EFFECTS OF WATER LEVEL FLUCTUATIONS ON THE LITTORAL MACROINVERTEBRATES OF WEST POINT RESERVOIR

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Abstract: The water level of West Point Reservoir is lowered 3 m from October to May for flood control purposes, exposing about 2,900 ha of littoral zone. The effects of water level fluctuations on the benthic organisms inhabiting this zone were determined from samples taken at 2 bottom contours; the contour exposed during winter drawdown and the contour just below the winter drawdown that remained permanently inundated. During May and July, fewer organisms ($P < 0.05$) were collected from the contour exposed during drawdown than from the contour never exposed. By August there were no differences ($P > 0.05$) in the number of organisms inhabiting both contours, indicating that the community had recovered after about 4 months of inundation. Soil particle size analysis showed a smaller percentage ($P < 0.05$) of silt and clay and a larger percentage ($P < 0.05$) of sand in the contour exposed during winter drawdown than the contour that remained permanently inundated. Continued annual fluctuation of the water level is expected to cause further deterioration in soil composition of the exposed littoral areas, leading to lower production of benthic fish-food organisms.

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The raising and lowering of water levels in reservoirs are common practices, resulting in the alteration of littoral benthic environment and communities (Cowell and Hudson 1968, Fillion 1967, Grimas 1962, 1965, Kaster and Jacobi 1978, Stube 1958). Grimas (1961) reported a 70 percent loss of benthic invertebrates in the littoral zone and a 25 percent loss in the profundal zone due to fluctuating water levels.

Macroinvertebrate standing crop is also partially dependent on the amount the reservoir is fluctuated. In Lake Francis Case, South Dakota, a reduction in the amount of drawdown from 10 to 12 m to 6 to 7 m resulted in a threefold increase in benthic organisms (Benson and Hudson 1975). Dendy (1946) attributed the lack of extensive bottom fauna to severe winter drawdowns in Norris Reservoir, Tennessee, a storage reservoir subjected to fluctuations of 20 to 26 m.

The direct effect of water level drawdown is the stranding of organisms as the water recedes (Kaster and Jacobi 1978, McLachlan 1970). The long-term effect of continued fluctuation is the erosion and redisposition of littoral sediments (Grimas 1962) and the loss of littoral hydrophytes (Quennerstedt 1958, Sublette 1957). Both processes result in a degraded benthic macroinvertebrate habitat (Wene 1940, Cowell and Hudson 1968, Stube 1958).

Benthic invertebrates are important fish-food organisms in reservoirs (Timmons et al. 1980, Applegate et al. 1966, Applegate and Mullen 1967). Applegate and Mullen (1967) reported that crustacean and chironomid larvae help "bridge the gap" between an entomostracan diet and a piscivorous diet in the newly impounded Beaver Reservoir in Arkansas.

In lakes of the southeastern United States, little is known of the effects of water level fluctuations on benthic communities. The present study was conducted to provide information on this subject and to determine if fluctuating water levels significantly reduced the production of fish-food organisms in West Point Reservoir, Alabama-Georgia. This paper is based on a thesis submitted to the Graduate Faculty of Auburn University in partial fulfillment of requirements of the Degree of Master of Science in Fishery Management.

METHODS

West Point Reservoir, a U.S. Army Corps of Engineers impoundment of the Chattahoochee River, extends from the dam, 5.2 km north of West Point, Georgia, to the headwaters at Franklin, Georgia. It was impounded in October 1974 and reached a full pool of 10,480 ha in May 1975. At full pool, shoreline length is 845 km with a shoreline development (D_L) of 23. The reservoir level is maintained at 194 m above mean sea level (msl) from mid-May through September and at 191 m from October to mid-May. This drawdown exposes about 2,900 ha of littoral habitat.

This study encompassed the entire reservoir, from the dam to the headwaters near Franklin, Georgia. Samples were taken from 12 different stations to include many different habitats. Creek mouths, upper reaches of creeks, nutrient-enriched as well as nutrient-poor streams, protected coves, riverine and mainstem habitats were sampled.

A 23 x 23 cm Ponar dredge was used to sample the bottom sediments. Two depths were sampled at each station, the 193 to 194 m contour (regulated zone) and the 190 to 191 m contour (nonregulated zone) in May, July and August of 1978. During December 1977 and December 1978, only the 190 to 191 m contour was sampled, the 194 m contour being exposed at that time. Duplicate samples were taken at each depth.

A small portion of the sediment sample was stored for soil particle size analysis. The remainder of the sample was washed in the field through a U.S. Standard No. 30 sieve (Weber 1973) and the retained material preserved with 10 percent formalin. In the laboratory the material was floated in a saturated salt solution (Lyman 1942), concentrated, preserved with 5 percent formalin and stained with rose bengal.

Due to the large amount of organic material collected, 152 of the 192 samples were subsampled. The macroinvertebrates were sorted with the aid of a 7x stereo microscope and identified to the generic and species level, where practical, with current and standard invertebrate keys. Diversity ($\bar{d}$) and equitability (e) values (Weber 1973) were used to compare differences in the benthic communities sampled at both contours.

