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Influence of fishes on the turbulent parameters and the mixing. Study case in a reservoir.

Jesús Planella, Elena Roget, and Xavier Sanchez
Group of Environmental Physics, Department of Physics, University of Girona, Catalonia, Spain (jesus.planella@udg.edu)

Fishes, like other swimming organisms, are internal energy sources in natural aquatic systems which usually form dense schools in their habitats. The energy injected into the water bodies by fishes is finally dissipated and the net dissipation rate of fishes depends on the power of the individuals but also on their number per unit volume. Although some controversy exists over the turbulence intensity generated by fishing schools, recent studies pointed out that dissipation rates, ε, within these aggregations at intermediate depths can be rather high, even comparable to the dissipation rates measured at the upper active mixed layer. However, for a given stratification, efficiency of mixing, γ_{mix} not only depends on ε but also on scales affected by the turbulence. In stratified shear flows, well developed turbulence affects the water column up to the buoyancy length scale $B = \left(\varepsilon/N^3\right)^{1/2}$where $N$is the Brunt-Väisälä frequency, and $\gamma_{mix} = B/\varepsilon$. However, fishes can not inject energy into a flow at lengths scales larger than themselves. Accordingly, the effect of fish swimming into schools can be an important source of mixing, but on the other hand turbulence generated by small fishes can be rather inefficient for mixing. Moreover, the possible interaction between fishing induced turbulence and the patchy turbulent events found in stratified layers is a challenging task and should be analyzed when dealing with mixing.

Reservoirs are often used as leisure places where fishing is not only permitted but promoted, so that repopulation of fishes are usual practices and the number of individuals can be very high. In this presentation the case of Boadella reservoir, in Catalonia, Spain, is presented based on microstructure measurements performed at the end of March. During the campaign the water column started to be stratified with a temperature of about 8 ºC and 12 ºC in the epilimnion and school of fishes where placed within the thermocline and moving at velocities as high as 40 cm/s. Dissipation rates measured within the path of the swimming fishes is of the order of 10^{-5} W/kg but the efficiency of mixing is significantly lower than the one expected for well developed shear induced turbulence.

Given the relatively high abundance of small and medium size fishes in the reservoirs and the fact the that dissipation rates is the most readily measured turbulent parameter in natural aquatic systems to parameterize the short time mixing considering standard mixing efficiencies, the knowledge of the spatial distribution of fishes and their migrations is important in order to use the correct mixing efficiency and avoid errors on the turbulent diffusivities as high as two orders of magnitude. On the other hand it is starting to be accepted that biomixing can play a role not only in lakes but in the sea where there are big fishes and large schools and even swimming mammals.

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