Impact Assessment of Extreme Drawdown on the Watauga Reservoir Fishery

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Abstract: A 70% reduction of total reservoir area during an extended drawdown impacted Watauga Reservoir fish populations. Response to the drawdown and refilling was species specific. Abundance of alewife (*Alosa Pseudoharengus*) and bluegill (*Lepomis macrochirus*), 2 primary prey species, decreased while young of year gizzard shad (*Dorosoma cepedianum*) increased. Changes in growth and relative weight indicated some predators (walleye *Stizostedion vitreum vitreum*) benefited by the reduction of lake volume. This was not the case with black bass (*Microterus* spp). Species composition and relative abundance following the drawdown were similar to those which occur when a new reservoir is filled. The fishery, though affected, was not greatly impacted during the drawdown.

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During fall-winter 1983 the Tennessee Valley Authority (TVA) lowered the water level in Watauga Reservoir to elevation 556 m above mean sea level (msl), 27 m lower than normal winter pool, to conduct inspection and maintenance of Watauga Dam and its intake and sluice structures. Reaching the target elevation by early December required beginning the drawdown during June. Elevation 556 m above msl was to be maintained for only 1 week before the lake was allowed to refill. With normal inflow and releases, lake elevation the following summer was projected to be approximately 9 m below normal.

An abundance of literature indicated that an extreme drawdown and prolonged period of abnormally low water would substantially affect fish populations. In addition, the sport fishery was expected to be affected by reduced boat access. Therefore, an ongoing creel survey was continued through this period and relative abundance of prey and predators, and condition and growth of larger predators were measured to determine changes between pre- and post-drawdown fish stocks.

The objectives of this study were 1) to quantify impacts to the fishery and fish assemblages to determine needs and feasibility for mitigation and 2) to extend information required to project more precisely impacts of similar drawdowns on TVA storage impoundments.

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Methods

Watauga Reservoir was created in December 1948 by completion of Watauga Dam at Watauga River Mile (WRM) 36.7, 8.1 km east of Elizabethton, Tennessee. It is a typical deep, oligotrophic, mountain reservoir with steep shorelines which have been eroded leaving much of the drawdown zone covered by rock. Watauga has an approximate drawdown zone of 13.4 m between the normal maximum and minimum pool elevations of 597 m above msl (2,603 ha) to 584 m above msl (1,899 ha), respectively. At normal maximum pool Watauga has 171 km of shoreline and a total backwater length of 26.3 km. Other major tributary streams include the Elk River and Roan Creek.

Pre-drawdown (1983) and post-drawdown (1984) fish samples were collected using gill nets, electrofishing, and rotenone. Target species were smallmouth bass (*Micropterus dolomieui*), largemouth bass (*M.salmoides*), walleye (*Stizostedion vitreum vitreum*), rainbow trout (*Salmo gairdneri*), alewife (*Alosa pseudoharengus*), and gizzard shad (*Dorosoma cepedianum*). Data collected prior to 1983 were also examined to assist in detecting any long- or short-term trends involving resident fish populations in Watauga.

The reservoir was sampled with gill nets in April 1983 and 1984 to collect walleye. Both sinking monofilament experimental gill nets—30.5 m x 2.4 m with 5 6.1-m panels, 1.3, 2.5, 3.8, 5.1 and 6.4-cm bar mesh—and nylon mesh gill nets—30.5 m x 2.4 m with either 3.8 or 5.1-cm bar mesh—were used. Five experimental, 4 3.8-cm, and 2 5.1-cm bar mesh gill nets were set perpendicular to the shoreline in the upper half of the reservoir for 1 overnight period during 1983. Eight experimental and 4 3.8-cm mesh nets were set for 1 overnight period in April 1984. Additional walleye were collected by night electrofishing during both pre- and post-drawdown years.

Watauga was sampled by night electrofishing during April 1983 and April–May 1984 to collect basic life history information (length, weight, and scales) from smallmouth and largemouth bass. Electrofishing information collected by the Tennessee Wildlife Resource Agency (TWRA) in spring 1983 was also included.