The sand, silt and clay percentages of the collected sediment were calculated by the Bouyoucos Hydrometer Method (Foth and Jacobs 1969) to determine if a relationship existed between soil particle size and the composition of benthic communities.

RESULTS AND DISCUSSION

Four major groups (Oligochaeta, Chironomidae, Copepoda and Chaoboridae) composed 95 percent of the total invertebrate population collected from West Point Reservoir (Table 1). Two families of oligochaetes (Naididae and Tubificidae) were identified, with the tubificids comprising 95 percent of these 2 families. Of the 72 taxa identified, 44 were from the family Chironomidae (Table 2). At West Point Reservoir, Timmons et al. (1980) found that young bass, 25 to 49 mm long, fed chiefly on cladocerans, copepods and chironomid larvae, the latter 2 being represented in the 4 major groups shown in Table 1.

Seasonal trends (Table 1) in abundance were evident for the chironomids and chaoborids; the oligochaetes and copepods showed no seasonal trends. Chironomids reached their highest density in December 1977 and 1978 and reached their lowest density in July 1978 (Fig. 1). Fewer larval forms were found in July because the chironomids had emerged as adults. This indicates little or no overlapping of chironomid generations at West Point Reservoir. As the newly emerged adults laid eggs which soon developed into

Table 1. Percent composition by number (from the pooled samples taken at both depths) of the 4 major groups of organisms identified from West Point Reservoir from December 1977 to December 1978.

Taxon	Dec. 1977	May 1978	July 1978	Aug. 1978	Dec. 1978	Mean
Oligochaeta	25.9	56.1	50.6	59.3	46.2	47.6
Chironomidae	47.6	24.4	17.6	19.6	35.4	23.9
Copepoda	14.8	13.3	9.5	5.1	10.3	10.7
Chaoboridae	0.5	3.2	19.3	13.5	1.1	7.5

Table 2. Percent composition by number (from the pooled samples taken at both depths) of the 5 dominant genera of chironomids collected from December 1977 to December 1978 at West Point Reservoir.

Genus	Dec. 1977	May 1978	July 1978	Aug. 1978	Dec. 1978	Mean
Glyptotendipes	42.2	12.1	20.5	21.9	9.0	21.1
Cryptochironomus	19.2	11.5	15.4	24.0	10.5	16.1
Chironomus	7.3	11.5	2.8	1.9	47.2	14.1
Procladius	14.6	19.0	20.9	4.1	3.1	12.3
Tanytarsus	6.4	12.8	16.7	11.6	0.0	9.5

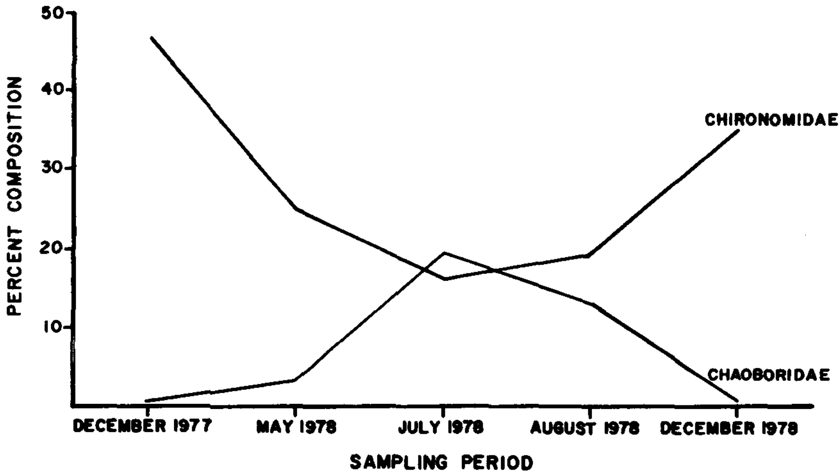

Fig. 1. Seasonal trends shown by percent composition of the total sample for the families Chironomidae and Chaoboridae for the 5 sampling dates, 1977-1978 at West Point Reservoir.

larvae, more larvae were captured by August and even more while overwintering in December. More intensive sampling between May and August including the use of emergence traps for adults should show if emergence is occurring at this time.

Because of the small number of larval chaoborids collected in the December samples (Fig. 1), it might appear that they were emerging during the winter. However, during the December samples only the 190 to 191 m contour was sampled. Stahl (1966) showed that chaoborids concentrated in deeper waters in winter months; therefore, the December shallow water sampling conducted in this study would not adequately sample the chaoborid standing crop.

In studies conducted in Swedish reservoirs (Grimas 1962) and in a Wisconsin reservoir (Kaster and Jacobi 1978), the greatest density of invertebrates occurred in the bottom areas just below the winter drawdown level. In Alberta, Canada, Fillion (1967) reported an average of 4,137 organisms/m^2 just below the regulated zone and 1,236 organisms/m^2 in the regulated zone. During the May, July and August sampling dates (when both depths were sampled), an average of 2,270 organisms/m^2 were collected from the regulated zone and 3,540 organisms/m^2 were collected below the regulated zone at West Point Reservoir.

