and catch periods for most taxa to JRR data are 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 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 provides a source of recruitable individuals to bolster the downsteam and JRR tailwaters fisheries. Production in this area would probably be most beneficial during periods of low flow when *Pomoxis* losses from JRR are minimal. This position is supported by catches of *Notropis* sp., *Notropis* sp. thought to be *buchanani*, and *Morone chrysops* which present evidence that this area is an effective nursery.

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

Morphological Basis for Identifications

Identifications of larval fish are contingent on ratios, percentages, and numbers of certain features. Although the relationships of these structures is 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 <u>Dorosoma</u> <u>cepedianum</u>, <u>Morone</u> <u>chrysops</u>, and <u>Aplodinotus</u> <u>grunniens</u> 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 are discussed in the text. The relationship of data collected in this study with data in the literature, along with the rationale for assignments made, is 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 <u>Lepisosteus</u> 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 collated for this species because of its distinctive appearance (Hogue et al. 1976).

Cyprinidae

Cyprinus carpio

Common carp larvae present 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) present morphometrical descriptions of this species. The data collected in this study (Table 9) compares favorably with Snyder (1981b) except for a slightly larger range for some features. The C. carpio data in Table 9 also compare 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 taxom fall into the Notropis genus by general characteristics. Head length (HL) and Prnl L (% TL) exhibit wider ranges but are generally close to Notropis lutrensis data provided by Snyder (1981b). Myomere counts for this taxa from this study (Table 10) are 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, could account for the wider ranges observed for some features.

Notropis sp. thought to be buchanani

Hogue et al. (1976) identifies a Cyprinidae group c which contains "postlarvae" having 19-20 preanal myomeres and 13-14 postanal myomeres. Pigmentation in this group is 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 is round in group c and the anal fin has 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. larvae 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 supports 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 bears a striking resemblance to Hogue unidentified Cyprinidae group a, except the postanal myomere count is slightly low (Table 12). Group a is thought by Hogue to contain the stargazing minnows (Phenacobius uranops).

The assignment of these larvae to this taxon was based on the elliptical eye, 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 are 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 (1979a), the family Catostomidae has three subfamilies described by Miller (1958); Cycleptinae; Ictiobinae; and Catostominae. The Cycleptinae are represented as a naturally occurring species by only Cycleptus elongatus. This taxon exhibits a distinctive morphology (Connor et al. 1980), and was not collected in 1981. The subfamily Catostominae is represented by three or four Moxostoma species in the study area. The preanal myomere counts for all Moxostoma sp. (Fuiman 1979b, 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 stages could not be made as confidently, though. All morphometrical data was 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 (1982).

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 is 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 by 28.9 mm TL, particularly the terminal mouth.

Ictaluridae

Ictalurus punctalus

This species was present as readily identifiable individuals due to the distinctive notched caudal fin. No morphometrical data was 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 thought to be 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 present a unique morphology not easily confused with any other taxon found in the study area. Morophometrical data for this taxon (Table 17) compares 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 was not compiled.

Centrarchidae

Lepomis sp.

Larval fish were assigned to this genera 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 is to be expected since as stated by Conner "many traditional characters that have been used to diagnose sunfish larvae are very environmentally 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 fall within Conner (1979) bluegill type (Table 19). The same qualifications cited above also apply to this taxon, however.

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 provide 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 cites the inclusion of individuals having 18 postanal myomeres in Pomoxis by Hogue et al. (1976), as

causing misidentification of <u>Lepomis</u> larvae. However, no <u>Lepomis</u> larvae enumerated in this study had >17 postanal myomeres and the sole <u>Micropterus</u> had a count of 16. These data would indicate that <u>Pomoxis</u> protolarvae and mesolarvae within the study area occassional include individuals with 18 postanal myomeres (Tables 20 and 21) contrary to Conner (1979) which stated only mesolarvae through juvenile <u>Pomoxis</u> have 18.

Chatry and Conner (1980) identify the EgbD (% TL) as the method of segregating <u>P. annularis</u> from <u>P. nigromacu-latus</u> larval fish. Specifically, EgbD (% TL) of <15.0% in larvae <13.0 mm TL are cited for <u>P. nigromaculatus</u> larvae while values >15.0% are given as diagnostic for <u>P. annularis</u> (Figures 9 and 10).

The differentiation of <u>Pomoxis</u> sp. versus <u>Pomoxis annularis</u> 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 result-ed in larvae with eye-gas bladder distance (EgbD % TL) val-ues of 15% falling in both <u>Pomoxis</u> sp. and <u>Pomoxis annularis</u> (Tables 20 and 21).

This situation creates confusion in relation to the proper label for <u>Pomoxis</u> larvae and is further complicated by the fact that <u>P. nigromaculatus</u> adults were not collected in the Neosho River in 1981 (King 1981) and have not been collected in the three years previous to 1981 (Bliss 1978, 1979, 1980).

Although P. nigromaculatus occurs in the Neosho and is occasionally caught by anglers, evidence would indicate that all 1981 Pomoxis larvae are 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 the general description of Hogue et al. (1976) group b which includes Percina caprodes and the Percina caprodes data presented by Cooper (1978). These Percina larvae do not fit the general Etheostoma blennioides description of Baker (1979).

Diagnostic features for these larvae include an overall slender appearance, prominent anterior oil globule, and small head (Figure 1). The small head is 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.

Considering the diverse nature of the middle Neosho River ichthyofauna, the larval fish population characterized by this study exhibited a remarkable lack of diversity. Dorosoma cepedianum was found to be the dominant component of the larval fish assemblage at all locations. Domination by this taxon was reflective of the high reproductive capability and extended spawning period of this important forage species. Location 3: Burlington proved to be the sole exception to an assemblage otherwise lacking in predator species due to the collection of Pomoxis taxa larvae.

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 were collected from the
three locations sampled.

2.   Nocturnal efforts at Location 2: Hartford re-
sulted in the collection of 2,499 eggs, 2,330 larvae, and
eight juvenile fish from seven families and 18 taxa. Mem-
bers of the families Catostomidae and Clupeidae dominated
the larval fish drift at this location. Larval fish den-
sities ranged from a minimum of none on 21 May to a maximum
of $1246.7/100m^3$ on 28 May.

3.   Diurnal and nocturnal efforts at Location 1: JRR
tailwaters resulted in the collection of one egg, 6,773 lar-
vae, 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 allocthonous input into JRR at Hartford, at JRR tailwaters they generally characterize those fish released from the reservoir, and at Burlington these data represent both releases from JRR and production in the area below the impoundment.

6. Morphometrical data are presented in tabular form for 14 taxa. These data generally compare 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 45-57. 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 Wildl. 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. 1979a. Descriptions and comparisons of catostomid fish larvae: Northern Atlantic drainage species. Trans. Amer. Fish. Soc. 108:560-603.

Fuiman, L.A. 1979b. Descriptions and comparisons of catostomid fish larvae: C. catostomid and _Moxos erythrurum_.

Fuiman, L.A. and D.C. Witman. 1979. Descriptions and comparisons of catostomid fish larvae: _Catostomus catosto mus_ and _Moxostoma erythrururum_. 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 Wildl. 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 billifish (_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.