Biomass Measured Electronically

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Until recently, the estimation of zooplankton biomass has been by crude total volume measurements. A biomass vs size histogram can be obtained from the results of differential sieving which separates the plankton into several size categories. This is a laborious procedure, and information on small-scale spatial distribution is still lacking.

The study described in this paper used an electric sensing zone instrument to make an "in situ" measurement of particles in the range 0.5 to 3.0 mm diameter in the ocean. Now, very few non-biological particles in the indicated range are present in ocean water. Since pulse heights are linearly related to particle volume, 'biomass' and 'pulse height' are virtually synonymous.

The pulses output by the sensing zone electronics were measured by a LINC-8 computer which had been programmed to reject noise and also keep track of the time between true pulses. Since a typical tow is about one mile long, and the net mouth is only three inches in diameter, we have an essentially one-dimensional transect of the area examined. Thus, the time measurements are equivalent to distance between particles.

In July 1967, a transect was run from Halifax into the Sargasso Sea. For each station, histograms of biomass vs size were derived from the records. Accuracy of the method is discussed.

It has recently become clear that planktonic predators are selective in their choice of food, each species tending to eat a certain size-range of prey. Thus, all of the organic material (total biomass) is not available as food to any given species. The biomass present would be better measured as a biomass per unit size of particle. Long and tedious methods have been used to get this information. Mullin (1965) used differential filtration to separate plankton in the range 1μ to 500μ into seven size categories. The plankton thus separated were wet-oxidized to determine their carbon content. The Coulter Counter has also been used to measure the size frequencies of phytoplankton. The collection methods do not easily lend themselves to measuring spatial distributions because of the relatively long time required to handle each sample.

In this study, an electric sensing zone instrument was used to count and size all particles retained by a conical net (263μ Nitex mesh). Such instruments have been discussed in general by Berg (1965) and Harvey (1968), and in particular by Maddux and Kanwisher (1965), and Boyd and Johnson (1969).

In the 1967 series of tows, the net and electronics were housed in an Icelandic high speed plankton sampler. A rope (containing three wire conductors used for power, ground, and signal) was used to tow the sampler from a boom on the side of CSS Hudson. The signal was frequency modulated before recording on magnetic tape.

The pulse measuring program had four main objectives to meet. First, voltage sampling must be taken often enough to ensure adequate representation of a pulse. Second, the program should measure time between pulses while third, rejecting false pre- and/or post- pulse noise. Finally, for the information and peace of mind of the operator, the accumulating data should be displayed on the computer's oscilloscope.

Typical pulses measured at sea have an average duration of 9.5 mSEC, the shortest observed being about 6 mSEC. Typical calibration pulses have a duration of 5 mSEC, with less spread of durations. Thus, if we assume that the pulses have a sinusoidal shape, the most difficult pulses to sample are equivalent to sine waves with a period (twice the duration) of 10 mSEC or frequency of 100 Hz. It can be shown that an inter-sampling period of 300 SEC can handle all sine waves with a period greater than 10 mSEC with less than 0.5% error. Since the accuracy of the analog conversion is 1 part in 256 or 0.4%, this was deemed to be a sufficient frequency of sampling.

To make the time measurement, the program was designed so that all paths from analog sample of the signal channel back to the sample again were exactly 200 machine cycle times (300.0μSEC). The program then merely counts program cycles and measures time in arbitrary units (33.0 mSEC has been used to date). The accuracy of the time measurement was measured against the accuracy of a Preset counter using sine wave input. No fault could be found!

The present design of the sampling chamber introduces spurious pulses both before and after all pulses. Since these are much smaller than the main pulse, they are only a problem with very large pulses. The program tests the time interval between measured pulses, and if it is less than an arbitrary threshold (1.5 time units or 49.5 mSEC has been used to date), then it assumes that the smaller of the two is one of these noise pulses and rejects it.

In each part of the program that required long delays to wait for the 300 μSEC sampling period, portions of an oscilloscope display are used as a delay. Thus, the operator can see the accumulating histogram.

Non-linearity in the response curve (signal amplitude vs particle volume) and pulse saturation in the amplifier limit the size of particles measured to 3 mm diameter or less. Electronic noise sets the lower limit at about 0.5 mm, conveniently near the size of mesh used in the collecting net. Since the response curve is linear, a measurement of the pulse height can be considered to be the biomass of the particle.

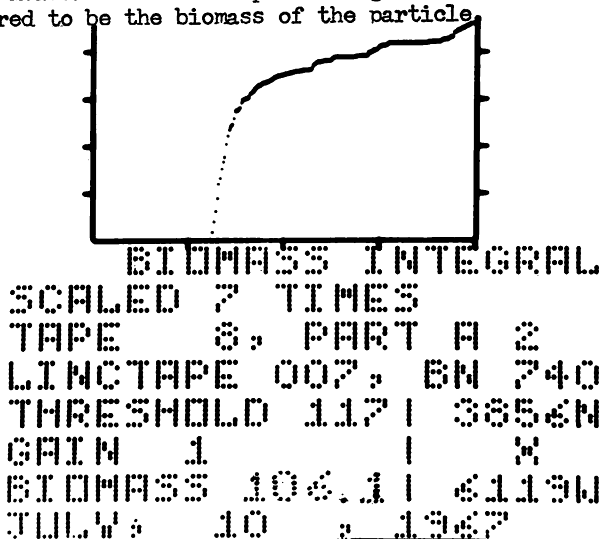

Figure 1

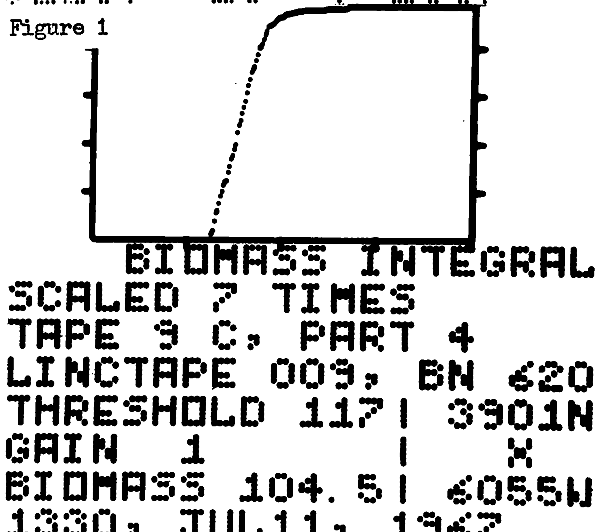

Figure 2

The data can be displayed as biomass (number of particles multiplied by particle size) vs particle size. As well, this histogram can be integrated to show the total biomass less than a particular size. Two of these latter displays were photographed and are shown here as figures 1 and 2. These are compared in the table.

The two tows were taken within twenty miles of each other near the surface at a towing speed of about 4 knots. These are typical of the plots that were obtained in the Sargasso Sea area. In spite of the obvious difference in the shape of the curves, the average particle is nearly the same in the two cases: 0.4 volts. The entry "rate of equivalent particles" is just the rate that 7 cubic mm particles (2.4 mm diam.) would have to flow to give the same results.

	fig. 1	fig. 2
tow number	8A	9C
duration (minutes)	3.9	0.70
time of day	23:45	13:30
total biomass (volts)	106.0	104.5
biomass per particle	0.412	0.406
biomass per minute	26.5	149
rate of equivalent particles	53	300

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