LARVAL FISH POPULATIONS DURING THE FIRST THREE YEARS OF IMPOUNDMENT IN NORMANDY RESERVOIR, TENNESSEE

JOHNNY P. BUCHANAN, Tennessee Valley Authority, Norris, TN 37828
EDWIN M. SCOTT, JR., Tennessee Valley Authority, Norris, TN 37828

Abstract: Seasonal abundance of larval fishes in Normandy Reservoir, Tennessee, was determined during the first 3 years (1976-1978) following impoundment. Relative abundance of major taxa collected with a 0.5 m frame net was compared with results of cove rotenone samples to measure year-class strength. Centrarchids dominated both larval and cove rotenone populations throughout the investigation. The strongest year class of crappie (*Pomoxis* spp.) was observed in 1976, even though greater larval abundance (5 times) was recorded in 1978. Threadfin shad (*Dorosoma petenense*) were stocked and subsequently spawned in 1977, but failed to survive the winter; gizzard shad (*D. cepedianum*) were the only clupeids collected in 1978.

Proc. Ann. Conf. S.E. Assoc. Fish & Wildl. Agencies 33:648-659

Postimpoundment investigations of fish populations in new reservoirs have often been conducted utilizing methods selective for larger juvenile or adult fishes; e.g., seining, trawling, gill netting, rotenone, and creel surveys (Martin and Campbell 1953; Carter 1969; Gasaway 1970; Beckman and Elrod 1971; Hashagen 1973; June 1976; Walburg 1976). A common observation was successful reproduction and low mortality by most species during early impoundment, resulting in the formation of strong year classes. More precise measurement of spawning success and determination of the life stage at which year-class strength is established should be enhanced by quantitative sampling of larval and early juvenile stages of development. Nelson et al. (1968) sampled young-of-the-year fishes in 2 Missouri River reservoirs to estimate year-class strength and mortality rates. The usefulness of tow-net collections of fish larvae to estimate hatching and spawning periods for several species of fish was demonstrated by Amundrud et al. (1974).

This investigation was designed to observe and measure initial reproductive success of indigenous fishes through quantitative larval fish sampling following impoundment of Normandy Reservoir, Tennessee. The second objective was to monitor the success of introduced threadfin shad, which were stocked by the Tennessee Wildlife Resources Agency, in an attempt to establish a desirable prey base in the reservoir. Occurrence and abundance of larval fishes were compared with results of cove rotenone samples conducted during the first three years after impoundment to determine survival and year-class strength of selected taxa.

THE STUDY AREA

Normandy Reservoir, impounded in January 1976, is located on the Duck River in middle Tennessee and has a surface area of 1,307 ha. At elevation 875 msl (266.7 m), the reservoir is 27 km long and has a shoreline length of 113 km. Average (33 years) streamflow at the dam site is 9.1 m^3/s. A complete description of the reservoir and surrounding river basin is available in the final environmental statement for the Duck River Project (TVA 1972).

Preimpoundment fish populations in the Duck River were surveyed by TVA in 1972 with the station at Duck River Mile (DRM) 248.5 nearest the Normandy Dam site yielding 892 fish/ha of 33 species and weighing 20 kg. A complete species list and composition from this survey are available in TVA (1975). The only fish stocked during the first year of impoundment were 250,000 walleye fry in March 1976.

MATERIALS AND METHODS

Larval Fish Samples

Larval fish were sampled weekly from April through July 1976, March through August 1977, and biweekly from April through July 1978. Three stations representing the upper (DRM 259.5), middle (DRM 255.5), and lower (DRM 251) sections of the reservoir were sampled (Fig. 1). The sample gear and procedure used in this investigation were those of Graser (1977). At each station, samples were collected near the shorelines and in the channel or open-water area. The water column at each sample area was partitioned into from one to three strata, depending on depth. Each stratum was sampled by a square-framed, flowmeter-equipped, 0.5 m-diameter net (0.5 mm mesh) towed upstream in a step-wise oblique fashion for 10 minutes. This sampling strategy was conducted both day and night for a total of 26 samples per week (biweekly in 1978).