All walleye, smallmouth bass, largemouth bass, and rainbow trout were weighed (g) and measured (mm total length). TWRA data were recorded in English units and converted to metric units prior to analysis. Scale samples were taken from walleye, smallmouth bass, and largemouth bass. Scales were pressed on cellulose acetate slides and projected with a 17X power modified scale projector onto a digitizing pad linked to a personal computer (PC) similar to the system described by Frie (1982). Age and growth analysis was performed by PC with a modified Frie (1982) program using the direct proportion method to back-calculate lengths (Carlander 1981).

Rotenone samples were collected from 2 coves in July 1983 and 1984 (pre- and post-drawdown). Recent historical cove rotenone samples (1972–1982) were also used to supplement the 1983 pre-drawdown data. Cove selection was restricted to those previously sampled. Methods used are described in the Field Operations Standard Procedures Manual (TVA 1983). Cove rotenone data were analyzed for species occurrence, composition, standing stock, and biomass estimates divided into adult, juvenile, and young-of-year (Y-O-Y) classes.

TWRA creel survey records for Watauga Reservoir were available from July 1967 through June 1983. A joint TVA-TWRA creel survey was conducted from July 1983 through June 1985. These data were used to estimate yearly harvest, harvest raste (number per hour), hours of fishing, and mean weight per fish for both the overall fishery and specifically sought species. Simple linear regression was used to examine trends throughout the entire creel survey period.

Analysis of the electrofishing and gill netting samples included calculation of proportional stock densities (PSD), relative stock densities (RSD) and relative weight (W_r) (Anderson and Weithman 1978). Total lengths for stock, quality, preferred, memorable, and trophy sizes were based on percentages of the world record lengths (Gabelhouse 1984). Largemouth bass length categories were based on percentages of the Tennessee state record since the world record was a Florida subspecies. Standard weights used to calculate W_r for walleye, smallmouth bass, and largemouth bass were generated from length-weight relationships for those species based on all data from tributary reservoirs available in the TVA data base. A W_r of 100 (± 5) is considered good (Anderson and Weithman 1978). Student's t-test was used to test for differences in W_r between years. Additionally, growth rates between years were compared using back-calculated lengths at age for each age group.

Results and Discussion

Drawdown of Watauga Reservoir followed projections very closely. The target elevation of 556 m above msl was reached on schedule in early December and held for approximately 1 week. Refilling of the reservoir occurred more quickly than anticipated. Normally the reservoir reaches maximum elevation during April and May. During that period in 1984 Watauga Reservoir was still filling and reached a maximum elevation of 593 m above msl by early August. During mid-August 1984 the reservoir elevation was almost 3 m above the 15 year median. Therefore, effects of prolonged low water levels on the recreational fishery were reduced accordingly to approximately 8 months from September 1983 to April 1984.

Watauga became turbid during the drawdown due to resuspension of silt depositions from the exposed reservoir bottom. Turbidity remained unusually high throughout the drawdown period.

Cove rotenone data provided a general description of the pre- and post-drawdown Watauga Reservoir fish community in both species composition and, in most cases, relative abundance. A major exception was the absence of salmonids

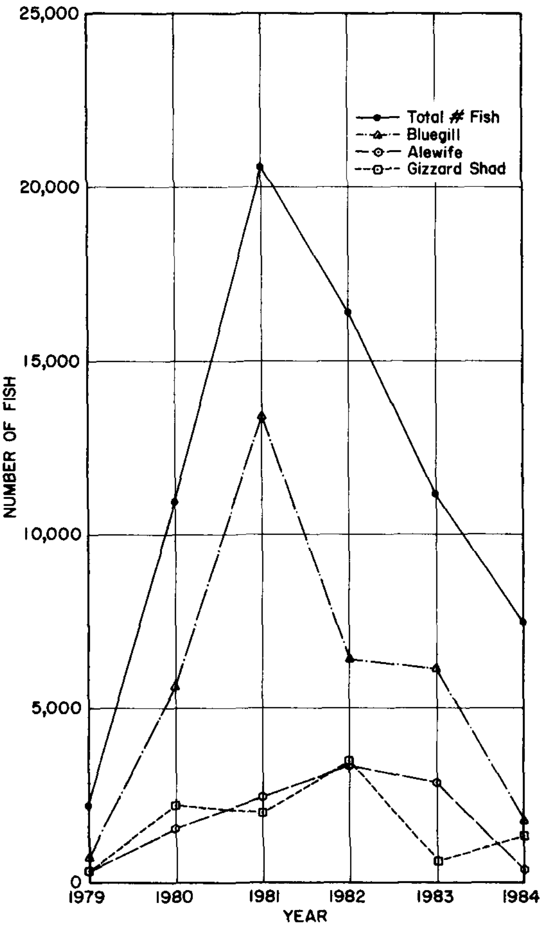

Figure 1. Number of fish per hectare in Watauga Reservoir cove rotenone samples 1979–1984.

