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A QUANTITATIVE-QUALITATIVE ZOOPLANKTON SAMPLING METHOD

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ABSTRACT

A sampling method has been developed that provides measurements of the zooplankton present within three environmental situations: (1) deep water, (2) shallow water, and (3) rapidly moving water.

The method utilizes a 0.5-m-diameter plankton net equipped with a flowmeter making possible the collection of a quantitative-qualitative zooplankton sample. Modifications in the sampling method have been formulated for the use of this method in the three environmental situations. The sampling apparatus is inexpensive, is easy to operate and maintain, and supplies a representative sample that minimizes variations caused by vertical distribution and avoidance of the sampling device by the organisms.

INTRODUCTION

The plankton net was evaluated as a sampling tool in an effort to obtain large volume samples that would provide realistic estimates of the zooplankton populations within the Tennessee Valley Authority (TVA) reservoirs and tributaries. A representative sample for nonspatial studies should include the entire water column, thereby minimizing the effects of vertical plankton migrations which might occur during the course of a survey. The plankton net is a relatively old limnological tool and many researchers have studied its attributes and weaknesses (Barnes, 1953; Bé, 1962; Barkley, 1964; Aron, et al., 1965; Fleminger and Clutter, 1965; and McGowan and Fraundorf, 1966) including its use in combination with flowmeters (Clarke and Bumpas, 1940; Bary and DeStefano, 1958; Cushing, 1962; and Fraser, 1966). However, no one has given detailed procedures for using these tools most effectively in various types of aquatic environments that must be sampled.

The initial apparatus consisted of a flowmeter suspended inside a 0.5-m-diameter plankton net. It was assumed that the flowmeter would record only the water that passed through the net. The number of flowmeter counts recorded during the timed retrieval of the net was used to calculate the volume of water filtered. However, it became obvious that some modification of the sampler was needed to synchronize the function of the net and flowmeter. Direct observations by SCUBA divers showed that the flowmeter commonly functioned apart from the net as the apparatus was lowered to the sampling position at the bottom of the water column. Samples based on such erroneous readings would underestimate zooplankton standing crop. To achieve this simultaneous function, three modifications of the net-flowmeter method were developed for use in the following situations: Modification I—for little or no current at depths greater than 3 m (deep water); Modification II—for little or no current in nonvegetated shallow areas not more than 3 m deep (shallow water); and Modification III—for steam plant condenser cooling water discharge canals (rapidly moving water).

The apparatus is assembled with the flowmeter centered 25 cm below the orifice of the net so that the net can be gathered and closed between the flowmeter and the rim of the net by the 15-cm nylon strap, one end of which is sewn to the net about 25 cm below the rim. Auerbach's device is tied directly to the bridle for use as an opening device (Fig. 1). The lead bar is attached to the crossbar at the rim to weight the apparatus for descent.

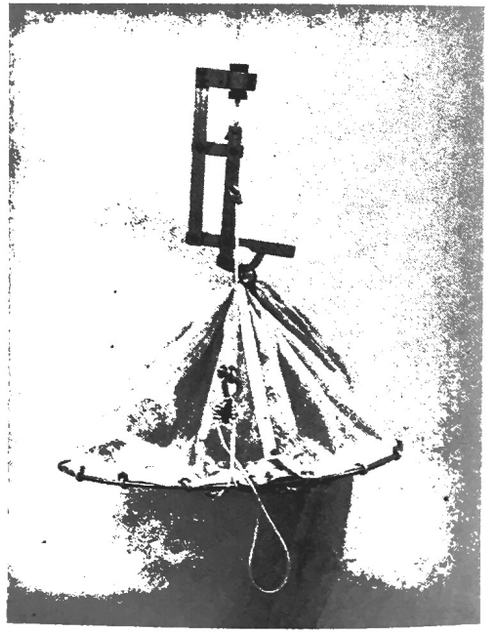

FIG. 1: *Modification I with apparatus shown in closed position and prepared for descent. Note net is held gathered by the nylon strap, which is maintained in position by placing the "D" rings on the clip of Auerbach's device. The flowmeter is enclosed within the net and cannot be seen. The lead bar weight is attached to the crossbar at the rim of the net.*

MODIFICATION I

The sampling apparatus for deep water consists of the following components:

1. Plankton net (0.5-m-diameter) equipped with no. 20 mesh (80-μm) nylon bolting cloth.
2. Digital flowmeter.
3. Auerbach's closing device (Schwoerbel, 1970).
4. Lead Bar weight (2-3 kg).
5. Crossbar.
6. Three-point flexible bridle.
7. Brass messengers.
8. "D" rings (two), one attached to each end of a nylon strap 15 cm long and 1 cm wide.
9. Stopwatch.

