The Influence of Differing Flow Regimes on the Tailwater Fishery Below Jordan Dam, Alabama

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Abstract: Few significant differences could be detected between a high flow year and a low flow year with respect to catch, effort, catch per unit effort, or the functional composition of the multi-species tailwater fishery below Jordan Dam on the Coosa River, Alabama. Additionally, no significant or consistent correlations were evident between mean daily discharge and daily catch during the 2 surveys. Correlations between daily effort and daily catch per unit effort with mean daily flow were few, inconsistent, and restricted to winter and late summer months when fishing effort was minimal. Angler responses during interviews indicated diverse preferences relative to flow regime.

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Tailwater fisheries have long been known to be very productive relative to their upstream reservoirs (Eschmeyer and Miller 1949, Miller and Chance 1954, Fry 1965, Moser and Hicks 1970). As demands for the resources afforded by tailwater streams increase, the necessity for understanding the dynamics of these systems and of establishing sound provision for the allocation of the resources have become imperative. Management opportunities exist because hydroelectric facilities often have the capacity to regulate the stream flow from which lotic environments and their associated fisheries derive their distinct characteristics.

Development and implementation of instream flow methodology has attempted to address water resource allocation problems, especially in the western part of the United States (Tenant 1976, Bovee and Milhouse 1978, Hyra 1978, Bovee 1982). The methodology, however, may not be applicable to diverse, multi-species, warmwater stream fisheries found farther east (Orth and Maughan 1981, 1982, Mathur et al. 1983). Multi-species stream fisheries are very resilient (Welcomme 1979) and

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although subjected to extreme environmental fluctuations, the structure and function of stream fish assemblages can be quite stable (Gerking 1950, Moyle and Li 1979, Matthews and Hill 1980, Matthews and Styron 1981).

Angler-resource interactions with a multi-species tailwater fishery can be quite complex. In a management sense, however, a practical understanding of such a fishery could evolve through the collection of catch, angler effort and associated stream flow data. By applying appropriate statistical treatment, a conceptualization of the system is possible.

Using this approach, Holcik and Bastl (1977) were able to relate yield and fishing effort to flow on the Danube River. Hanson (1969, 1977) used correlations to discern creel data relationships with flow regimes on Missouri tailwater fisheries.

On the Coosa River tailwater below Jordan Dam, agency and public opinion suggested that this multi-species warmwater fishery was dependant upon flow regime. In response to these concerns, the following hypotheses were generated:

1. Catch (number of fish), effort (number of angler hours), and catch per unit of effort (CPE) are significantly related to flow regime.

2. Composition of the catch relative to species or species groups (i.e., *Lepomis* sp.; *Morone* sp.) is significantly related to flow regime.

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Methods

Study Site

Jordan Dam is located on the Coosa River, Elmore County, Alabama, 30.2 km upstream from its confluence with the Alabama River and approximately 32 km from metropolitan Montgomery. The tailwater extends from Jordan Dam downstream approximately 10 km to the U.S. Highway 14 bridge at Wetumpka and flows across the fall line separating the Piedmont from the Coastal Plain.

Under a minimum flow regime, the tailwater is a riffle-pool lotic environment broken by large rock outcroppings, falls and braided channels. No major tributaries enter the tailwater. Access other than by boat is generally restricted to the immediate stilling basin area below Jordan Dam because of private landholdings. The tailwater can be hazardous under elevated flow conditions. However, critical passage points have sufficient depth to facilitate travel by motorized boat under such conditions (Hyra 1978).

Jordan Dam operated as a run-of-the-river peaking facility from December 1928 through September 1963. In 1963 construction began on the Walter F. Bouldin Hydroelectric Project which was designed to divert the majority of the Coosa River flow through an artificial tailrace canal into the Coosa River approximately 11 km downstream from Wetumpka.

Excess flow is released through the turbines of Jordan Dam when the Coosa River flows exceed the capacity of the Walter F. Bouldin turbines. Beyond the com-

bined generating capacity of both facilities, water passes over the Jordan Dam spillway in a release regime coordinated with other facilities on the river.