in these samples. Species composition was relatively stable for the pre-drawdown period, 1979 through 1983. Bluegill (*Lepomis macrochirus*) were consistently the most abundant contributing from 30% to 65% of the sample annually followed by alewife and/or gizzard shad which constituted from 20% to 40% of the sample. These are the primary prey species in Watauga. Estimated total abundance of all species increased from 1979 through 1981 then declined through 1984 (Fig. 1). This general pattern was a reflection of changes in abundance of the three primary prey species. Although introduction of alewife in 1976 may have affected the other prey species, it is more likely the rise and fall in abundance of prey populations was related to changing physical parameters affecting reproduction and survival through this period. In this case, the decrease in abundance of both bluegill and alewife from 1983 to 1984 was pronounced (Table 1). Although 1984 was a continuation of the downward trend in prey abundance, the drawdown apparently accel-

Table 1. Percent composition of fish taken in cove rotenone samples prior to (1983) and after (1984) drawdown. Number in parentheses represent estimated numbers per hectare.

Species	1983	1984
Alewife *Alosa pseudoharengus*	25.36(2,833.1)	4.01(298.4)
Gizzard shad *Dorosoma cepedianum*	5.03(561.9)	17.28(1,284.5)
Central stoneroller *Campostoma anomalum*	0.05(5.7)	0.07(5.3)
Carp *Cyprinus carpio*	0.11(12.8)	1.30(96.7)
Bigeye chub *Hybopsis amblops*	0	0.01(0.8)
Golden shiner *Notemigonus crysoleucas*	0.20(22.3)	1.64(122.1)
Striped shiner *Notropis chrysocephalus*	0	0.03(2.4)
Warpaint shiner *N. coccogenis*	0.02(2.7)	0
Whitetail shiner *N. galacturus*	0.05(6.0)	0.03(2.0)
Spotfin shiner *N. spilopterus*	0.61(68.7)	0.68(50.4)
Telescope shiner *N. telescopus*	T(0.3)	T(0.4)
Bluntnose minnow *Pimephales notatus*	8.58(958.7)	12.04(895.0)
Fathead minnow *P. promelas*	0.01(1.6)	T.(0.4)
Bullhead minnow *P. vigilax*	0	3.66(272.2)
Blacknose dace *Rhinichthys atratulus*	0	0.01(0.8)
Creek chub *Semotilus atromaculatus*	T(0.3)	0
White sucker *Catostomus commersoni*	0.04(4.9)	0.04(3.3)
Northern hog sucker *Hypentelium nigricans*	0.04(1.4)	0.01(0.8)
River redhorse *Moxostoma carinatum*	0	T(0.4)
Black redhorse *M. duquesnei*	0.07(8.2)	0.05(4.0)
Golden redhorse *M. erythrurum*	0.23(25.7)	1.12(83.2)
Shorthead redhorse *M. macrolepidotum*	0.03(3.1)	0
Yellow bullhead *Ictalurus natalis*	0	T(0.4)
Channel catfish *I. punctatus*	0.88(98.4)	1.51(112.5)
Stonecat *Noturus flavus*	0	T(0.4)
Margined madtom *N. insignis*	0	0.01(0.8)
Flathead catfish *Pylodictis olivaris*	0.05(6.1)	0.03(2.3)
Brook silverside *Labidesthes sicculus*	0	0.11(8.2)
Rock bass *Ambloplites rupestris*	0.54(60.1)	0.15(11.3)
Redbreast sunfish *Lepomis auritus*	T(0.3)	0
Green sunfish *L. cyanellus*	0	0.06(4.2)
Bluegill *L. macrochirus*	54.29(6,066.3)	22.58(1,678.5)
Smallmouth bass *Micropterus dolomieni*	0.87(96.9)	6.12(454.5)
Largemouth bass *M. salmoides*	2.32(259.1)	25.93(1,927.5)
White crappie *Pomoxis annularis*	0.27(30.0)	0.81(60.3)
Black crappie *P. nigromaculatus*	0.26(28.6)	0.35(25.8)
Logperch *Percina caprodes*	0.01(1.4)	0
Walleye *Stizostedion vitreum vitreum*	0.04(4.7)	0.04(3.3)
Freshwater drum *Aplodinotus grunniens*	0.04(3.9)	0.02(1.2)

