Clogging and Filtration Coefficient in a High-Speed Plankton Sampler

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Abstract

Data upon water exit-velocity in an encased high-speed plankton sampler were obtained during field use and analysed; the results show that reduction in size of mouth opening allows complete avoidance of clogging under normal working conditions in temperate waters. Reduction of mouth opening has the further effect of increasing the filtration coefficient in such a way that the sampler apparently filters more than the theoretical quantity of water that would be expected from the mouth area. Unobstructed flow through the net probably reduces avoidance by fast-moving plankters.

Introduction

A large amount of literature is devoted to the hydrodynamic properties and filtration capacity of conventional plankton nets. On the other hand, a very small number of investigations have been carried out upon working properties of high-speed plankton samplers. When describing their closing sampler, Bary et al. (1958) described the flow pattern in the entrance of their gear and, recently, Harding and Arnold (1971) undertook a series of flume experiments on the hydrodynamics of high-speed plankton samplers. However, these are purely hydrodynamic accounts, obtained under experimental conditions that differ from field working conditions by absence of suspended material which, when collected, affects some of the properties of the net. Nellen and Hempel (1969) published a comparison of two samplers under field working conditions, but this dealt with overall catching capacity, irrespective of the evolution of filtering properties and precision of quantitative data obtained. As emphasized by Tranter and Smith (1968), there is a general lack of available information upon the clogging and filtration coefficients of high-speed plankton samplers.

This paper presents an approach towards these problems based upon a simple statistical utilisation of data routinely collected during field investigations, the purpose of which was ecological, and which were carried out without any special intention of obtaining information about clogging and filtration coefficients.

Material and Methods

The sampler used was a “Lowestoft 12” diameter high-speed plankton sampler, a smaller version of the well-known “Gulf III”. The catching part consists of a conical plankton net, made of monofilament nylon plainwave bolting cloth (250 μ mesh width). The collecting bucket is a small bag, made of the same cloth as the net. The net is encased in a fibreglass cylinder of 32 cm internal diameter, fitted with 3 stabilizing fins at the posterior end. Water enters through the bridle-free opening of a nose-cone. Two different nose-cones have been used successively, their entrance diameter being 16 and 12 cm, respectively. A TSK flow-meter was mounted in the centre of the water exit, behind the collecting bucket, in a PVC cylinder (40 cm long, 32 cm internal diameter) which was fitted for this purpose to the end of the sampler. The tows were made at a speed of about 6 knots, evaluated from the speed of the engine (revs/min).

A number of plankton samples were collected in 1967 and 1968 off the coasts of Brittany, in the waters which mark the transition between the open Atlantic Ocean and the English Channel, for ecological studies, some of the results of which have been published elsewhere (Le Fèvre and Grall, 1970; Grall et al., 1971). For each tow, the exact towing time and the number of revolutions of the flow-meter’s propeller were recorded, in order to calculate the volume of water filtered. The formula given in the rating certificate provided with the flow-meter was used for this purpose, and this formula is of such a type that the mean water velocity, at the flow-meter’s site during the tow, is an intermediate result of the calculation. Water exit-velocity can be considered as a significant value: since the flow-meter is actuated by water having passed through the net, and since the towing speed is roughly constant from tow to tow, the variation in measured water exit-velocity is mainly due to changes of the hydrodynamic properties of the gear. A study of the evolution of the water exit-velocity during the lifetime of the sampler can, therefore, provide information
on the evolution of filtering properties, and especially on clogging.

It must be emphasized, however, that the volume of water filtered and the water exit-velocity were not actually measured, but only estimated, assuming a constant flow across the exit diameter. In fact, the flow-meter is situated behind the collecting bag, which clogs very quickly; one must expect, therefore, that the velocity estimation obtained is an underestimation of the actual mean velocity. It was not possible to determine the optimal site of the flow-meter, i.e., that where the measured velocity is equal to the mean velocity through the whole exit, as determined for the standard WP2 net by Tranter (1968). However, since the disposition of the different parts of the sampler remained the same throughout its use, one can admit that the different values are biased in the same way and, therefore, may be compared altogether.

Results and Discussion

Fig. 1. plots the values of calculated water exit-velocity \( v \) in chronological order; the main features of their distribution are pointed out in the legend to this figure. A striking difference is apparent between the values obtained when the gear was fitted with the original 16 cm diameter nose-cone (Samples 82 to 243) and those measured at the exit of the gear fitted with the 12 cm diameter nose-cone (Samples 254 to 326 and 344 to 355). As shown by statistical tests \( (\chi^2 = 2.967 \text{ for 2 degrees of freedom}) \), the values within the second series \( (v_2) \) can be considered as normally distributed around a stable mean value:

\[
\bar{v}_2 = 0.485 \text{ m/sec}.
\]

At the 5% probability threshold, we can, therefore, write:

\[
v_2 = \bar{v}_2 \pm 2\sigma_v,
\]

Fig. 1. Calculated water exit-velocity \( v \), plotted for different samples, in chronological order. Inc1: loss of nose-cone No. 1 (16 cm diameter); nc2: beginning of use of nose-cone No. 2 (12 cm diameter). Distribution of values depends clearly on nose-cone used: for nose-cone No. 2, dots are arranged as a plateau, \( v \) being distributed around a stable mean value; the replacement of the net (R), which occurred for instance after sample No. 280, has no effect on \( v \). For nose-cone No. 1, \( v \) tends to decrease with time, and replacement of net has, each time, the effect of increasing \( v \). However, values of \( v \) are stable at beginning of use of nose-cone No. 1, until some loss in filtration capacity appears; the occurrence of this clogging may tentatively be fixed at either \( c_1 \) or \( c_2 \).

ow: other work, carried out with conventional nets.