The Jordan Dam license, issued by the Federal Energy Regulatory Commission, requires that a minimum of 3.1 million cubic meters of water be released during any 72-hour period to protect downstream fish and wildlife resources. This minimum release can normally be accomplished by generating 2 hours each day through 1 Jordan Dam turbine operating at efficiency loading. Rapidly varying, unstable flows result from this release pattern.

On 10 February 1975 the east dike of Walter F. Bouldin Dam failed, causing the facility to be out of service until 1 September 1980. During this period the majority of the Coosa River flow once again passed through the Jordan Dam facility.

Survey Design

The Alabama Department of Conservation and Natural Resources conducted a catch assessment survey during the elevated flow regime on the tailwater fishery below Jordan Dam from June 1977 through May 1978. After Walter F. Bouldin Dam was repaired, the minimal flow regime was reinstituted for the Jordan Dam tailwater. From December 1982 through March 1984, the Department of Fisheries and Allied Aquacultures, Auburn University, conducted a comparative catch assessment survey on the tailwater. For comparative purposes however with the 1977–1978 survey, only data from December 1982 through November 1983 were used.

Stratified random sampling using non-uniform probabilities, modified after Malvestuto et al. (1978) was employed. Sampling effort consisted of 120 days in the field (10 days each month) evenly distributed between weekday and weekend days. Sixty percent of the sampling effort was allocated to shoreline interception of fishermen in the immediate stilling basin area near Jordan Dam. Forty percent was allocated to travel by boat and interception of fishermen in the downstream reaches of the tailwater. These spatial probabilities were designated in attempts to increase precision of estimates in the area receiving the highest angling pressure (i.e., the stilling basin). Sample days and time of day sampled were randomly selected. Night samples were not attempted.

Sampling effort during the 1977–1978 survey generally exceeded 10 days per month. To improve consistency of sample design, 10 sample days per month were randomly selected from the population of sample days of the 1977–1978 survey. Probabilities established during the 1977–1978 survey were maintained.

Data Analysis

Estimates of total catch (number of fish harvested), total effort (number of angler hours), and catch per unit effort were generated monthly along with the 95% confidence intervals for both surveys. These estimates were analyzed for homogeneity of variance (F-test). When found, heterogeneity of variance was corrected for using Satterthwaite's approximation method to compute degrees of freedom associated with the approximate t (Steel and Torrie 1980).

Historical flow data through Jordan Dam from 1929 through 1966 were supplied by the U.S. Geological Survey of Montgomery, Alabama. Mean daily discharge data (ft^3/s) from Jordan Dam from June 1977 through May 1978 and from December 1982 through November 1983 were provided by Alabama Power Company.

Monthly means and 95% confidence intervals were calculated for the 1929–1966 historical flow data. Mean daily flows for each month of the 1977–1978 and 1982–1983 fishing season were graphically compared to determine if means from the 2 survey periods were within the limits of normal historical variation in flow. Following tests for homogeneity of variance, mean daily flows for each month of the 2 surveys were compared with the appropriate *t*-test.

The relationship between mean daily discharge and daily catch, effort and CPE were subjected to Pearson product-moment correlation analysis by month for each of the 2 surveys. Dates when CPE was not calculated were not included in the CPE-flow correlations. Composition of the catch in terms of the percent contributed by particular species for the two surveys were subjected to arcsine transformation to normalize distributions and then subjected to analysis of variance by species to discern differences if they existed. All estimates and statistical procedures were computed with Statistical Analysis Systems (SAS Institute Inc. 1982) programs.

Results and Discussion

Flow Characteristics

With the exception of mean monthly flow for May and June of the 1977–1978 survey period, flows for the spring and summer fishing seasons during both the 1977–1978 and 1982–1983 surveys were lower than the 95% confidence intervals for historical flows below Jordan Dam (Fig. 1). Additionally, the flow regime during 1982 and 1983 resulted in flows lower than historical low flows recorded from 1929 through 1966 during January and March, and from June through October. Monthly comparisons between mean daily flows for the 2 surveys indicated that flows during the 1977–1978 survey were generally higher (with the exception of April) than flows during the 1982–1983 survey. Significant differences existed between all months compared except for December and February ($P \leq 0.05$)

Angler-Resource Interactions

No significant differences in angler effort could be detected for any month between the 2 surveys (Table 1). Likewise, with the exception of December, September and May for total catch, and December and September for CPE, significant differences could not be detected between the 2 surveys. The power of tests employed for monthly estimates of catch and effort at the levels of 0.90, 0.95, and 0.99 had capacities of resolution generally much less than 10,000 (number of fish and number of hours respectively).