T = <0.01%

erated this trend by concentrating predator and prey, reducing the food base for prey species in the highly turbid pool, and reducing cover. Also, an undetermined number of alewife were lost downstream through the dam during the drawdown. Although dead walleye were also observed below Watauga Dam, losses appeared to be extremely limited for species other than alewife.

A dramatic shift in species composition occurred following the drawdown. Largemouth bass, primarily Y-O-Y, became the most abundant species (1,927.5 per hectare) in cove rotenone samples increasing from 2.3% to 25.9% of the sample

(Table 1). Smallmouth bass also appeared in much larger numbers increasing from 0.9% to 6.1% of the sample (Table 1). Large increases in black bass reproduction are typical when reservoirs are first inundated, subcharged, or rapidly filled following extensive drawdowns (Keith 1975). Approximately 500 acres of shoreline seeding and bank fertilization was completed by an active regional sportsman society with the assistance of TVA and TWRA. Most of these plantings were in the upper reservoir area early in the drawdown period allowing coverage before winter. The drawdown in combination with revegetation apparently simulated the new reservoir cycle. Two or more years are needed before the effect of increased reproduction of bass populations on the Watauga fishery can be measured because recruitment can be poor following an event of this nature. With the decrease in prey abundance in Watauga Reservoir following the drawdown, it appears likely few of the large 1984 year-class of largemouth bass will be recruited to harvestable size.

Abundance of other species may have also been affected by the drawdown. For the sake of simplicity, only 1983 data were compared to those from the 1984 post-drawdown year (Table 1). Species that increased in abundance include golden shiner (*Notemingonus crysoleucas*), carp (*Cyprinus carpio*), bullhead minnow (*Pimephales vigilax*), and white crappie (*Pomoxis annularis*) (Table 1). This was probably a result of the new reservoir cycle effect discussed earlier. Several typical stream species also first appeared in the 1984 sample. These probably moved downstream during the drawdown and remained there during filling. Species included are telescope shiner (*Notropis telescopus*), striped shiner (*N. chrysocephalus*), bigeye chub (*Hybopsis amblops*), blacknose dace (*Rhinichtys atratulus*), margined madtom (*Noturus insignis*), and stonecat (*N. flavus*). These species are not expected to become a part of the reservoir fish community.

Few Y-O-Y walleye were present in cove rotenone samples from 1979 through 1984 indicating little or no walleye reproduction. During this period, only in 1979 and 1984 were juvenile walleye collected in cove rotenone samples (1.12 and 0.78 per hectare, respectively). During the early 1970s (1971–1973) Y-O-Y walleye averaged 59.8 per hectare in cove rotenone samples domonstrating limited reproductive success in recent years.

Fifteen fish species (463 fish) were collected with gill nets during spring 1983 and 1984. Gizzard shad were the most abundant species constituting 41% of the sample with catch rates of 2.3 and 13.3 per net night during 1983 and 1984 respectively. Walleye made up 40% of the sample with similar catch rates for both 1983 (7.9) and 1984 (7.4). Bluegill had a catch rate of 1.1 per net night in 1984, while the remaining species had catch rates less than 1 per net night. Although netting was limited, catch rates were similar for most species both years.