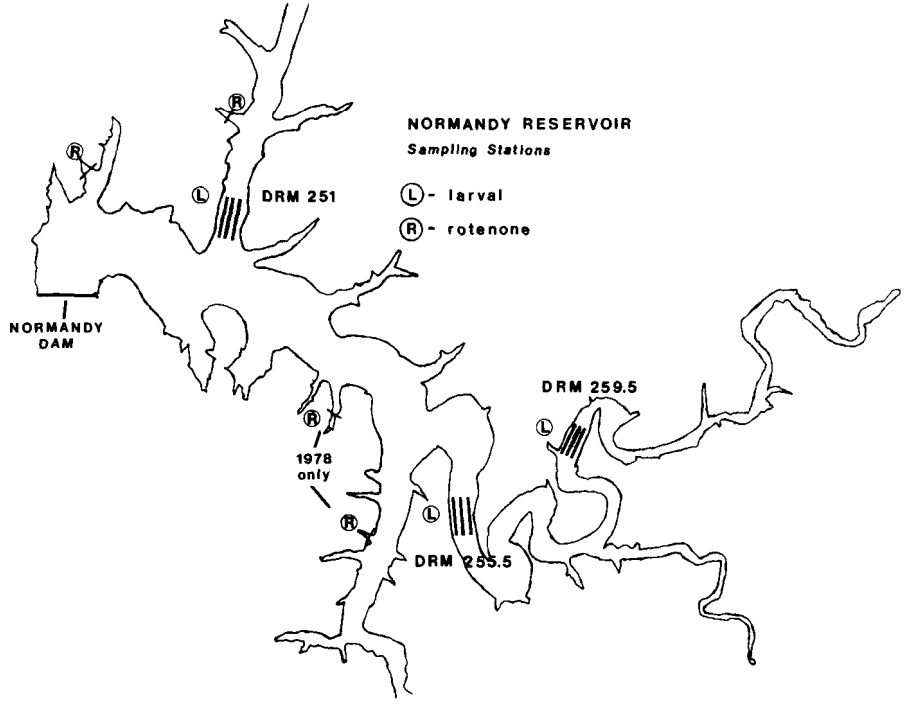

Fig. 1. Map of Normandy Reservoir with locations of larval sampling stations (L) and cove rotenone sites (R).

Samples were rinsed into catch-cups, labeled, and preserved in formaldehyde (5-10 percent solution) immediately upon collection in the field. Samples were enumerated, measured, and identified in the laboratory to the lowest possible taxon according to Hogue et al. (1977). Periodic abundance of fish larvae was expressed as number/ 1000 m^3.

Cove Rotenone Samples

Cove rotenone data from 1976, 1977, and 1978 provided information on adult fish standing stocks and were collected according to methods outlined in Hall (1974). Locations of the coves sampled are indicated in Fig. 1. Total surface area sampled was 1.0 ha in 1976, 0.65 ha in 1977, and 1.54 ha in 1978.

RESULTS

Larval Fish

Three years of sampling for fish larvae in Normandy Reservoir resulted in the identification of 23 taxa from a total of 91,362 larvae collected. Table 1 lists, by year, each taxon collected with total number, relative abundance, minimum and maximum length, and total volume of water filtered.

Temporal distribution of all larvae by sample date for each year is shown in Fig. 2. Values represent densities averaged from both day and night samples as well as all transects and stations combined. Mean reservoir temperatures recorded at the time of first larval fish occurrence were approximately 14 C during each of the three years of sampling. Larvae of at least 3 species (*Campostoma anomalum*, *Pomoxis* spp., unspecifiable percid) were collected on the first sample date (8 April) in 1976, indicating that the first spawning in Normandy Reservoir had occurred on or before 1 April.

Initial larval concentrations in 1976 (Fig. 2) consisted primarily of unspecifiable percid larvae on 19 April and *Pomoxis* larvae on 26 April and 3 May. Beginning with the 24 May sample and for the rest of the 1976 samples, larval densities [from] in Normandy Reservoir were dominated by *Lepomis*.

In 1977, larval stonerollers (*Campostoma anomalum*) and 1 larval catostomid were the first larvae observed (4 April). *Pomoxis* was the most abundant taxon during April. The highest larval densities observed in 1978 (biweekly sampling) were 863/1000m^3 and 846/1000 m^3 on 10 and 24 May, respectively (Fig. 2); over 90% of these larvae were *Pomoxis* spp.

Cove Rotenone

Two cove rotenone samples (1.0 ha) in 1976 yielded 2,525 fish weighing 111 kg. Centrarchids, at 70%, dominated the cove populations, followed by cyprinids and ictalurids, at 16.6 and 3.5%, respectively. Among the centrarchids, green sunfish (*Lepomis cyanellus*) were most abundant (22%), followed by largemouth bass (*Micropterus salmoides*), longear sunfish (*L. megalotis*), and bluegill (*L. macrochirus*) at 16, 11, and 8%, respectively. The only percids collected from the 2 coves were 37 logperch (*Percina caprodes*) and 8 walleye (*Stizostedion vitreum*). No clupeids were collected from cove samples in 1976. Total fish numbers and relative abundance data from 1976-1978 cove rotenone samples are given in Table 2.

In 1977, rotenone samples from the same 2 coves (area reduced to 0.65 ha) were dominated by bluegill (71%), threadfin shad (16%), and longear sunfish (5%). Combined centrarchids increased in abundance in 1977 (82% from 70% in 1976). Cyprinids were less abundant in 1977 (0.42%) than in 1976 (16.6%).

Two additional coves (Fig. 1) were sampled in 1978, for a total area sampled of 1.54 ha. Bluegills, as in 1977, dominated the total sample (79%). Centrarchids made up 92% of the total sample. In contrast to 1977, when threadfin shad ranked second in relative abundance (16%), gizzard shad in 1978 comprised over 5% of the total sample. No threadfin shad were recovered in 1978.