No significant correlations were evident between mean daily discharge from Jordan Dam and daily catch during the 2 surveys (Table 2). Significant correlations

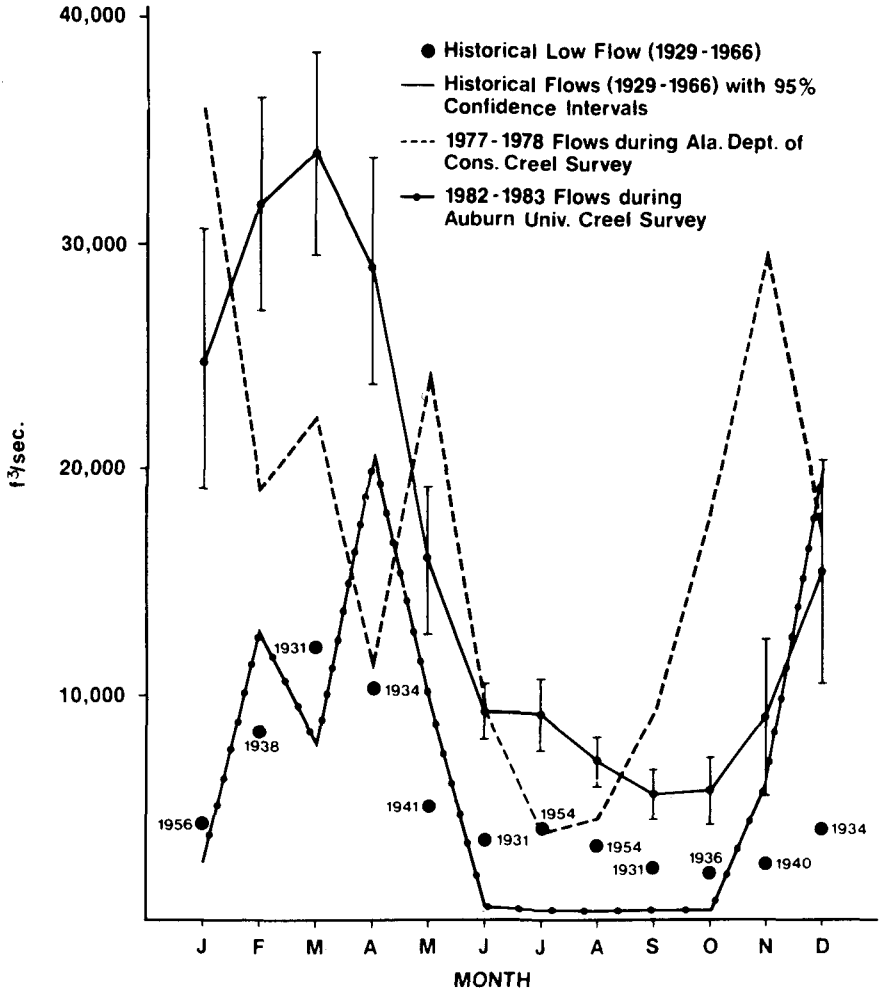

Figure 1. Mean monthly discharges (ft^3/s) from Jordan Dam, Wetumpka, Alabama.

between daily effort and daily CPE with mean daily flow were few and restricted to winter and late summer months when fishing effort was minimal.

Angler preferences regarding flow regime showed no strong patterns. From December 1982 through March 1984, 23.6% of the boat fishermen questioned on the tailwater indicated a preference for low flow, 29.1% indicated a preference for high flow and 47.3% had no preference. Of bank anglers interviewed, 34.8% preferred low flow, 26.5% preferred high flow and 38.7% indicated no preference regarding flow.