The apparatus is prepared for sample collection by gathering the net within the nylon strap and attaching the two "D" rings to the clip of Auerbach's device as it is placed in the "set" position (Fig. 1). This preparation encloses the flowmeter within the net and prevents the net and flowmeter from operating until Auerbach's device is released, thus ensuring the simultaneous functioning necessary for reliable sample collection. Before the sample is collected, the initial reading from the flowmeter is recorded on a field sheet. With the bucket of the net detached, the apparatus is slowly lowered into the water until all trapped air has escaped from the net. The bucket is then attached, and the apparatus is lowered until it is about 0.5 m above the bottom. The messenger is dropped to open Auerbach's device, thereby releasing the net and flowmeter to the sampling position (Fig. 2). A stopwatch is started, and the apparatus is retrieved at a constant rate (between 0.5 and 0.7 m/sec.) When the flowmeter reaches the surface of the water, the watch is stopped. The elapsed time and the final flowmeter readings are recorded on the field sheet.

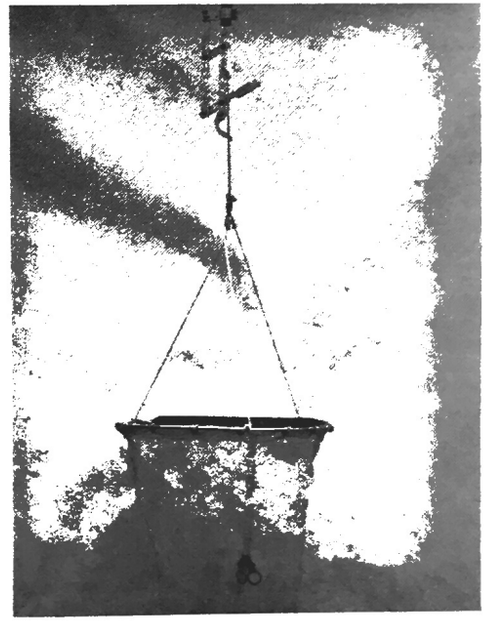

FIG. 2: *Modification I with apparatus shown in sampling position ready for retrieval. The flowmeter is in the throat of the net and cannot be seen.*

MODIFICATION II

The sampling apparatus for shallow water consists of the following components:

1. Plankton net (0.5-m-diameter) equipped with no. 20 mesh (80-μm) nylon bolting cloth.
2. Digital flowmeter.
3. Auerbach's closing device (Schwoerbel, 1970).
4. Crossbar with central loop.
5. Brass messenger.
6. "D" rings (two), each attached to an end of a nylon strap 15 cm long and 1 cm wide.
7. Stopwatch

The apparatus is assembled with the flowmeter centered just inside the net, and Auerbach's device is tied directly to the loop on the net's crossbar with a rope 20 cm long. The "D" ring on one end of the 15-cm strap is attached to Auerbach's device, and the other end is left hanging free.

The apparatus is prepared for sample collection by inserting the clip of Auerbach's device through the loop on the crossbar, inverting the flowmeter, and wrapping the free end of the nylon strap around the propeller of the flowmeter. The "D" ring on the free end of the strap is placed on the clip of Auerbach's device, and the device is then placed in the "set" position (Fig. 3). The initial flowmeter reading is recorded on a field sheet. The apparatus is then lowered into the water, bucket first, until it is about 0.5 m above the bottom. When this modification is used in flowing water, the net must be lowered at the same rate or faster than the current in order to maintain simultaneous functioning of the net and flowmeter. After the net has been lowered, the messenger is dropped to release the flowmeter to the recording position (Fig. 4). The sample is then collected and the time and final reading are recorded in the same manner as in Modification I.