DISCUSSION OF SELECTED TAXA

Cyprinidae

Cyprinids, including carp (*Cyprinus carpio*) comprised 2.5% (710 specimens) of the 1976 larval samples (Table 1). Stonerollers (*Campostoma anomalum*) were the most abundant cyprinid taxon, reaching a maximum density of 54/1000 m^3 on 24 May. Many of the cyprinids (*Notropis* spp.) were adults and represented riverine species present in the reservoir as a result of impoundment. In 1977, the relative abundance of cyprinids

TABLE 1. Total numbers, percent relative abundance, and length ranges of larval and juvenile fishes collected at Normandy Reservoir, 1976-1978.

Family	Family Rel. Abundance (%)	Taxon	Total Collected	Taxon Rel. Abundance (%)	Length Range (mm) Min.	Max.
1976 (April 8 - August 20) Total volume of water sampled 67,000 m^3.						
Centrarchidae	94.66	Lepomis spp.	25,790	88.91	4	24
		Pomoxis spp.	1,246	4.30	4	25
		P. nigromaculatus	265	0.91	20	82
		Unspecified centrarchids	76	0.26	4	7
		P. annularis	59	0.20	20	55
		Ambloplites rupestris	13	0.04	8	37
		Micropterus spp.	5	0.02	6	11
		M. dolomieui	5	0.02	12	45
Percidae	2.84	Unspecified percids	822	2.83	5	23
		Stizostedion spp.	1	0.00	18	18
Cyprinidae	2.45	Campostoma anomalum	365	1.26	9	56
		Notropis spp.	152	0.52	6	57
		Cyprinus carpio	112	0.37	5	22
		Unspecified cyprinids	81	0.28	5	41
Clupeidae	0.03	Unspecified clupeids	8	0.03	5	14
Catostomidae	0.02	Unspecified catostomids	5	0.02	11	33
		Minytrema melanops	1	0.00	15	15
Esocidae	tr	Esox spp.	1	0.00	22	22
Ictaluridae	tr	Ictalurus natalis	1	0.00	16	16
		Total Fish	29,008			
		Average Density	0.43/m^3			
1977 (March 14 - August 24) Total volume of water sampled 93,000 m^3.						
Centrarchidae	92.50	Lepomis spp.	45,098	88.87	4	30
		Pomoxis spp.	1,699	3.35	4	21
		Unspecified centrarchids	74	0.15	5	11
		P. nigromaculatus	52	0.10	87	146
		P. annularis	16	0.03	113	143
Clupeidae	7.27	Unspecified clupeids	3,459	6.82	4	24
		Dorosoma petenense	231	0.46	20	51
Cyprinidae	0.19	Campostoma anomalum	69	0.14	9	11
		Cyprinus carpio	14	0.03	5	7
		Notemigonus crysoleucas	12	0.02	5	100
		Unspecified cyprinids	2	0.00	5	6
Percidae	0.04	Unspecified percids	18	0.04	7	11
Catostomidae	tr	Unspecified catostomids	2	0.00	8	11
		Total Fish	50,7[illegible]			
		Average Density	0.55/m^3			
1976 (March 29 - August 31) Total volume of water sampled 43,000 m^3.						
Centrarchidae	88.51	Pomoxis spp.	6,102	48.87	4	27
		Lepomis spp.	4,933	39.51	4	27
		Unspecified centrarchids	14	0.11	6	9
		Micropterus dolomieui	1	0.01	11	11
		Pomoxis nigromaculatus	1	0.01	156	156
Clupeidae	10.93	Unspecified clupeids	1,338	10.72	3	22
		Dorosoma cepedianum	27	0.22	20	36
Cyprinidae	0.33	Cyprinus carpio	41	0.33	5	6
Percidae	0.22	Unspecified percids	26	0.21	7	24
		Percina caprodes	2	0.02	25	26
		Total Fish	12,485			
		Average Density	0.29/m^3			

