Macrobenthos–sediment relationships in Ross Barnett Reservoir, Mississippi

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Abstract

A 1979 study of the macrobenthos of Ross Barnett Reservoir, Mississippi, identified 20 genera of invertebrates. Benthic invertebrate productivity ranged from 1.45 g m^{-2} yr^{-1} in profundal zones to 5.07 g m^{-2} yr^{-1} in littoral zones with major contributors including *Hexagenia bilineata, Chaoborus punctipennis, Chironomus attenuatus, Tanypus stellatus* and *Coelotanypus tricolor*. Numerical and species variation were influenced by depth zones, factors associated with reservoir age (17 years), and sediment and vegetative development in the reservoir benthic zones. Littoral productivity, although limited by lack of zone development, was greater than that of flood control reservoirs in the south central United States because of water level stability. Profundal productivity was limited by hypolimnional oxygen stress. Benthos was a major food source of freshwater drum (*Aplodinotus grunniens*) which forms a significant portion of the reservoir fisheries.

Introduction

Benthic macrofauna encompasses a large component of the secondary productivity of lake and reservoir ecosystems. It occupies an equally important position as a fish food component. Because of reservoir water level instability, benthos in flood control reservoirs in the United States is strikingly different in composition and usually less productive than that of stable natural lakes (Cooper, 1980). The few lentic studies concerned with benthic productivity in the southern United States have focused on flood control reservoirs (Sublette, 1957; Cooper, 1981). The opportunity to conduct a study on a medium-sized reservoir with a stable water level similar to that of natural lakes presented itself in 1979. Thus, the benthos of Ross Barnett Reservoir was examined as a part of a fish food preference study to ascertain (1) benthic species comparison, (2) distribution by habitat, (3) consumption by freshwater drum and (4) to compare benthic productivity with other lacustrine habitats.

Study area and methods

Ross Barnett Reservoir, a monomictic, mesotrophic reservoir, was constructed in the 1960's on the Pearl River northeast of Jackson, Mississippi, principally as a water supply for the city of Jackson and for recreation in central Mississippi. The reservoir covers 12 550 hectares at full pool. Over one-third of the reservoir is less than 1 m deep; two-third of the reservoir bottom was cleared of timber prior to impoundment in 1965. Since the reservoir was constructed for water supply and recreation, water level fluctuations average less than 1 m and few littoral areas are dewatered.

Bottom substrate (0.28 m^{-2}) was taken monthly by Ekman dredge at five stations (Fig. 1) selected to represent major benthic habitats (Table 1). After seiving (0.589 mm^{-2}), samples were preserved, sorted and counted. Exclusive of Mollusca, organisms not permanently fixed for identification were sorted to species level and divided into 1-mm size classes when necessary. Size-classes and life history

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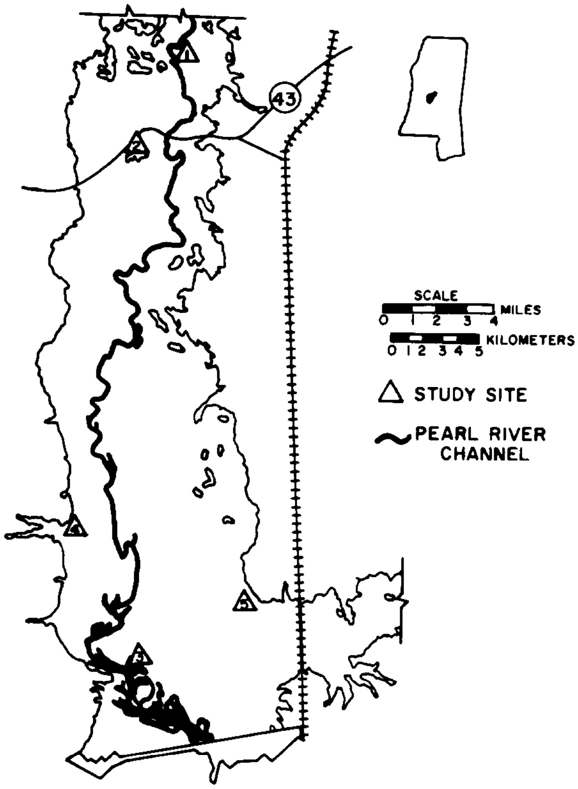

Fig. 1. Map of Ross Barnett Reservoir, Mississippi, including 1979 sampling sites.

