Filtration performance of plankton nets used to catch micro- and mesozooplankton

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Abstract

Zooplankton is of great significance in waters. It acts as an indicator for water quality, links the lower trophic levels like algae in the food chain with higher trophic levels like fish and plays an important, not yet fully known, part in the cycling of biogeochemical key elements. Abundance estimates of zooplankton build the base for the associated fields of research. The most widely used devices to take zooplankton samples to form abundance estimates are up to now plankton nets. Nets of various sizes and designs are in use which do have different sampling characteristics and in consequence, result in different abundance estimates of zooplankton.

To document the different sampling characteristics of nine commonly used plankton nets the hydrodynamics of the catching devices were numerically investigated with computational fluid dynamic (CFD) methods, more precisely "Reynolds averaged Navier-Stokes" (RANS) methods.
The investigation included the 1-m^2 MOCNESS, CalCOFI 1-m Ring net, Multinet Midi, Bongo net (Ø=60 cm), WP-2 net and the Bongo net (Ø=20 cm) to sample the smaller mesozooplankton and 3 different Apstein nets to sample microzooplankton.

The netting of the plankton nets (mesh width and twine diameter are of $O(10^{-4}$ m), porosity less than 0.5) was modelled as a porous medium which replicates the influence of the netting onto the flow, since it is too computational expensive to model the netting in detail. The

hydrodynamic characteristics of the netting, required to describe the porous medium, were determined by CFD investigations and were confirmed by experimental data where available.
The method of how to implement the porous medium is presented and its reliability was checked.

Selected plankton nets were investigated in the wind tunnel to record velocity data with a hot-wire anemometer in front of the nets. The data were used to prove the CFD method with its simplifications to be a suitable instrument to investigate the plankton net hydrodynamics.
Vertical plankton net tows were simulated to determine the filtration efficiency (dimensionless coefficient for the volume flow rate into the net), the filtration pressure (pressure difference between the inside and the outside of the netting) and the pressure distribution in front of the nets. The towing velocity ranged from 0.5 up to 2.3 kn for the nets to catch the smaller mesozooplankton. For the microzooplankton nets the towing velocity was in the range of 0.07 to 0.66 m/s. The findings were combined in technical characteristic sheets available for each investigated net. The qualitative assessment of the findings showed that the filtration efficiency decreases with a decrease of the mesh width and a decrease of the porosity. The filtration efficiency may be regarded as initially constant (clogging effects are not taken into account) at a towing velocity above approx. 1 kn (0.5 m/s). A large open area ratio (ratio of the open netting area to the mouth area of the net) will reduce the decrease of the filtration efficiency at towing velocities below 1 kn. The filtration pressure will decrease with an increase of the open area ratios and will increase with an increase of the towing velocity.

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