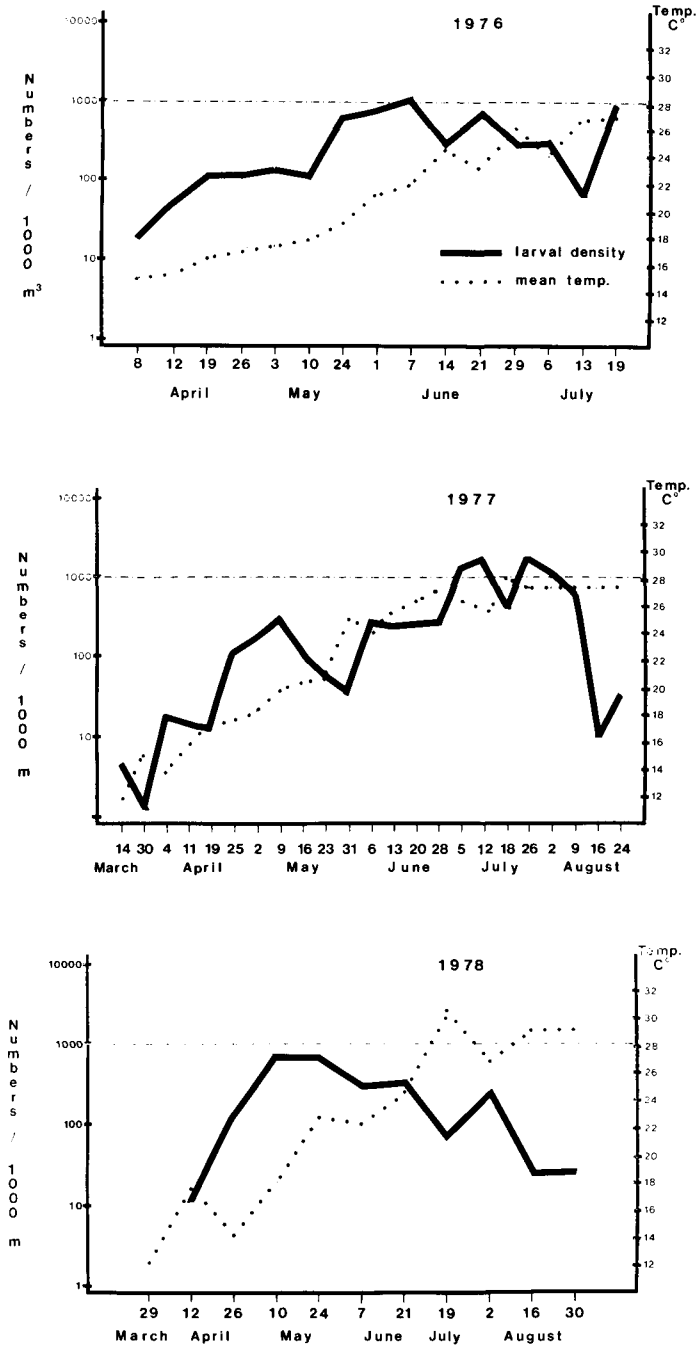

Fig. 2. Seasonal densities of total fish from larval samples (numbers per 1000 m^3) observed at Normandy Reservoir, 1976-1978.

TABLE 2. Total numbers and percent relative abundance of fishes collected in rotenone samples from Normandy Reservoir, 1976-78.

Family	Family Rel. Abundance (%)	Taxon	Total Collected	Taxon Rel. Abundance (%)
1976 area sampled 1.0 hectares. Sample date July 14-17.				
Centrarchidae	70.1	Lepomis cyanellus	347	21.86
		Micropterus salmoides	400	15.99
		Lepomis megalotis	282	11.27
		Lepomis macrochirus	209	8.35
		Pomoxis annularis	167	6.67
		Ambloplites rupestris	47	1.88
		Lepomis gulosus	41	1.64
		Micropterus punctulatus	31	1.24
		Lepomis microlophus	30	1.20
Cyprinidae	16.62	Cyprinus carpio	177	7.07
		Campostoma anomalum	165	6.59
		Notropis cornutus	39	1.56
		Notropis spp.	24	0.96
		Notropis atherinoides	9	0.36
		Semotilus atromaculatus	2	0.08
Ictaluridae	5.08	Ictalurus natalis	56	2.24
		Ictalurus melas	48	1.92
		Ictalurus nebulosus	22	0.88
		Ictalurus punctatus	1	0.04
Catostomidae	3.48	Minytrema melanops	32	1.28
		Moxostoma erythrurum	19	0.76
		Catostomus commersoni	12	0.48
		Hypentelium nigricans	9	0.36
		Moxostoma carinatum	8	0.32
		Moxostoma duquesnei	4	0.16
		Moxostoma anisurum	3	0.12
Esocidae	1.84	Esox niger	46	1.84
Percidae	1.80	Percina caprodes	37	1.48
		Stizostedion vitreum vitreum	8	0.32
Cyprinodontidae	0.96	Fundulus notatus	13	0.52
		Fundulus olivaceus	11	0.44
Poeciliidae	0.08	Gambusia affinis	2	0.08
Cottidae	0.04	Cottus carolinae	1	0.04
		Total Fish	2,502	
1977 area sampled 0.65 hectares. Sample date September 20-22.				
Centrarchidae	84.14	Lepomis macrochirus	7,719	70.64
		Lepomis megalotis	584	5.34
		Lepomis gulosus	440	4.03
		Lepomis cyanellus	150	1.37
		Micropterus salmoides	53	0.49
		Lepomis microlophus	14	0.13
		Pomoxis annularis	10	0.09
		Pomoxis nigromaculatus	6	0.05
Clupeidae	16.34	Dorosoma petenense	1,785	16.34
Catostomidae	0.58	Minytrema melanops	34	0.31
		Moxostoma duquesnei	22	0.20
		Hypentelium nigricans	4	0.04
		Moxostoma macrolepidotum	2	0.02
		Catostomus commersoni	1	0.01

