AUV-Based Measurements of Turbulence in the Oregon Coastal Ocean

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LONG-TERM GOALS

Our long-term goals are to understand the mechanisms of turbulence and mixing in the coastal ocean environment sufficiently well to be able to incorporate mixing processes in coastal circulation models as sub-grid scale parameterizations. We plan to achieve our long-range objectives by collecting concurrent data sets of microscale, finescale, and mesoscale variables from sensors mounted on an autonomous underwater vehicle.

SPECIFIC OBJECTIVES

The main objective of this study is to demonstrate the feasibility of simultaneously collecting microstructure, hydrographic, and velocity data from an autonomous underwater vehicle (AUV) platform and ancillary data from a small boat in Oregon coastal waters.

APPROACH

The approach is to collect data off the coast of Newport, Oregon using an AUV acquired from Bluefin Robotics in combination with a sensor payload section developed at OSU. Our field program has been delayed until November, 2002, due to delays in the delivery of the AUV from Bluefin Robotics, and the proposed test cruises were conducted during March, April, May, and June 2003.

WORK COMPLETED

We have developed a sensor payload section for use with a Bluefin Robotics Odyssey III Autonomous Underwater Vehicle (AUV). We have conducted several different test cruises to familiarize ourselves with AUV navigation, cruise planning, deployment and retrieval techniques, and testing of a variety of sensor packages including CTD, microstructure instruments, ADCP, and optical sensor packages. We practiced several different deployment and retrieval strategies from boats varying in size from 30’ (a water taxi) to 175’ (R/V Wecoma) and in a variety of conditions ranging from calm to stormy. We have learned to fly in a variety of modes, including constant depth, saw-tooth, and combinations of these. This vehicle should be able to fly along, i.e. within a small margin either side of, constant property surfaces (e.g. isopycnals), but currently we do not have that capability.

We conducted a total of 10 days of test trials in the Yaquina Bay and off the coast Oregon using R/V Elakha. We piggy-backed on an NSF CoOP mooring recovery cruise on R/V Wecoma, where we gained valuable experience on deployment and retrieval under strong wind (~ 25 knots) conditions. We noted that handling this vehicle in rough sea was extremely difficult.

Figure 1: AUV with full payloads. Getting ready to perform a compass calibration in Homer, Alaska (left panel). Deployment of AUV from OSU’s 54’ long R/V Elakha in the Yaquina Bay during acceptance trails (right panel).

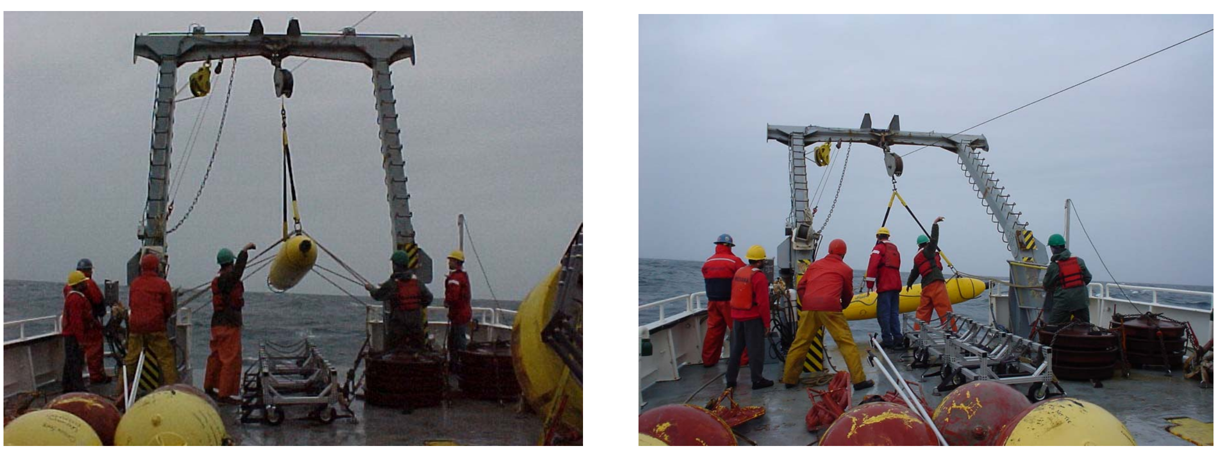

Figure 2: Deployment (right) and retrieval (left) of AUV from R/V Wecoma off the coast of Oregon, March 19, 2003.