Table 1. Types of bottom deposits and substrate in Ross Barnett Reservoir, Mississippi.

Station	Normal water depth (m)	Bottom type
1	2.5	Depositional mud, high percent decomposing vegetation, allochthonous debris
2	1.0	Sandy gravel, some snag debris
3	10.0	Mud, high percent of clay, some snag debris
4	4.0	Muck-mud, some decomposing snag debris
5	2.0	Sand overlying clay

information were used to separate generations or cohorts. Generally, all organisms in a cohort were then dried at 105 °C, e.g. station 3 in Table 2. Production estimates were calculated by removal-summation (Waters, 1977) where the sum of mortality between successive samples for each cohort was calculated in terms of weight changes. Thus, production was based on the total loss. Estimated weight per organism was interpolated to the mean between two successive sampling values to minimize possible error. These estimated weights were used when species representation did not allow a reliable weight.

Table 2. Calculation of standing crop of *Hexagenia bilineata* for April, 1979 at Station 3.

No/m^2	Length Freq. (mm)	Mean Wt. (mg)	Standing Crop (g/m^2)
22	5	0.5	0.011
14	6	1.0	0.014
30	7	0.76	0.023
22	8	0.83	0.018
115	10	1.20	0.138
50	11	1.70	0.085
22	12	2.1	0.046
7	14	4.5	0.032
36	15	4.3	0.155
			0.522

Results and discussion

Twenty genera of benthic invertebrates were found, including three annelid worms, nine molluscs and eight larval insects (Table 3). Four genera were not identified to species because of lack of proper characters in the specimens collected.

Major contributors to the benthos included *Hexagenia bilineata, Chaoborus punctipennis, Chironomus attenuatus, Tanypus stellatus*, and *Coelotanypus tricolor*, all of which are common inhabitants of southern lakes. Water depth and substrate influenced the distribution of benthos. *Chaoborus punctipennis* preferred water 3–5 m deep (Fig. 2). Although they occurred at other depths after reproductive periods, such habitation was sporadic. Larval chironomidae populations showed greatest densities in the 1–5 m littoral and sub-littoral regions. *Hexagenia* favored sheltered littoral zones (1 m) or secondarily the soft muds of profundal zones. Unlike most Mississippi reservoirs, benthos distribution in Barnett Reservoir followed that of northern natural lakes because of similarities in littoral and sub-littoral stability. Miller (1941) found that of 50 benthic species in

Table 3. Benthic invertebrates collected from Ross Barnett Reservoir, Mississippi.

Annelida		
		Barnchiura sowerbyi
		Limnodrilus sp.
		Tubifex tubifex
Diptera		
		Chaoborus punctipennis
	Chironomidae	
		Ablabesmia sp.
		Chironomus attenuatus
		Coelotanypus tricolor
		Cryptochironomus digitatus
		Procladius culiciformes
		Tanypus stellatus
	Ephemeroptera	
		Hexagenia bilineata
	Mollusca	
		Corbicula manilensis
		Musculum sp.
		Sphaeriidae (larval)
		Anodonta grandis
		Lampsilis teres
		Lampsilis straminea claibornensis
		Ligumia subrostrata
		Plectomerus dombeyana
		Potamilus (Proptera) purpuratus

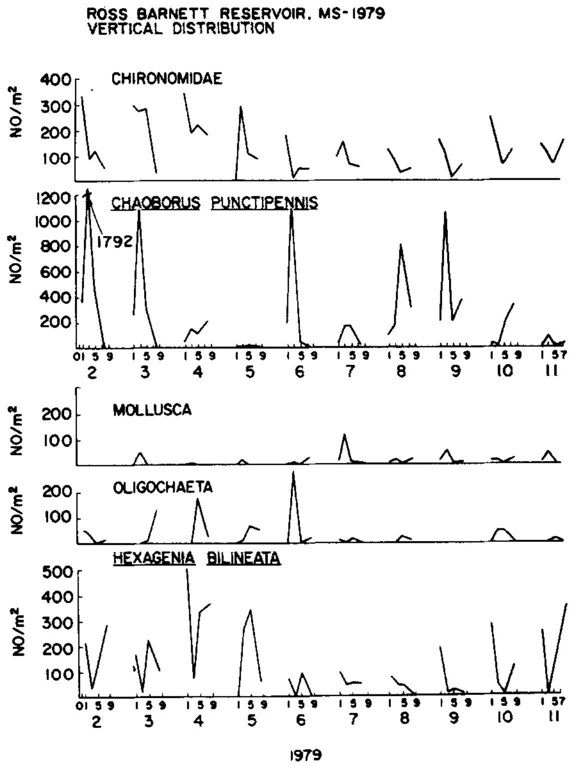

Fig. 2. Distribution of prominent benthos by depth in Ross Barnett Reservoir.