Cyprinidae	0.42	Cyprinus carpio	28	0.26
		Notropis atherinoides	11	0.10
		Campostoma anomalum	6	0.05
		Notemigonus crysoleucas	1	0.01
Ictaluridae	0.30	Ictalurus nebulosus	12	0.11
		Ictalurus natalis	3	0.03
		Ictalurus punctatus	2	0.02
		Ictalurus melas	1	0.01
Percidae	0.20	Percina caprodes	22	0.20
Cyprinodontidae	0.13	Fundulus notatus	14	0.13
Esocidae	0.03	Esox niger	3	0.03
		Total Fish	10,927	
1978 area sampled 1.54 hectares.		Sample date September 5-19.		
Centrarchidae	91.87	Lepomis macrochirus	33,345	78.67
		Lepomis gulosus	1,670	3.94
		Lepomis megalotis	1,656	3.91
		Lepomis cyanellus	1,080	2.55
		Micropterus salmoides	408	0.96
		Pomoxis annularis	340	0.80
		Pomoxis nigromaculatus	319	0.75
		Lepomis microlophus	59	0.14
		Ambloplites rupestris	54	0.13
		Hybrid lepomis spp.	8	0.02
		Micropterus punctulatus	1	0.00
Clupeidae	5.36	Dorosoma cepedianum	2,271	5.36
Cyprinidae	1.64	Cyprinus carpio	665	1.57
		Notropis spilopterus	29	0.07
		Notropis spp.	2	0.00
		Notropis crysoleucas	1	0.00
Catostomidae	0.57	Minytrema melanops	119	0.28
		Moxostoma duquesnei	75	0.18
		Moxostoma macrolepidotum	23	0.05
		Hypentelium nigricans	13	0.03
		Moxostoma anisurum	12	0.03
		Catostomus commersoni	1	0.00
Percidae	0.24	Percina caprodes	101	0.24
		Etheostoma caeruleum	2	0.00
		Stizostedion vitreum vitreum	1	0.00
Ictaluridae	0.22	Ictalurus natalis	52	0.12
		Ictalurus melas	36	0.08
		Ictalurus punctatus	8	0.02
Cyprinodontidae	0.05	Fundulus notatus	21	0.05
Esocidae	0.01	Exos niger	4	0.01
Poeciliidae	0.01	Gambusia affinis	5	0.01
Cottidae	0.01	Cottus carolinae	3	0.01
		Total Fish	42,384	

decreased to 0.2% of over 50,000 larvae collected. Mean length of cyprinids also decreased in 1977 (Table 1), with stonerollers remaining the most abundant taxon. In 1978, 41 carp larvae (5-6 mm) collected on 10 May were the only cyprinids observed among over 12,000 fish in 286 samples.

Percidae

Percids comprised 2.8% (822) of all larvae collected in Normandy Reservoir in 1976. One 18 mm specimen of *Stizostedion*, apparently one of the 250,000 walleye fry stocked in March 1976, was collected. the remaining 821 specimens, representing the genera *Etheostoma* and *Percina*, were identified as unspecifiable percids (Table 1) and reached a peak density of 107/1000 m^3 on April 19. Ninety percent of these were collected at the upstream transect and, as they represent typical stream-dwelling darter species, would not be expected to occur commonly in reservoir samples in subsequent years of impoundment. In 1977 and 1978, percids made up only 0.04 and 0.22% of the catch, respectively.

Centrarchidae

Larval populations were dominated during all 3 years by centrarchids, primarily *Lepomis* spp. (more than 90% of all larvae collected). Larval centrarchids were observed at a peak seasonal density of over 5000/1000 m^3 in 1976 (7 June). In 1977, the peak density increased to over 2,200 larvae/1 000 m^3 (12 July). Biweekly sampling in 1978 recorded a peak density of only 800 centrarchid larvae/1,000 m^3. The majority of the centrarchid larvae collected were 5-10 mm in total length. Relative abundance of larval centrarchids decreased during the three years of sampling from 94.6% in 1976 to 92.5 and 88.5% in 1977 and 1978, respectively (Table 1). Relative abundance of centrarchids in rotenone samples (Table 2) increased each year, i.e., 70% in 1976, 84% in 1977, and 92% in 1978.

Larval *Pomoxis* spp. (identified only to genus <20 mm) were collected during all 3 years of sampling in Normandy Reservoir. No crappie were collected from the Duck River during the survey by TVA (1975) prior to impoundment. Peak densities of larval crappie increased progressively during each year following impoundment (Table 1 and Fig. 3). Over 6,000 larval *Pomoxis* were collected in 1978, constituting 49% (Table 1) of the total catch. The periods of greatest larval density in 1978 (10 and 24 May Fig. 2) were dominated (90%) by larval crappie (780 and 760/1000 m^3, respectively).