Analysis of creel survey records using linear regression for pressure and harvest against time show a significant decline ($P \leq 0.05$) in both fishing pressure and harvest over the entire creel period (Fig. 2). Effort declined from >300,000 hours annually during the late 1960s and early 1970s to <100,000 hours annually for the past few years. Annual harvest, expressed in the number of fish taken, decreased from >70,000 to <30,000 during this same period. Mean weight per fish increased

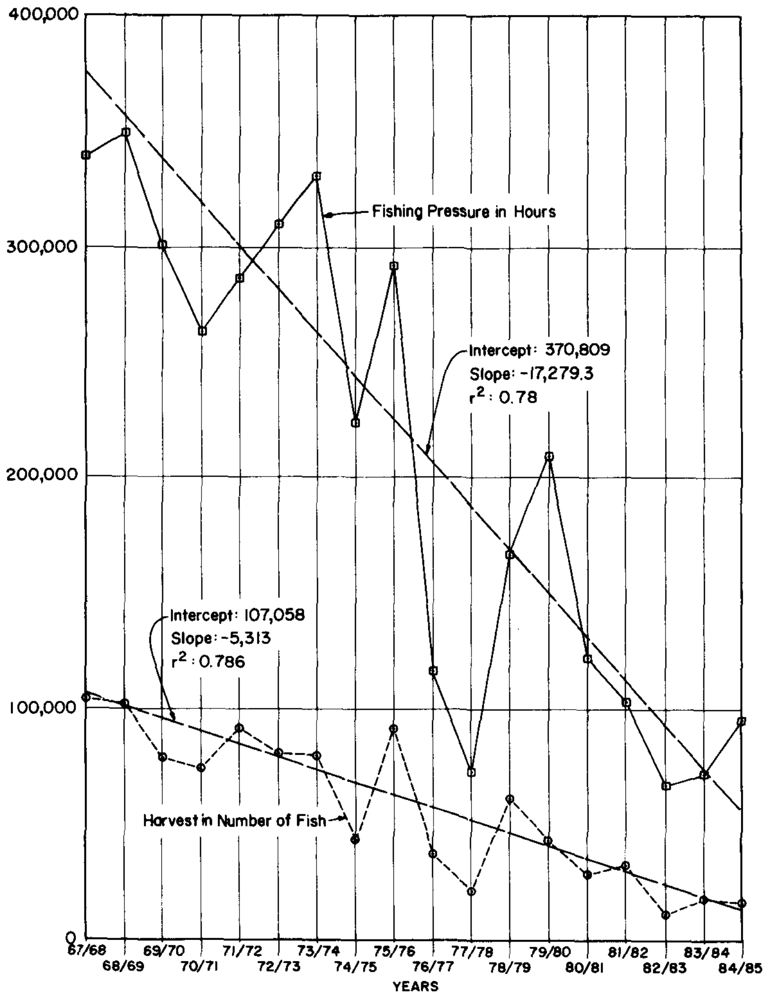

Figure 2. Estimated annual fishing effort and harvest from Watauga Reservoir, 1967–1985.

significantly ($P \leq 0.05$) and appeared to be inversely related to fishing effort. Catch rate did not change significantly throughout this period.

Creel records were analyzed by fish groups (i.e. black bass, trout) for fishermen specifically fishing for a stated species. Although crappie, sunfish, and people fishing for "anything that bites" may have influenced the creel results during a given year, the fishery was primarily directed at trout, walleye, and black bass. Smallmouth bass made up 86% of the annual bass harvest, while trout harvest consisted primarily of rainbow trout except in 1979–80 when an estimated 11,551 Ohrid trout (*Salmo letnica*) were caught.

Table 2. Catch statistics for species specific fishermen in the Watauga Reservoir creel survey 1973–1985 for black bass, walleye, and trout.

	Black bass				Walleye				Trout			
Year	Hr.	*N*	$\bar{x}$ Wt.	C/F	Hr.	*N*	$\bar{x}$ Wt.	C/F	Hr.	*N*	$\bar{x}$ Wt.	C/F
73/74	103302	9975	1.4	.09	128740	21671	1.4	.13	30412	6074	1.6	.17
74/75	69411	6967	1.6	.11	54879	5580	1.6	.11	30221	3055	1.6	.09
75/76	96286	16286	1.6	.15	101831	35880	1.3	.24	20838	2705	1.0	.12
76/77	17452	1726	1.4	.13	40902	12799	1.1	.31	16594	2528	1.1	.17
77/78	18189	1755	1.3	.10	29626	11424	.8	.24	17159	4730	.9	.29
78/79	54771	10416	1.3	.17	61423	28455	.8	.35	17814	4972	1.6	.26
79/80	54615	3924	1.2	.07	35949	3578	1.2	.08	55065	14678	1.0	.24
80/81	36817	6654	1.7	.15	22916	3906	1.8	.15	25665	5757	.7	.26
81/82	29005	4393	1.7	.15	20959	3818	2.0	.18	25908	9437	.8	.26
82/83	23021	2490	1.9	.11	10595	514	2.4	.06	20223	4365	.7	.20
83/84	32927	4695	2.5	.13	11806	3166	2.7	.22	17024	4793	.7	.30
84/85	34748	7235	2.0	.19	22418	3237	3.1	.11	16037	2862	1.9	.19