Fogle and Shields (1961) through Hanson (1969) reported that fishing on tailwaters was generally best at intermediate or moderate water levels, and Hanson

Table 1. Monthly comparisons for effort (angler hours), catch (number of fish), and CPE (fish per hour) between the minimal flow (1982–1983) survey and the elevated flow (1977–1978) survey on the Coosa River tailwater fishery below Jordan Dam.

	Effort		Total Catch		CPE	
Month	1977–1978	1982–1983	1977–1978	1982–1983	1977–1978	1982–1983
Dec	754	630	1,171*	138	2.76*	0.24
Jan	837	1,200	286	301	0.37	0.13
Feb	1,588	745	335	111	0.07	0.88
Mar	3,090	3,849	1,662	4,447	0.60	1.16
Apr	4,852	5,389	2,878	3,506	0.60	1.08
May	7,224	14,454	5,706*	31,521	0.86	1.97
Jun	9,642	13,976	7,349	11,011	0.83	0.72
Jul	9,911	6,560	4,399	3,735	0.49	0.50
Aug	4,879	6,005	2,426	2,302	0.48	0.33
Sep	3,198	2,912	2,087*	596	0.64*	0.12
Oct	3,450	1,495	1,849	1,216	0.73	1.56
Nov	1,434	1,337	1,258	748	1.16	0.51

*Denotes significant difference ($P \leq 0.05$) between surveys.

Table 2. Correlations (r) for daily catch, effort and CPE with mean daily discharge (ft^3/s) for the minimal flow (1982–1983) survey and the elevated flow (1977–1978) survey on the Coosa River tailwater fishery below Jordan Dam.

	Catch		Effort		CPE	
	1977–1978	1982–1983	1977–1978	1982–1983	1977–1978	1982–1983
Month	r	r	r	r	r	r
Dec	−0.06	−0.12	0.76	0.95*	−0.56	−0.20
Jan	−0.56	0.14	−0.29	0.78	−0.26	−0.30
Feb	−0.47	0.45	−0.64	−0.79	0.01	0.85*
Mar	−0.001	−0.18	0.34	0.38	−0.13	−0.54
Apr	−0.58	−0.41	−0.30	−0.19	−0.20	−0.33
May	−0.50	0.06	−0.30	−0.32	−0.44	0.31
Jun	−0.20	−0.32	−0.35	−0.29	0.50	−0.28
Jul	−0.35	−0.21	0.05	−0.31	−0.34	−0.22
Aug	−0.66	0.25	−0.71*	−0.17	−0.40	0.43
Sep	−0.37	0.02	−0.66*	0.27	0.19	−0.40
Oct	−0.27	−0.30	−0.23	0.16	−0.12	−0.32
Nov	−0.37	−0.49	−0.23	−0.23	−0.13	−0.48

*Denotes significant correlation ($P \leq 0$ 05).

(1977) found high correlations between discharge and both catch and catch rates. Hamilton et al. (1985) found effort and harvest to be almost twice as great during discharge periods as during non-discharge periods on the Keystone tailwater (Oklahoma). On the other hand, White (1969) noted that high water hindered angler effort in tailwaters. Holcik and Bastl (1977) also found fishing effort to be reduced at high water levels regardless of whether it was a "high flow year" or a "low flow year." However, when all years were pooled, yields were generally higher with higher water levels for the year in question and with regard to water levels the previous year. This suggests that the abundance of harvestable fish during a particular year

may be related to streamflow conditions during the years prior to recruitment, while fishing effort seems related to the extant flow conditions encountered by fishermen.

Interactions between fish abundance and fishermen effort may dampen between-year variability in harvest. Correspondingly, the inability to detect differences in harvest between an elevated flow regime and a minimal flow regime on the Coosa River tailwater does not necessarily indicate that abundances of harvestable fish were similar under the different regimes. Furthermore, inverse relationships have been shown between the catchability of fish (q) and fish stock abundance (N) by several authors (see review by Bannerot and Austin 1983). Reasons for this include schooling or clumping behavior of fish, gear saturation, limited available search time and area and non-random search patterns by fishermen. Tennant (1976) points out that at minimum flows (<10% average annual flow) fishing will often be very good in the deeper pools and runs since fish will be concentrated. He further notes that many fishermen prefer this level of flow and that fish may be vulnerable to overharvest under these conditions.