Figure 3: Deployment of AUV by lowering a boat trailer in a boat ramp (right panel) in Kachemak Bay, Homer, Alaska. AUV steaming at the surface in the Kachmak Bay on June 2, 2003.

RESULTS

We have developed and tested a sensor payload section consisting of CTD, optics, ADCP, and microstructure sensors for use with a Bluefin Robotics Odyssey III Autonomous Underwater Vehicle (AUV). We have deployed the AUV, including our payload section, from various platforms in a variety of weather conditions and sea states.

We have tested the AUV's ability to sample in the upper ocean in a variety of modes: including sawtooth (i.e. "yo-yo") transects, repeated horizontal transects at several depths in a single plane (a "ladder"), and horizontal surveys (i.e. "mowing the lawn"). During this testing we established some baseline characteristics of the AUV as presently configured, and identified areas that need future improvement. For example, when traveling on a straight and level path the AUV is extremely stable, with rms depth fluctuations < 0.05m, rms pitch <1º and rms roll <1º. On the other hand, navigational accuracy needs improvement from the order 10% of distance traveled at present. An example of small amplitude (~1.5m) sawtooth sampling bracketing a constant depth horizon is shown Figure 4.

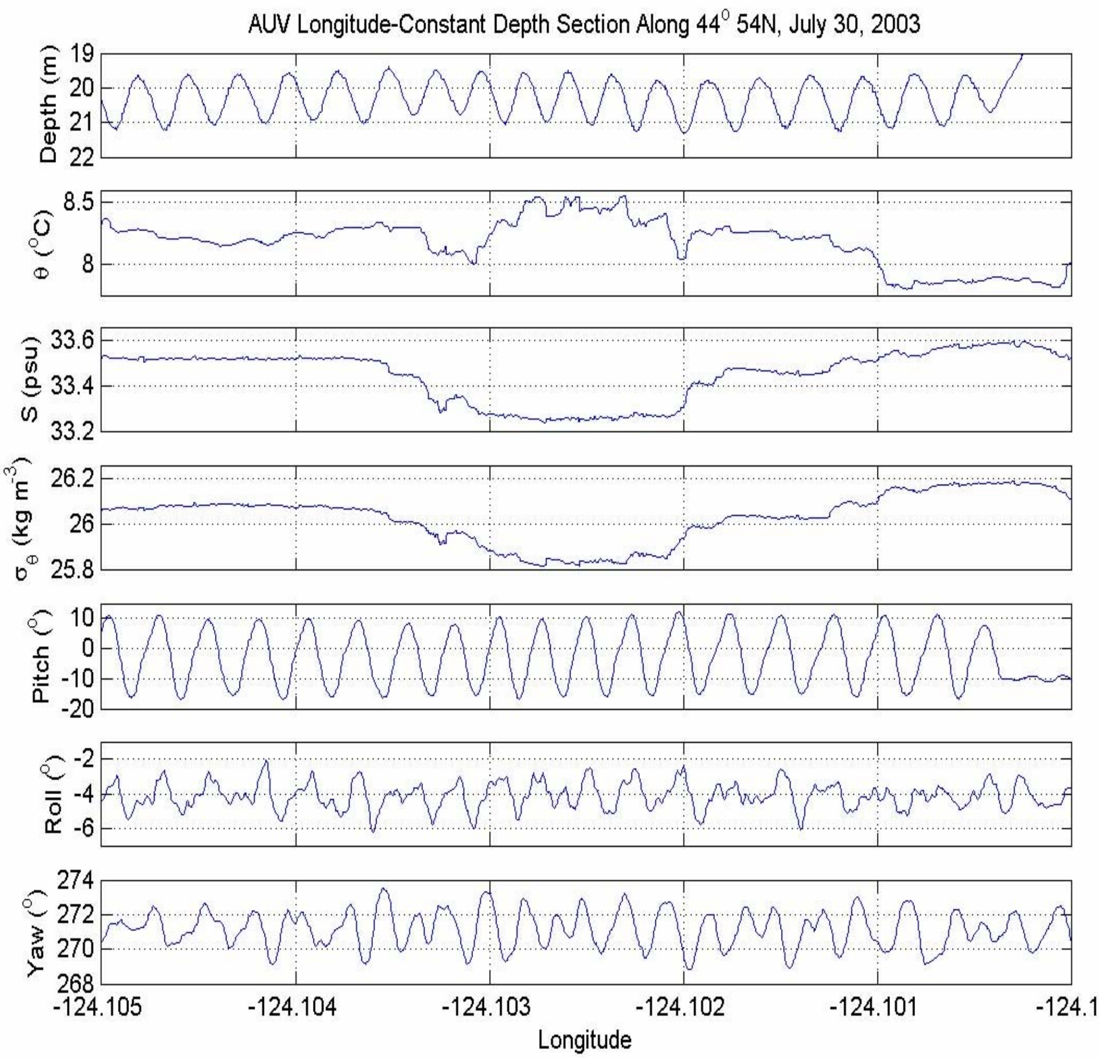