Catch statistics from fishermen specifically fishing for trout, walleye, and bass were available from July 1973 through June 1985 (Table 2). Creel records were not divided by species-specific fishermen prior to this period. These data show that walleye follow the same declining trends in effort and harvest as the overall fishery, an increase in average size of fish harvested and no change in catch rate. Bass had no significant change in harvest, however variability between years was high. Fishing effort for bass decreased, mean size increased and catch rate remined relatively stable. Trout, however, had no significant changes in effort, harvest, or mean size if the 1979–80 creel data, which was unusual due to the harvest of 11,551 Ohrid trout, are ignored. The catch rate of trout increased significantly ($P \leqslant 0.05$) in recent years. Stability of the trout fishery and increase in catch rate can be attributed to the TWRA stocking program and points out that fishermen will generally take advantage of the availability of harvestable fish.

The decline in fishing pressure and harvest in Watauga was unrelated to the catch rate, normally considered a good measure of fishermen success. Catch rate remained relatively stable over the 18-year creel period while mean size of bass and walleye harvested increased, usually indicative of decreased mortaility and an improving fishery. If fishing pressure is determined by angler success, as success decreases effort should decrease until an acceptable catch rate is again reached. Conversely, with a stable fish population, as fishing pressure decreases catch rate should increase since fewer fishermen are competing for the same resource. In Watauga, the catch rate did not improve as fishing pressure decreased indicating a decline in the availability of harvestable size fish. The walleye fishery in Watauga is a good example of this. There is no doubt that the Watauga walleye population declined in number over the last 4 years due to lack of recruitment. Not only were no Y-O-Y walleye collected, age classes <3 were not present. Effort for and harvest of walleye declined between 1973 and 1984 (Table 2), but catch rate did not. The decline in fishing pressure in Watauga Reservoir is probably an accurate yardstick for availability of harvestable size fish during the creel period. The decline of the walleye population has contributed to this.

Creel records reveal only minor changes in the fishery between pre- (1983–84) and post-drawdown (1984–85) period. Harvest and catch rate of bass increased between the 2 years (Table 2). The catch rate of 0.19 bass per hour in 1984–85 was the highest for any year of record. Harvest of walleye was similar for both years although catch rate declined. Harvest and catch rate of trout decreased following the drawdown possibly due to losses through the turbines and the unusually high turbidity during the drawdown. The trout fishery is not expected to be affected much after this initial year as turbidity returns to normal and stocking replenishes trout lost through the turbines. Except for trout, the fishery was not adversely affected by the drawdown.

A total of 109 and 118 smallmouth bass was captured by electrofishing in 1983 an 1984 respectively. The PSD index decreased from 62% during 1983 to 42% during 1984. Both estimates were within the 40%–70% range that indicates a desirable population size structure. The decrease in PSD may have been the result of

Table 3. PSD, RSD, and Wr values for smallmouth bass, largemouth bass, and walleye captured from Watauga Reservoir during 1983 (pre-drawdown) and 1984 (post-drawdown).

Species	Year	PSD	RSD[1]	RSD[2]	RSD[3]	Wr
Smallmouth bass	1983	62	22	7	2	109
	1984	42	5	0	0	95
Largemouth bass	1983	63	38	7	0	102
	1984	–	–	–	–	96
Walleye	1983	99	11	0	0	104
	1984	100	18	2	0	111

harvest since RSD values also decreased (Table 3), indicating proportionally fewer large specimens in the population.

Age determination from scales showed smallmouth bass were from 1 to 6 years of age. Back-calculated lengths at age were less for each age group following the drawdown indicating poor growth during this period. W_r values also decreased significantly (t-test $P < 0.01$) between years from 109 to 95, refuting the hypothesis that smallmouth bass would consume more prey and grow faster during the drawdown. The drawdown apparently stressed the smallmouth bass population.

