Development of a National Littoral Ocean Observing and Prediction System: Field Estimation Via Interdisciplinary Data Assimilation: Turbulence Characterization from an AUV

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LONG-TERM GOAL

My long term scientific goal is to understand coastal mixing processes, utilizing turbulence measurements obtained from small Autonomous Underwater Vehicle (AUV) based sensors, and to contribute to the improvement of subgrid characterization in combined coastal ocean observation/prediction networks.

OBJECTIVES

Within the context of the Cape Cod Bay/Mass. Bay based National Ocean Partnership Program (NOPP) coupled ocean observation/modeling system, I wish to use AUV-based turbulence measurements to quantify mixing in shallow water physical process studies (upwelling regions, fronts. boundary layers). This includes identifying regions of enhanced mixing, determining the horizontal spatial scale of mixing events, defining the role of boundary layers, and parameterizing results for coastal predictive model testing studies of subgrid scale processes.

APPROACH

My approach is to integrate an optimum turbulence sensor suite into a small, logistically simple, AUV, with input from the ocean turbulence and modeling communities. Then, I seek to establish this small AUV as a viable platform for coastal turbulence research. Towards this end, I obtain horizontals profiles of dissipation rate, temperature microstructure, 3-dimensional small scale velocity, larger scale vertical shear of horizontal current, and stratification in the coastal environment.

Subsequently, I studied mixing in the context of the multi-scale measurements surrounding the Littoral Ocean Observation and Prediction System (LOOPS) site in Cape Cod Bay/Mass. Bay. I sampled adaptively using a continental shelf model, the HOPS model (Lozano et al, 1996).

The sensors provided data for estimates of eddy diffusivity profile (Gargett and Moum (1995), eddy viscosity profile (using the truncated TKE equation), bulk and gradient Richardson numbers, fluxes [using the correlation technique]. These data enable us to evaluate to tune and improve filter parameters in the HOPS numerical model.

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WORK COMPLETED

We electrically and mechanically integrated a turbulence sensor package was into the REMUS AUV (Levine and Lueck, 1998). Sensors include two shear probes, an ultra-fast thermistor, an upward and downward looking ADCP, two CTDs, and an ADV-O. Preliminary field trials were conducted in Narragansett Bay to test sensor/platform synergy and software viability.

Utilizing these techniques, we conducted scientific studies during varied circulation patterns in the LOOPS region of study in Cape Cod Bay during September 1998, including an upwelling event. Harvard model forecasts concentrate on a multiscale examination of the patchiness of the biological/physical regime that supports zooplankon layers associated with right whale feeding in Cape Cod Bay (relate patchiness to dispersion processes**).** In the field experiment, high quality data were obtained from all sensors, and data analysis is proceeding well.

RESULTS

Using model-based adaptive sampling, the AUV was deployed along a trajectories through components of Cape Cod Bay general circulation, including the upwelling region and the gyre center. These measurements were made synoptically with those from other platforms which characterize larger scale structures in nearby Cape Cod Bay and the larger Mass. Bay influences. Model predictions which include assimilated data from the wide variety of sampling platforms is also available for intercomparison, including shipboard, satellite and Odyssey AUV data acquisition .The turbulence sensor instrumented REMUS provided the smallest of the nested scales

Results indicate that the modified REMUS AUV (Fig 1) was a viable platform for turbulence data acquisition in the coastal ocean, with good data obtained from all sensor systems. For example, a data sample obtained from the vertical and transverse shear probes, for a short transect in the upwelling region during peak upwelling in Northern Cape Cod Bay near the Race on September 24, 1998, has been analyzed. These data have been processed to remove noise associated with vehicle vibrations utilizing data from accelerometers located in the probe pressure case directly behind the probe mounts, utilizing the techniques of Levine and Lueck (1998), and also low pass filtered. The autospectra for this segment are shown in Figure 2, and correspond to a dissipation rate of approximately $5x\ 10^{-9}$ W/kg based on the computed spectral variance. The Nasmyth “universal spectrum” (Oakey, 1982) for this dissipation rate and appropriate viscosity agrees well in level and shape with the observations out to wavenumbers close to the physical size of the sensing tip of the shear probes.

IMPACT/APPLICATION

The AUV-based turbulence measurements provide a unique horizontal profiling view of the variability of the mixing environment that cannot be obtained by more conventional sampling measurements, and this approach can be further exploited in yo-yoed horizontal sections. These techniques will be invaluable in upwelling process studies in which competing alternatives are testing in HOPS to parameterize subgrid processes according to the Shapiro filter tuning of Lermusiaux, (1997) or other methods (Chassignet and Verron, 1998)

TRANSITIONS

Our AUV sensor technologies, hardware and software, are being considered for inclusion as tactical oceanography payloads for the Manta UUV Initiative, proposed for an upcoming Accelerated Research Initiative (ARI).

RELATED PROJECTS

Our AUV-based turbulence measurement system is also being utilized in NOPP studies with the Rutgers University led project at LEO-15. Measurements were also made in the Mid-Atlantic Bight in July 1998.