Figure 4. A short (~ 400 m) section of small amplitude sawtooth sampling at around 20m depth, showing (from top to bottom): depth of the AUV, temperature (θ), salinity (S), and density (σ_θ) along the AUV path, followed by AUV pitch, roll, and yaw. Note that the vehicle pitch changes smoothly as the AUV progresses, and that roll and yaw fluctuations are small amplitude.

We measured temperature variance dissipation rate with our microstructure package mounted in the nose cone (Figure 1). The acceleration sensors show a relatively broad vibrational peak at 15-17 Hz, due to propulsion system, and a narrow peak at 50 Hz, due to the CTD pump which is mounted in the nose cone section below the microstructure package. Displacement due to the 15-17Hz spectral band is about 0.5 mm, which is significantly smaller than the horizontal resolution of our conductivity sensor. Thus, the present levels of AUV vibration does not affect conductivity microstructure measurement. The present level of vibration would affect velocity microstructure measurement, however, and in the present configuration would limit the measurement of TKE dissipation rates to greater than 10^{-7} W/kg.

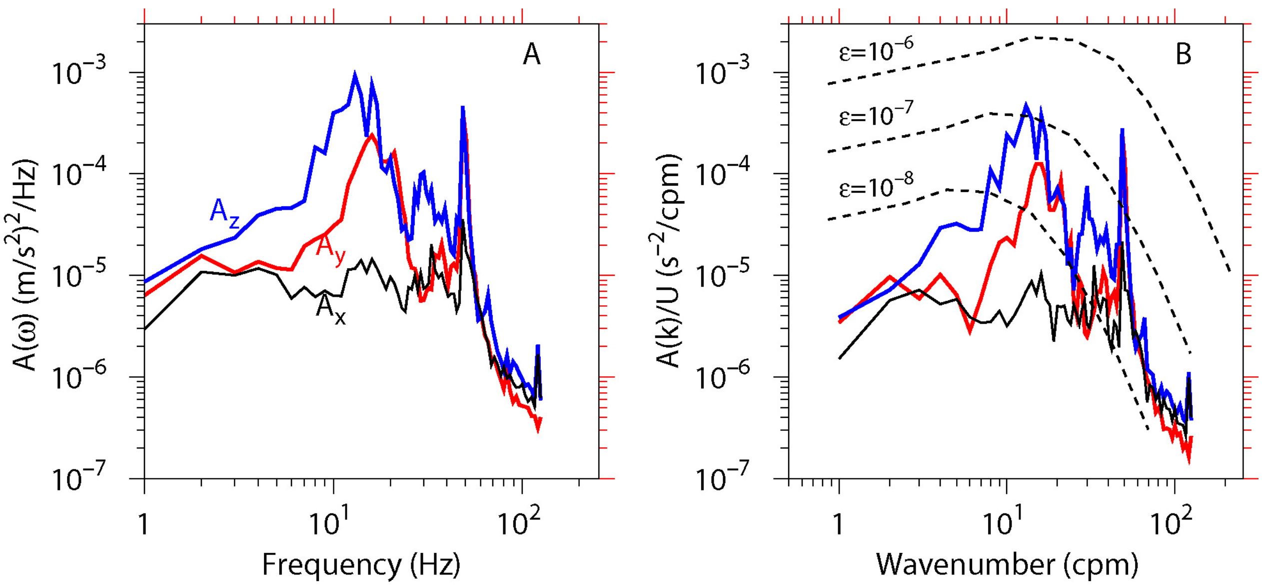

Figure 5: Acceleration spectra based on 10 s acceleration record from the MicroSoar accelerometer. Sampling rate was 256 Hz. (A) longitudinal, A_x, transverse A_y, and vertical A_z spectra. (B) Normalized acceleration spectra, where is U is the speed of AUV, where horizontal wave number, k = ω/U. The dashed lines denote Nasmyth's universal shear spectra for different values TKE dissipation rates.