Composition of Fish Harvests

The Coosa River tailwater below Jordan Dam is an established multi-species fishery (Table 3). From a functional perspective the fishery has 3 principal components: the black bass (*Micropterus* sp.), the catfish (*Ictalurus* sp.), and the white bass and/or hybrid bass (*Morone* sp.) complex. Turner (1978) suggests considering multi-species complexes as single units because this approach can provide guidelines for management much earlier than any scheme which may depend on separate or selected individual species analysis. As a multi-species fishery, mixed creels were the rule, not the exception, in the tailwater below Jordan Dam. While anglers throughout the tailwater predominantly targeted 1 of the 3 principal components, techniques employed generally enabled fishermen to harvest a variety of fish. With

Table 3. Species composition (%) of fish harvested from the Coosa River tailwater fishery below Jordan Dam during elevated and minimal flow regimes.

Species	Elevated flow	Minimal flow
Spotted bass (*Micropterus punctulatus*)	1.9	8.1*
Largemouth bass (*Micropterus salmoides*)	2.8	1.3
Crappie (*Pomoxis* sp.)	13.4	2.5*
Sunfish (*Lepomis* sp.)	5.7	8.3
White bass/hybrids (*Morone chrysops* and *M. chrysops* × *M. saxatilis* hybrids)	14.9	17.2
Striped bass (*Morone saxatilis*)	3.0	1.1
Blue catfish (*Ictalurus furcatus*)	38.7	24.3*
Channel catfish (*Ictalurus punctatus*)	8.2	12.5*
Common carp (*Cyprinus carpio*)	1.5	0.8
Other species[a]	9.8	23.6

*$P \leq 0.05$ for significance; df = 1,22

[a]Comparisons for freshwater drum (*Aplodinotus grunniens*) could not be made because they were not specifically considered in the elevated flow regime survey. These fish were included under the category of "other."

few exceptions, fish caught were retained regardless of species. Additionally, an average of 23.2% of the fishermen in the stilling basin immediately below the dam (where 80.1% of all fishermen were encountered) said that they had no preference with regard to species. In the downstream reaches an average of 17.4% of the fishermen encountered expressed no species preferences.

Collectively, the 3 principal components to the fishery mentioned above accounted for 66.5% of the harvest during the elevated flow regime and 63.4% of the harvest during the minimal flow regime. While significant differences in actual species composition were detected between the elevated and minimal flow regimes, the similarity of collective contributions to the total harvest by the 3 principal components suggests functional stability in this tailwater fishery.

It should be noted that proportionally more crappie (*Pomoxis* sp.) were harvested during the elevated flow regime and that freshwater drum (*Aplodinotus grunniens*) contributed significantly to the harvest during the minimal flow regime (21.8%). Comparable data for freshwater drum are not available for comparative purposes from the elevated flow regime survey because this species was not considered separately as a distinct component of the fishery during that period.

Welcomme (1979) suggests that in established multi-species river fisheries, catch is related to 1- and 2-year-old fish that represent the excess ichthyomass over that which can be supported during low water periods. The 1977–1978 catch assessment survey on the Coosa River tailwater below Jordan Dam was conducted 2 spawning seasons after elevated flow conditions began on the system. The 1982–1983 survey was conducted 2 spawning seasons after the minimal release regime was reinstated. The peak fishing season for both surveys coincided with the third spawning season under the respective flow regime. Catches are considered reflective of the capacity of the tailwater to provide exploitable fish resources under the different conditions. While the relative abundances of harvestable fish in the Jordan tailwater under the 2 flow regimes are unknown, angler effort, catch, and the composition of the catch, in a functional sense, remained essentially the same. Our conclusion is, therefore, that the 2 flow regimes provided very similar benefits to anglers in this tailwater.

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