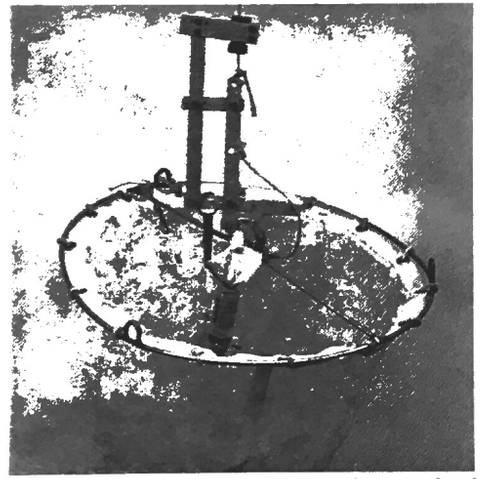

FIG. 3: *Modification II with apparatus shown in closed position and prepared for descent. Note nylon strap holding propeller of the inverted flowmeter.*

MODIFICATION III

The sampling apparatus for rapidly moving water consists of the following components:

1. Plankton net (0.5-m-diameter) equipped with no. 20 mesh (80-μm) nylon bolting cloth.
2. Digital flowmeter.
3. Three-point flexible bridle.
4. Spherical lead weight (7-8 kg).

5. Stopwatch.

The apparatus is assembled wth the flowmeter centered just inside the net, and the weight is attached to the bridle by a rope 50 cm long (Fig. 5).

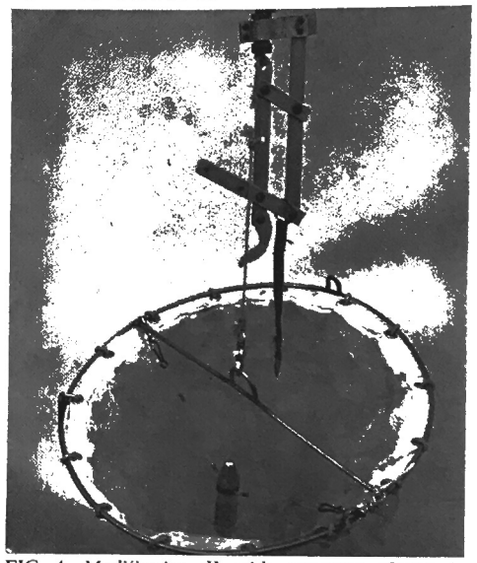

FIG. 4: *Modification II with apparatus shown in sampling position ready for retrieval. The flowmeter can be seen in the throat of the net.*

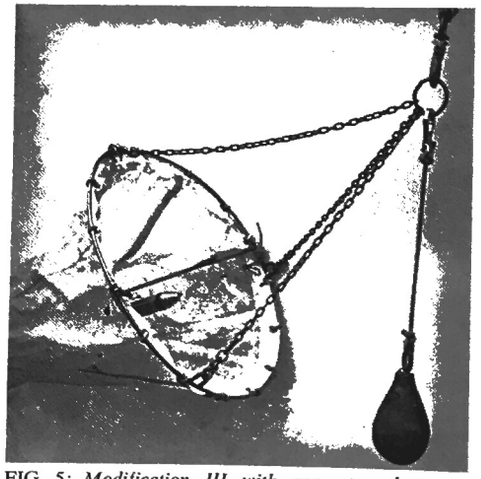

FIG. 5: *Modification III with apparatus shown in sampling position for descent and retrieval.*

For this modification the apparatus needs no additional preparation. Two persons are required to collect a sample. One person controls the retrieval rope and weight with one hand and the orifice of the net and the flowmeter with the other hand (for easiest operation, this person should be in the front of the boat facing the current). The other person holds the lower end of the net with the bucket under water. After the initial flowmeter reading is recorded, the first person releases the retrieval rope and weight simultaneously with one hand, and with the other hand turns the orifice of the net downward into the water (being careful not to trap any air in the net) and releases it and the flowmeter. The second person then starts a stopwatch and releases the lower end of the net. The apparatus is allowed to fall freely, being pulled down by the weight. As soon as the apparatus reaches the bottom it is retrieved. The net filters continuously both during descent and ascent. The time and flowmeter readings are then recorded.