Costello Lake, Ontario, 43 were littoral while Cooper (1980) reported that the majority of benthic invertebrates in several Mississippi lakes and reservoirs were profundal because of detrimental effects of water level fluctuations on littoral fauna.

Although benthos in Barnett Reservoir followed the distribution pattern of natural lakes, species number was poor in both littoral and profundal zones. Barnett Reservoir supported 11 species of benthos, exclusive of the Mollusca. Mississippi flood control reservoirs commonly have 20–29 species (Cooper, 1980), and natural oxbow lakes in the Mississippi River delta may harbor 20–30 species of benthos, exclusive of Mollusca. Several insect taxa common to Mississippi apparently were absent from Barnett Reservoir. Some isolated littoral zones, characterized by extensive emergent macrophytes in the upper reaches of the reservoir, supported other arthropods, but were not indicative of habitats in the main body of the reservoir. In littoral zones, this lack of species representation was attributed to lack of suitable substrate and vegetative development. Our observation was that, while age may be a factor, the susceptability of most littoral areas to strong wind and wave action is the major deterrent to littoral zone development. Most littoral substrates were coarse sand or hardpan clay, both of which provided limited habitat. Such undeveloped areas do not have the components necessary fo supporting diverse fauna (Swedberg, 1968). Wetzel (1975) and Ball (1948) showed that diversity and distribution of macrobenthos were affected in the north central United States by water quality, bottom sediment and distribution and abundance of plants. While rapid addition of sediments decreases benthic density (Lenat *et al.*, 1981), many species of lentic benthos (burrowers, spawlers) re-

Table 4. Secondary Productivity from macrobenthos in Ross Barnett Reservoir during 1979 (Dry weight in g m^{-2}).

Station	1	2	3	4	5
Chaoborus	0.644	0.193	0.290	0.097	0.147
Oligochaeta	1.162	0.114	0.385	0.244	0.396
Chironomidae	2.040	0.199	0.370	0.336	0.567
Hexagenia	0.495	4.670	0.403	1.103	1.615
Total g m^{-2}	4.34	5.07	1.45	1.78	2.37

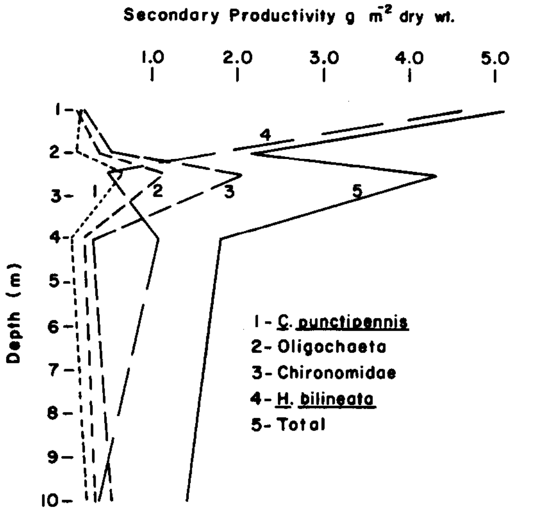

Fig. 3. Vertical distribution of secondary productivity (g m^{-2} yr^{-1} dry wt) from macrobenthos in Ross Barnett Reservoir during 1979.

quire a substantial depositional mud substrate (Cooper, 1977). McLachlan & McLachlan (1971) found that benthos in a newly formed Rhodesian reservoir correlated positively to the amount of organic carbon in the profundal zone and correlated negatively to coarse sand in the littoral zone. Benthos in Barnett Reservoir correlated negatively to sand in littoral zones, e.g. station 5 in Table 4. No correlations with organic carbon could be made where sand was not a factor.

Macrobenthos in profundal zones were limited mainly by summer thermal stratification. Although dipterans, mayflies, and oligochaetes were represented in the profundal zone, numbers were lower and occurrence was more seasonal than in sheltered littoral zones.