In 1976, 324 specimens of juvenile crappie (20-80 mm), much larger than normally captured by a fine-meshed larval net, were observed in the samples. The length frequency analysis (Fig. 3) of all *Pomoxis* for each year indicated this phenomenon recurred in the first sample periods of 1977 when 69 crappie from 87-146 mm in length were captured. Exceptionally high survival by the first year's spawn, resulting in concentrations of juvenile crappie vulnerable to capture by a 0.5 m larval net appears to have occurred. The 80-150 mm crappie collected in 1977 represented the 1976 year class, and none of the 1977 spawn collected were over 25 mm in length compared to 324 20-80 mm fish captured in 1976. In 1978, only 1 crappie (156 mm) greater than 27 mm total length was collected by the larval net. The absence of juvenile crappie (20-80 mm) from the 1977 and 1978 larval samples, in light of their occurrence in 1976, suggests a much lower survival rate by crappie spawned during the second and third years of impoundment. This assumption is supported by the paucity of young-of-the-year (<130 mm) crappie recovered from cove rotenone samples during 1977 and 1978. Siefert (1969) also observed the strongest year class of white crappie (*Pomoxis annularis*) to occur during the first year after impoundment of Lewis and Clark Lake followed by 3 consecutive years of relatively poor year-class strength. Patriarche and Campbell (1958) recorded the strongest year class of white crappie during the third year of impoundment in Clearwater Lake, Missouri.

Table 3 compares potential year-class strength of young-of-the-year crappie as measured by larval and rotenone sampling during the first three years of impoundment. Values from larval sampling represent mean seasonal densities (number of larvae per 1000 m^3 of water filtered). From this study, it is concluded that the establishment of a strong year class of crappie is not dependent on a profilic spawn as measured by larval abundance.

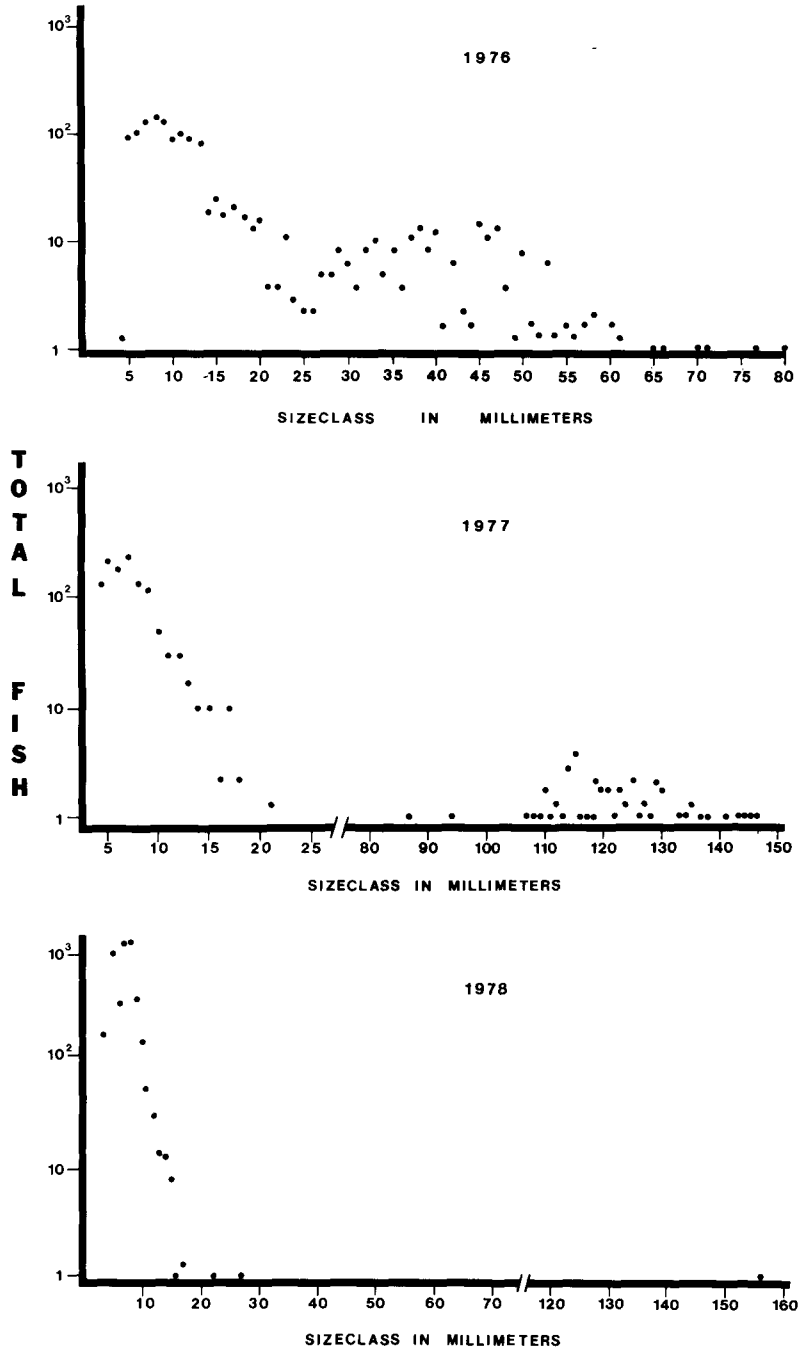

Fig. 3. Length frequency of all *Pomoxis* collected by larval sampling in Normandy Reservoir, 1976-1978.