A total of 136 largemouth bass was captured by electrofishing in 1983. A PSD of 63% indicated this population had a desirable size structure although the high PSD can be indicative of recruitment problems. The W_r of 102 was near normal for a TVA storage impoundment. Because only 44 largemouth were captured in the 1984 electrofishing samples, a PSD value was not calculated. There was no significant difference in growth or W_r between years.

Walleye were captured with both gill nets and by electrofishing. Because experimental gill nets normally introduce less size bias for walleye, only fish captured in nets are usually included in length frequency data. In this case there were no small fish. Therefore, all walleye, regardless of capture method, were included in these analyses. Totals of 152 and 146 walleye were captured during 1983 and 1984 respectively. PSD values of 99% and 100% clearly demonstrated poor recruitment. Age determination supports this conclusion. The 1983 sample had no 1-year-old and 1 2-year-old fish. In 1984, there were no walleye less than 4 years old in the sample.

Growth of walleye increased between years. This was supported by a significant (t-test, $P < 0.01$) increase in W_r from 104 to 111. This supports the hypothesis of increased predation by walleye during the drawdown, indicating the response of predators to the reduction of the lake was species specific. The more pelagic walleye benefited from the drawdown.

This study has shown that a 70% reduction of total reservoir surface area during the drawdown had major impacts on fish populations. Crowding of fish, loss of cover normally available in the drawdown zone, high turbidity, and loss of fish downstream through the turbines were the most obvious causes for increased stress, mortality, and predation.

Abundance of 2 prey species, bluegill and alewife, decreased. Gizzard shad increased in abundance, especially Y-O-Y. Most gizzard shad were too large to be prey and evidently produced a strong year class in response to expanding habitat during refilling. The reduction of lake volume appeared to aid walleye in capturing prey, but this was not the case with black bass as indicated by growth and relative weight. Therefore, it is unlikely the decrease in the abundance of alewife and bluegill was solely due to increased predation. These fish probably succumbed to inadequate food resources in the much smaller and highly turbid pood. An unknown number of alewife also passed through the turbines during the heavy release schedule.

Species composition and relative abundance following the drawdown were similar to those which occur when a new reservoir is filled. It is possible changes in the Watauga fish populations will mimic those of new reservoirs over the next few years. Rapidly expanding fish populations generally mean fast growth and a higher than usual ratio of desirable sport species. This could mean an improvement in the fishery over the next few years. However, it is not known how long this might last or to what extent the new reservoir cycle will develop since Watauga may not have the nutrient input normally seen in the early years of a new reservoir. Although minimal, the shoreline seeding done during the drawdown should increase nutrient input.

The fishery, though affected, was not greatly impacted by the extensive drawdown. Fishing pressure increased slightly during the period July 1983 to July 1984, perhaps in response to the novelty of the drawdown. The trout fishery declined slightly but should recover quickly since it is maintained through a stocking program. The bass fishery recorded the highest catch rate in the last 18 years and fish averaged 2 pounds each. However, the long-term response of the bass fishery has yet to be determined. The walleye fishery has definitely declined in recent years due to a lack of recruitment, but this was unrelated to the drawdown.

Maintenance of dams is vital and unavoidable, and deep drawdowns will be required at Watauga and similar projects in the future. Therefore, it is essential to gain a thorough understanding of effects of such extreme occurrences. There were both positive and negative outcomes of the Watauga drawdown, both of which may affect the fishery for several years to come.

Several parameters describing the fish assemblage, some fish populations, and the fishery (e.g., standing stocks, relative weight, and catch rate) were measured before and after the Watauga drawdown. However, changes in these parameters resulting from the drawdown are not useful for quantitatively predicting effects of drawdowns for other reservoirs, or even a drawdown of different magnitude or duration in Watauga Reservoir. Data from this drawdown evaluation provide one point on a continuous cause and effect response curve. Quantitative predictions will be possible only when models relating water level and fish abundance are developed. If these data were combined with similar data from other deep tributary impoundments, models could be developed relating fish assemblages (e.g., change in biomass, total numbers, or density) to physical variables associated with reservoir water level (e.g., surface area, shoreline length). Only such an approach will provide the range of variables necessary to quantify effects of an event that occurs rarely in any one reservoir.

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