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The role of turbulence in biological physical interactions

L.Goodman (1) and A.R. Robinson(2)

1. School for Marine Science and Technology, University of Massachusetts Dartmouth, New Bedford Massachusetts, USA (l.goodman@umassd.edu)

(2)School of Engineering and Applied Sciences, Harvard University Cambridge Massachusetts, USA (robinson@pacific.harvard.edu)

A nonlinear model for biological and physical dynamical interactions in a laminar upwelling flow developed by Robinson (1997,1990) is extended to advective turbulent flow. A probability density function approach is used to obtain the statistics of the biodynamical state variables and their self interaction. Explicit evaluation of the mean moments of the biodynamical variables are performed. To illustrate the theory, a simple Nutrient (N), Phytoplankton (P) problem is considered- upwelling into a surface turbulent layer. Biological interaction is modeled as bilinear, representing the uptake of N by P in a uniform light euphotic zone. A random walk model is used to obtain the appropriate probability density function for the advective turbulent field. The mean quantities,$\bar{N}$, $\bar{P}$, as well as the biological interaction term $\bar{F} =< NP >$ are calculated. $\bar{F}$ has two contributions, $(\bar{N}\bar{P})$, and the turbulence induced interaction term, $< N'P' >$. It shown that the often neglected turbulence induced interaction $< N'P' >$ is of order $(\bar{N}\bar{P})$ and opposite in sign. This results in, over a wide range of Peclet numbers, the interaction term $\bar{F}$being significantly smaller than either of its constituent terms, $(\bar{N}\bar{P})$ and $< N'P' >$.