TABLE 3. Comparison of potential year-class strength of YOY crappie (*Pomoxis* spp.) as indicated by larval and rotenone sampling in Normandy Reservoir, 1976-1978.

Year	Larval Sampling		Rotenone Sampling	
	Total Larvae Collected	Larvae 1000/m^3	Total YOY/ha	Total Area (ha) Sampled
1976	1,246	18.6	167	1.00
1977	1,699	18.3	0	0.65
1978	6,902	142.0	39	1.54

Clupeidae

Beginning in 1977, the Tennessee Wildlife Resources Agency stocked adult threadfin shad in Normandy Reservoir in an attempt to establish a desirable prey base for black bass and other piscivorous species. Ten thousand threadfin were stocked in March 1977; and 3,000, in June 1978. In 1976, prior to stocking threadfin shad, 330 larval samples contained only eight clupeid larvae from 5-14 mm in total length. These were thought to be larval gizzard shad, as this was the only clupeid known to occur in the Duck River above mile 17 prior to impoundment (TVA 1975). Larval clupeids are not currently identifiable to species at less than 20 mm total length.

In 1977, following the introduction of threadfin, approximately 3,500 clupeids and 231 threadfin shad (>20 mm) were identified from the larval samples. No gizzard shad were identified. Larval clupeids first occurred in 1977 on 19 April and were observed as larvae or postlarvae on every sample date until sampling ceased on 24 August. The highest clupeid density observed was 140/1000 m^3 on 16 May. Rotenone samples from two coves (0.65 ha) in 1977 contained 1,785 threadfin (16.3%) and no gizzard shad.

Larval samples in 1978 contained 1,338 shad larvae less than 20 mm in length. Twenty-seven specimens (>20 mm) were identified as gizzard shad. Absence of threadfin shad from 1978 samples was apparently the result of failure to overwinter in Normandy Reservoir. An additional 3,000 threadfin were stocked in June 1978, but no spawn was observed, and only gizzard shad (2,271) were taken in the 4 cove rotenone samples. A sample (15) of these gizzard shad was aged; 14 (95%) belonged to the 1977 year class (age 1+). Only 305 specimens from the rotenone samples were less than 130 mm in length, which would be the maximum expected growth for young-of-the-year gizzard shad. No explanation is apparent for the absence of 1977 year-class gizzard shad from both larval and rotenone samples in 1977, though the species was abundant in all 4 coves poisoned in 1978.

SUMMARY

Diversity of larval fish populations in Normandy Reservoir decreased by the third year of impoundment to only 6 taxa (Table 1) representing 4 families. Two of these families (Cyprinidae, 0.33 %, **Percidae,** 0.22%) represented a total of less than 1% of all larvae captured.

Mean seasonal densities (total larvae per volume sampled) of larval fish populations observed during the first 3 years of impoundment were: 0.43/1000 m^3, 0.55/1000 m^3, and 0.29/1000 m^3 in 1976, 1977, and 1978, respectively. The increased density in 1977, as well as the decline in 1978, resulted from significant increase and decreases in the magnitude of lepomis spawning in these two years (Table 1). High population density by 1976 and 1977

may have limited reproduction and survival in 1978 as has been observed elsewhere by Krumholz (1949) and Anderson (1971).

Species diversity did not change significantly during the first 3 years following impoundment of Normandy Reservoir as measured by cove rotenone sampling (Table 2). Thirty-three species (*Notropis* spp. counted as one) were identified from 2 coves in 1976, compared with 34 species collected at mile 245 of the Duck River in 1972 (TVA 1975). Total density of fish, however, increased dramatically from 2,502/ha in 1976, to 16,810/ha in 1977, and 27,522/ha in 1978. Reproduction by bluegill accounted for the majority of this increase (Table 2). Only 209 bluegill were collected from two coves in 1976, but the same coves yielded 7,719 bluegill in 1977, and in 1978, 33,345 bluegill were taken from four coves.

A direct relationship may exist between the overall dominance by bluegill and the less than expected abundance of shad in Normandy Reservoir. Competition for zooplankton was observed between bluegill larvae and shad in the same habitat by Mayhew (1977) in a new reservoir in Iowa. No competition for food was observed between gizzard shad and crappie larvae in that study.

Population trends of fishes in Normandy Reservoir during early impoundment were typical when compared with other postimpoundment studies. The observed dominance of centrarchids and clupeids was also noted by Carter (1969) during the first three years of impoundment in Barren Reservoir, Kentucky. Fitz (1968) noted an increase in number of white crappie and bluegill after impoundment of Melton Hill Reservoir in Tennessee.

Threadfin shad stocked in Normandy in 1977 spawned successfully, but apparently failed to overwinter and were replaced in 1978 by gizzard shad. Successful establishment of a threadfin population might be accomplished by further stocking, but winterkills appear to be a major limiting factor.

Factors associated with the high survival of the 1976 year class of crappie are thought to include: lack of competition for food and low concentration of predators. Reduction in survival of the 1977 and 1978 cohorts in spite of increased spawning and larval abundance could have been due to competition and predation by other centrarchids.