TABLE 1: *Sample statistics from Modifications I, II, and III.*

	Rotifera	Cladocera	Copepoda	Total
Modification I				
Duplicate samples collected on three different dates from Tennessee River mile 435.4 with no more than 4 minutes between replicate samples.				
$\overline{X}$[a]	20,315.0	21,017.5	1,679.0	43,011.5
SD[a]	172.5	3,260.5	58.0	3,145.9
CV,[a] %	0.9	15.5	3.5	7.3
$\overline{X}$	2,540.0	2,161.0	543.0	5,244.0
SD	67.9	446.9	101.8	413.0
CV, %	2.7	20.7	18.8	7.9
$\overline{X}$	156.0	1,029.5	323.5	1,509.0
SD	12.7	68.6	43.1	99.0
CV, %	8.1	6.7	13.3	6.6
Modification II				
Triplicate samples collected on three different dates from mouth of Cane Creek (Tennessee River mile 244.1) with no more than 3 minutes between replicate samples.				
$\overline{X}$	5,951.7	1,070.3	1,343.3	8,365.3
SD	867.5	208.3	267.6	666.2
CV, %	14.6	19.5	19.9	8.0
$\overline{X}$	4,339.3	789.3	883.0	6,011.7
SD	1,056.5	299.2	42.5	1,348.1
CV, %	24.4	37.9	4.8	22.4
$\overline{X}$	637.0	310.0	1,950.7	2,897.7
SD	154.8	91.9	461.6	415.9
CV, %	24.3	29.4	23.7	14.4
Modification III				
Triplicate samples collected on three different dates from discharge basin of a steam plant (Tennessee River mile 245) with no more than 3 minues between replicate samples.				
$\overline{X}$	6,577.7	786.3	1,597.3	8,961.3
SD	784.4	175.2	19.1	937.9
CV, %	11.9	22.3	1.2	10.5
$\overline{X}$	5,233.7	751.3	1,013.3	6,998.3
SD	512.1	33.1	105.9	551.0
CV, %	9.8	4.4	10.5	7.9
$\overline{X}$	636.3	451.0	2,178.3	3,265.7
SD	21.2	50.1	300.0	361.7
CV, %	3.3	11.1	13.8	11.1

a. $\overline{X}$ = Sample mean; #/m³
SD = Standard deviation
CV = Coefficient of variation = $\frac{SD \times 100}{\overline{X}}$

CALCULATIONS

The volume of water sampled in each case is calculated as follows:

1. The initial flowmeter reading is subtracted from the final reading to obtain the total number of counts.
2. The total number of counts is divided by the number of seconds elapsed during the retrieval of the net to obtain the number of counts per second.
3. By means of the graph supplied with each flowmeter, the number of counts per second is converted to centimeters per second to obtain the velocity at which the net was retrieved.
4. The velocity is multipled by the total number of seconds elapsed during retrieval of the net to obtain the total distance sampled.
5. The volume of water sampled can be calculated by using the formula for the volume of a cylinder, $V = \pi r^2 h$, where r is the radius of the orifice of the net and h is the distance sampled.

DISCUSSION

The equipment and modifications described here have proved useful in TVA's work on zooplankton. The equipment is relatively inexpensive, is easy to operate and maintain, and when used in accordance with the described procedures provides a representative sample with limited variation caused by nonuniform vertical distribution or by avoidance of the sampling device by the zooplankton. The variation caused by nonuniform vertical distribution is minimized because the oblique, bottom-to-surface tow provides a quantitatively and qualitatively integrated sample of the water column. Variation attributable to avoidance is minimized by the relatively large diameter of the net.

Samples collected in surveys utilizing Modifications I, II, or III have shown that acceptable replication can be obtained with all three modifications. Numbers of organisms per cubic meter for the three principal zooplankton groups (Rotifera, Cladocera, and Copepoda) and for the total combination of these important groups [zooplankton assemblage] were analyzed statistically for sample mean (X), standard deviation (SD), and the coefficient of variation (CV, percentage ratio of the standard deviation to the mean). (Table 1). Average CV values were 3.9, 14.3, and 11.9% for Modification I; 21.1, 28.9, and 16.1% for Modification II; and 8.3, 12.6, and 8.5% for Modification III for Rotifera, Cladocera, and Copepoda respectively. CV values for the total zooplankton assemblage were 7.3%, 14.9%, and 9.8% for Modifications I, II, and III respectively. Only 2 of the 27 samples (both collected with Modification II) had CV values above 25%, the maximum level considered acceptable for our sampling regimes.

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FLORISTIC SURVEY OF SPRING FLOWERING HERBS AT FROZEN HEAD STATE PARK, MORGAN COUNTY, TENNESSEE

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ABSTRACT

An isolated, little-disturbed forest in Frozen Head State Park, located in the Cumberland Mountains, has been surveyed to determine the floristics of spring herbs. Forty-seven families and 123 species in 91 genera were reported from the study area. The largest family was