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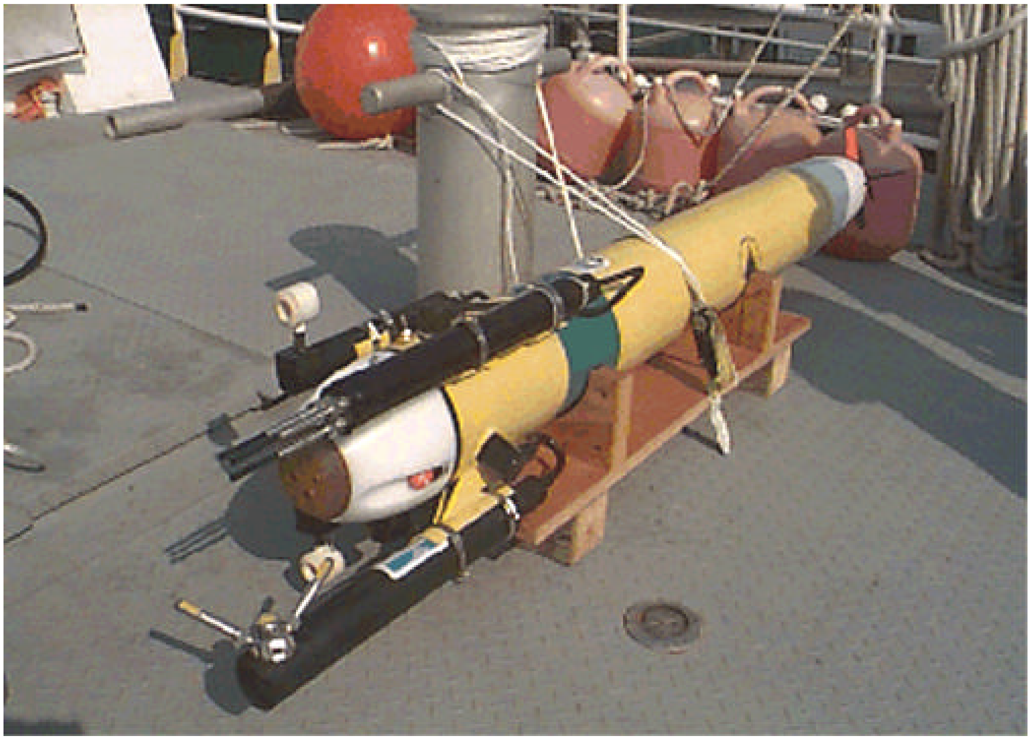

Fig 1. The REMUS AUV instrumented with turbulence sensors

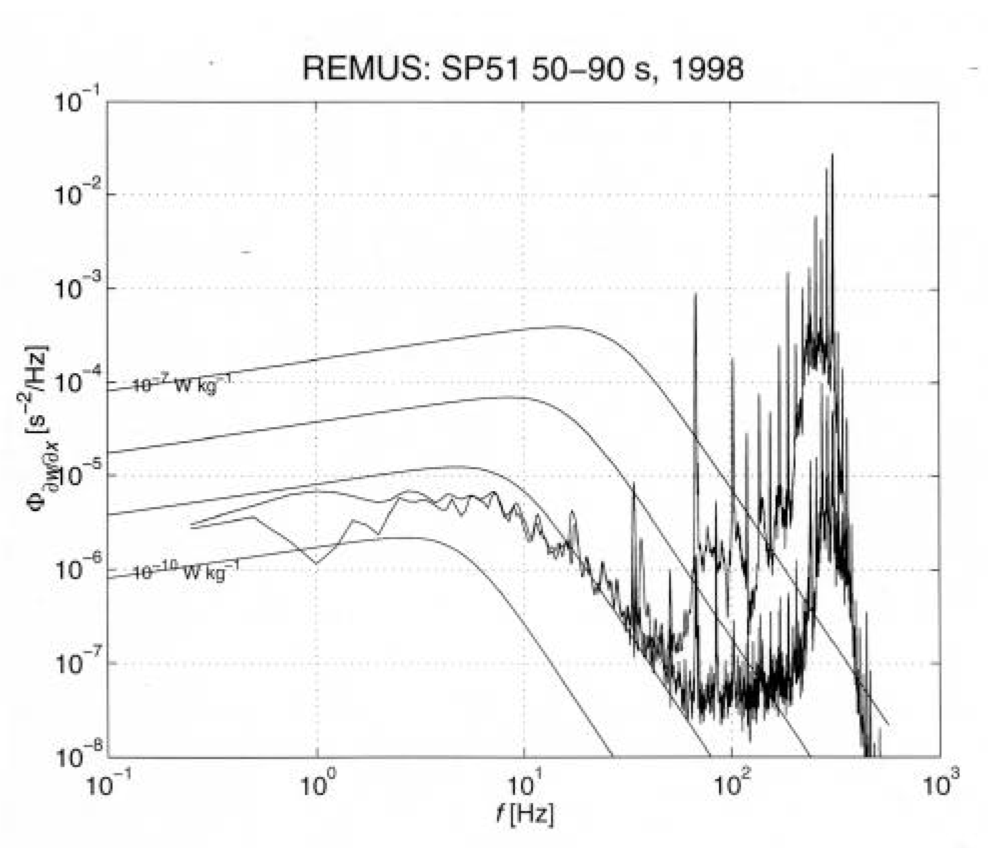

Fig. 2 Shear probe autospectra from the Cape Cod experiment compared with the "Universal" spectrum