NEW METHODOLOGICAL APPROACH TO ESTIMATE THE TURBULENT KINETIC ENERGY DISSIPATION RATE (ε)

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Abstract - The length scale and the spatio-temporal variation of turbulence intensity has relevant implications on phytoplankton dynamics. Thus, it is important to estimate the relevant parameters that characterize the turbulence in the water column, such as epsilon (kinetic energy dissipation rates). One of the main objectives in this work is the characterization of the physical dynamics at scales relevant to the biology. Here we show different approaches to estimate the epsilon in the Alfacs Bay (Ebre Delta), where recurrent harmful algal bloom events occur. First, we applied the solid boundary layer theory wind velocities obtained by a nearby meteorological station. Secondly, the gradient temperature microstructure method, based on the Batchelor spectrum adjustment was applied on temperature data obtained by a Self-Contained Autonomous MicroProfiler (SCAMP). These two approaches have methodological restrictions, i.e. isotropic turbulent or the process applied to do the Batchelor spectrum fitting.
A new method to characterize the turbulence is proposed. The velocity fields measured by a deployed high resolution 2 MHz acoustic Doppler current profiler were processed using the Reynolds decomposition to obtain an empirical parameter which provides us the information about the turbulent kinetic energy in the water column.

Keywords – Turbulent kinetic energy dissipation rate, Signal Processing, ADCP, new method to estimate turbulence

I. INTRODUCTION
Hydrodynamics plays a primary role in aquatic ecosystems. Understanding of any physical and biological interactions requires obtaining the characterization of the environmental changes derived from the transport mechanisms and the response of organisms to these changes. Interest in the interaction of small-scale processes is reflected in the increasing number of review papers [1] [2].
This paper presents two different methods used in the literature to estimate the turbulent kinetic energy dissipation rate. A new method to compute an empirical parameter similar to ε value from velocity profiles obtained from ADCP is presented.

II. METHODOLOGICAL APROACHES
The first method was developed by MacKenzie and Leggett [3].
This method uses the wind and the depth as inputs to compute the ε value. These input characteristics and the consideration of the exponentially decreasing energy, limit the potential of this method to characterize all water column. The results of this method are only valid from surface to the picnocline.
Next expression (1) represents the formula to compute epsilon.
Where ρa is the density of air (1.2Kg m-3), ρw is the density of seawater, CD is

$$\varepsilon = \left[\frac{\rho a}{\rho w} C_D\right]^{3/2} * \left[\frac{Wind^3}{0.4\,depth}\right]$$

coefficient of drag between the water surface and the wind and 0.4 represents the von Karmann's constant.

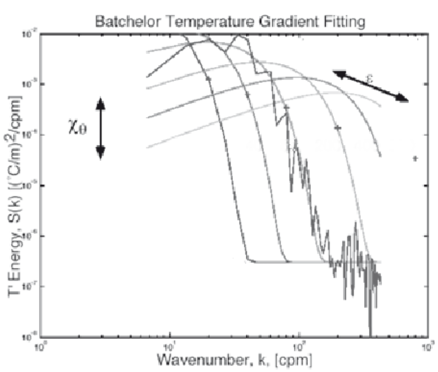

Fig.1 Batchelor temperature gradient fitting process to obtain the turbulent kinetic energy dissipation rate.

Second method apply the algorithm developed by Ruddick [4] to obtain the epsilon by fitting the theoretical Batchlelor spectrum [5] to the measured spectrum of temperature gradient, as is shown in figure 1.
This method presents restrictions in the fitting process and jittering effects on spatial sampling.
Wrong adjustments during the fitting process are difficult to identify and to reject, as we can see in figure 2.

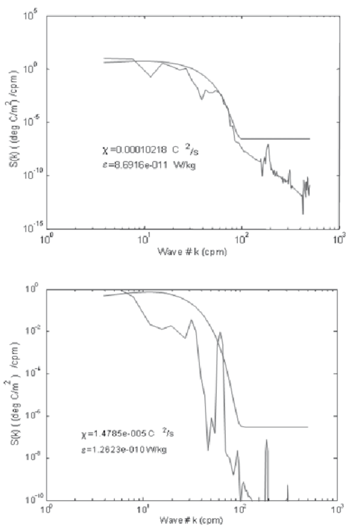

Fig. 2 Batchelor temperature gradient fitting process to obtain epsilon. i.e: (a) represent well adjusted spectrum – (b) wrong adjuste.It is difficult to identify the error to reject the epsilon value.

III. NEW METHOD
An empirical parameter computed from ADCP data is obtained from the new method to establish a relation between turbulence and kinetic energy in the water column.
Using Reynolds decomposition [6] we can obtain Kinetic energy of the mean and turbulent velocity components.
Where u represents the instantaneous velocity, U the mean component and u´ the turbulent velocity.
Power Spectrum density from kinetic energy gives us the information about energy at different frequencies. The kinetic energy spectrum integration indicates the energy concentration in a frequency range.

IV. SUMMARY
The ε estimation is important in the study of turbulence, but it requires many restrictions and difficult calculations. We aimed to find a more convenient, easy and empirical parameter to obtain similar information than epsilon. Our suggested parameter can be obtained in base of the Power Spectrum Density from the kinetic energy.

V. ACKNOWLEDGES
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