This illustrates the usefulness of larval sampling for better understanding the life history stage at which year-class strength of fishes is established in reservoirs. Relative spawning success and larval abundance appear in at least one instance to be negatively correlated with subsequent year-class strength. Larval sampling would appear to be most useful to document spawning occurrence and localities by selected species, but rotenone or other sampling is required to assess survival and year-class strength. If successful spawning is documented by larval sampling, but year-class strength is later found to be weak, fishery management decision makers would be better informed with regards to stocking needs, prey availability, etc.

LITERATURE CITED

Amundrud, J.R., D.J. Faber, and A. Keast. 1974. Seasonal succession of free-swimming perciform larvae in Lake Opinicon, Ontario. J. Fish. Res. Board Can. 31:1661-1665.

Anderson, R.O. 1971. Stocking strategies for warmwater fishes in lentic environments. Proc. North Cent. Warmwater Fish Cult. Manage. Workshop, Iowa Coop. Fish. Unit. 247 pp.

Beckman, L.G., and J.H. Elrod. 1971. Apparent abundance and distribution of young-of-the-year fishes in Lake Oahe. Pages 333-347 *in* G. Hall, ed. Reservoir Fisheries and Limnology. Spec. Publ. No. 8 Am. Fish. Soc., Washington, D.C.

Carter, J.P. 1969. Pre- and post-impoundment surveys on Barren River. Ky. Fish. Bull. No. 50, 33 pp.

Fitz, R.B. 1968. Fish habitat and population changes from impoundment of Clinch River by Melton Hill Reservoir. J. Tenn. Acad. Sci., 43:7-15.

Gasaway, C.R. 1970. Changes in the fish population in Lake Francis Case in South Dakota in the first 16 years of impoundment. U.S. Fish Wildl. Ser., Tech. Pap. 56. 30 pp.

Graser, L.F. 1977. Selectivity of larval fish gear and some new techniques for entrainment and open water larval fish sampling. Pages 56-71 *in* L.L. Olmsted, ed. Proc. First Symp. Freshwater Larval Fish. Duke Power Co., Huntersville, North Carolina. 251 pp.

Hall, G.E. 1974. Sampling reservoir fish populations with rotenone. Symposium on Methodology for the Survey, Monitoring, and Appraisal of Fishery Resources in Lakes and Large Rivers; 1974, May 2-4; Aviemore, Scotland. Rome: FAO; 1974. 14 pp. EIFAC technical paper-23.

Hashagen, K.A. 1973. Population structure changes and yields of fishes during the initial eight years of impoundment of a warmwater reservoir. Calif. Fish Game 59:221-224.

Hogue, J.J., R. Wallus, and L.K. Kay. 1976. Preliminary guide to the identification of larval fishes in the Tennessee River. Tech. Note B19. Fisheries and Waterfowl Resources Branch, TVA. 66 pp.

June, F.C. 1976. Changes in young-of-the-year fish stocks during and after filling of Lake Oahe, an upper Missouri River storage reservoir, 1966-74. U.S. Fish Wildl. Serv., Tech Pap. 87. 25 pp.

Krumholz, L.A. 1949. Rates of survival and growth of bluegill yolk fry stocked at different intensities in hatchery ponds. Trans. Amer. Fish. Soc. 76:190-203.

Martin, R.G., and R.S. Campbell. 1953. The small fishes of Black River and Clearwater Lake, Missouri. Univ. Mo. Studies, 26(2):45-65.

Mayhew, 1977. The effects of flood management regimes on larval fish and fish food organisms at Lake Rathbun. Iowa Conserv. Comm. Tech. Ser. 77-2.

Nelson, W.R., R.E. Siefert, and D.V. Swedberg. 1968. Studies of the early life history of reservoir fishes. Pages 374-385 *in* Reservoir Fishery Resources Symposium, Southern Division, Amer. Fish. Soc., Athens, Georgia, USA.

Patriarche, M.H., and R.S. Campbell. 1958. The development of the fish population in a new flood-control reservoir in Missouri, 1948-1954. Trans. Amer. Fish. Soc. 87:240-258.

Siefert, R.A. 1969. Biology of the white crappie in Lewis and Clark Lake. U.S. Bur. Sport Fish. Wild., Tech. Pap. 22, 16 pp.

Tennessee Valley Authority. 1972. Environmental Statement, Duck River Project. Office of Health and Environmental Science. TVA-OHES-EIS-72-5.

Tennessee Valley Authority. 1975. Tennessee Valley streams: their fish, bottom fauna, and aquatic habitat. Duck River Drainage Basin. Division of Forestry, Fisheries, and Wildlife Development, Fisheries and Waterfowl Resources Branch. 28 pp.

Walburg, C.H. 1976. Changes in the fish population of Lewis and Clark Lake, 1956-74, and their relation to water management and the environment. U.S. Fish Wildl. Serv., Res. Rep. 79. 32 pp.