Littoral zones with some developed substrate, e.g. stations 1 and 2 in Table 4 (4.3 to 5.1 g m^{-2}), were much more productive than littoral zones of regional flood control reservoirs which vary from 0.7 g m^{-2} to 1.2 g m^{-2} (Cooper, 1980). Profundal zones in Barnett Reservoir experienced the same stresses that occur in corresponding zones of flood control reservoirs and were also comparably low in productivity (1.5 to 1.8 g m^{-2}). Productivity in all benthic communities was based mainly on *Hexagenia bilineata* and Chironomidae (Fig. 3).

Secondary productivity estimates of all macrobenthos, excluding Mollusca, were based on annual cohort or generation production. In order to calculate productivity on an annual basis, it was necessary to observe monthly changes in each cohort of a species. Oligochaetes exhibited the simplest case with a single generation produced during the year period. By calculating the mortality between successive sampling periods and summing those weights, an annual production estimate was derived. Productivity of dipterans and mayflies was more difficult to estimate because production of a single cohort was not equal to annual production. *Chaoborus punctipennis* and all chironomid larvae overwintered with occasional scattered emergence as is common in temperate zone lakes. Emergence of the overwintering *Chaoborus* population occurred in April. Two generations during summer months preceded a late fall population that overwintered.

Emergence of overwintering chironomid larvae began in early March and continued through November. Species that occurred in enough density to make valid comparisons showed overlapping generations during the summer. *Chironomus attenuatus* had six generations during the year. The result was that, although species composition changed periodically, the total numbers of chironomids after emergence never declined like *Chaoborus punctipennis* (Fig. 2).

Hexagenia bilineata life history in Barnett Reservoir included a two year life cycle. Scattered emergence resulted in the sighting of new nymphal stages (3 mm) in February, especially in shallow portions of the reservoir. Emergence peaked in March, but scattered emergences occurred through October.

Gut content indicated that benthos was a major food source of freshwater drum (*Aplodinotus grunniens*) in Barnett Reservoir. While drum under 22 mm total length utilized *Chaoborus punctipennis*, small Chironomidae and planktonic copepods, larger juveniles and adults preferred midge larvae (Chironomidae) and *Hexagenia bilineata*.

Summary

A study of the benthos of Ross Barnett Reservoir revealed that the number of species present was

quite limited and indicative of a young lake. Because of greater water level stability, secondary productivity in littoral zones was greater than in area flood control reservoirs. Productivity was limited in littoral zones by a lack of substrate or vegetative development and in profundal zones by hypolimnional oxygen stress. Benthos provided a major food source for all life stages of freshwater drum.

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References

Ball, R. C., 1948. Relationship between available fish food, feeding habits of fish, and total fish production in a Michigan lake. Mich. St. College Ag. Exp. Stat. Tech. Bull. 206: 1-59.

Cooper, C. M., 1977. Abundance and production of littoral and profundal benthic fauna in a flood control reservoir. Proc. Miss. Chap. am. Fish. Soc. 1: 25-33.

Cooper, C. M., 1980. Benthic productivity in Mississippi lakes and reservoirs as compared with that of northern lakes. Proc. Miss. Chap. am. Fish. Soc. 4: 9-17.

Cooper, C. M., 1981. A population study of the Diptera (Insecta) of Grenada Reservoir, Mississippi. J. Freshwater Ecol. 1: 251-265.

Lenat, D. R., D. L. Penrose and K. W. Eagleson, 1981. Variable effects of sediment addition on stream benthos. Hydrobiologia 79: 187-194.

McLachlan, A. J. & S. M. McLachlan, 1971. Benthic fauna and sediments in the newly created Lake Kariba (Central Africa). Ecology 62: 801-809.

Miller, R. B., 1941. A contribution to the ecology of the Chironomidae of Costello Lake, Algonguin Park, Ontario. Univ. Toronto Studies, Biol. Serv. 49: 1-6.

Swedberg, D. W., 1968. Food and growth of the freshwater drum in Lewis and Clark Lake, South Dakota. Trans. am. Fish. Soc. 97: 442-447.

Sublette, J. E., 1957. The ecology of the macroscopic bottom fauna in Lake Texoma (Denison Reservoir), Oklahoma and Texas. Am. Midl. Nat. 57: 371-402.

Waters, T. F., 1977. Secondary production in inland waters. Adv. ecol. Res. 10: 91-164.

Wetzel, R. G., 1975. Limnology. W. B. Saunders Company, Philadelphia, PA.: 525.

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