During May and July, fewer organisms ($P < 0.05$) were collected from the regulated zone than from the nonregulated zone (Fig. 2). By August, however, there was no difference ($P > 0.05$) in the number of organisms collected from the 2 zones. This indicated that the invertebrates had recolonized the newly flooded area in about 4 months, but the lake level was lowered the following month, exposing the newly colonized zone. Kaster and Jacobi (1978) reported that it took 3 months for the invertebrates to reach predrawdown levels in Big Eau Pleine Reservoir in Wisconsin. By allowing the water level to remain at full pool through October for the duration of the growing season (water temperature > 20°C) the fish would be able to take better advantage of the increased invertebrate population.

No differences ($P > 0.05$) in the number of invertebrates were detected when comparing nutrient enriched to nutrient poor creek habitats or comparing creek to mainstem habitats.

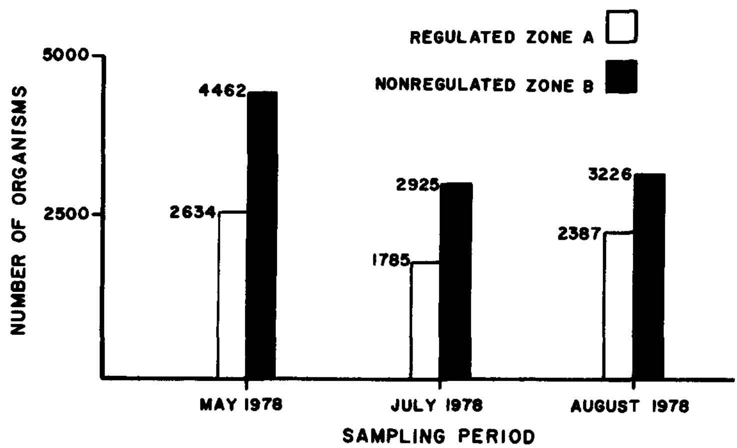

Fig. 2. Mean number of organisms/m^2 collected by dredge samples taken in May, July and August 1978 from the regulated and nonregulated zones of West Point Reservoir.

Fewer taxa ($P < 0.05$) were identified from the nonregulated zone in August. This was probably because the regulated zone contained a rapidly expanding invertebrate population, and because no differences ($P > 0.05$) in density between the 2 contours occurred in August. Favorable physical and chemical factors in the regulated zone, such as increased light and oxygen, could also have contributed to the larger number of taxa found in August. No differences ($P > 0.05$) were found when comparing $\bar{d}$ and e values for both zones.

Grimas (1962) reported that water level fluctuations in Swedish reservoirs resulted in the addition of fine sediments to the nonregulated zone and an impoverishment of fine sediments in the regulated zone. Although regulated for only 4 years, West Point Reservoir was already following this pattern. Smaller percentages ($P < 0.05$) of fine particles (silt and clay) and larger percentages ($P < 0.05$) of larger particles (sand) were found in the regulated zone as opposed to the nonregulated zone at West Point Reservoir.

Soil particle size has been found to play an important role in the size and type of benthic communities (Sublette 1957, Wene 1940). In Ohio streams, Wene (1940) showed a strong inverse relationship between soil particle size and chironomid density. The same relationship was found at West Point Reservoir. Fewer organisms were found in the regulated zone at West Point Reservoir at least partially because a smaller percentage of silt and clay and a larger percentage of sand was found in the regulated zone.

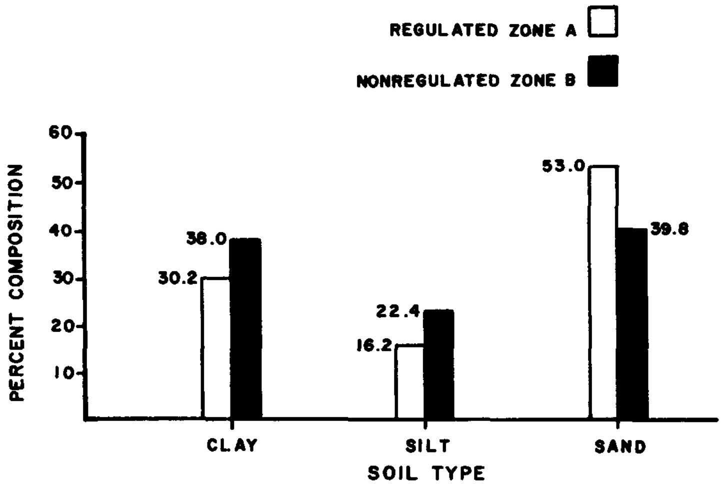

Fig. 3. Percent composition of sand, silt and clay in bottom sediments of the regulated and nonregulated zones of West Point Reservoir collected during December 1977 and May, July and August 1978.

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