Ocean Dynamics

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LONG-TERM GOALS

To gain a more complete understanding of ocean dynamical processes, particularly at fine-scale, through comparison of high, mid- and low-latitude observations, near the sea surface, in the main thermocline, and near the sea floor.

OBJECTIVES

To identify the phenomena involved in the cascade of energy from meso-scales to turbulent scales. In particular, we wish to quantify the relationship between fine-scale background conditions and the occurrence of microscale breaking.

APPROACH

Progress is achieved through a steady-state cycle of instrument development, field observation and data analysis. The primary instruments employed include Doppler sonar and rapidly profiling CTD's. Our instruments produce information that is quasi-continuous in space and time, typically spanning two decades in the wave number domain. This broad band space-time coverage enables the investigation of multi-scale interactions.

WORK COMPLETED

Figure 1. R/P FLIP deployed as part of AESOP. Port boom is on the left, picture is taken from the aft boom, and starboard boom is on the right. (Photo: T. Hughen

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The Upper Ocean Physics Group from Scripps Institution of Oceanography deployed aboard R/P FLIP as part of the ONR-AESOP field program s. Our goal was to observe and to characterize internal waves, to determine their sources and to document the cascade to turbulence. This exercise was closely coordinated with two other groups, Johnson and Rudnick performing a Sea Soar survey aboard the R/V Wecoma and Girton and Kunze aboard the R/V Pt. Sur. Our observations were obtained with a rapidly-profiling CTD and an up- and down-looking Doppler sonar system. For the most part, these were deployed in a mode that covered as much of the water column as possible (~0-940m) as quickly as possible. On two days we switched to an intensive mode in a 200-m swath near the sonar at 400 m.

Our participation in AESOP was delayed for a week because the Navy tug that tows R/P FLIP was under repairs in Hawaii. We were able to negotiate an extra three days at the end of the cruise, to compensate for some of the days lost. We left San Diego Aug 16 for a 40 hour tow to Monterey. Mooring operations began Aug 18. The latest current prediction from the R/V Wecoma indicated a south-westward current so we positioned slightly north-east of the target site and flipped to vertical. The prediction proved to be incorrect, and R/P FLIP drifted southeast. The tug held us in position, and gained back some of the lost ground, but we were unable to position as far west as we wanted. The final position was 36 29.7480N,122 5.6450W, maintained by a tri-moor of anchors at positions indicated in table 1 and figure 2.

Table 1. FLIP location and anchor drop locations. Each anchor was on 1829 m lines in 1000 m of water, so the anchors are closer to R/P FLIP than the drop positions indicate.

	Lat 36° N	Lon 122° W
R/P FLIP	29.748′	5.645′
Keel Anchor	30.767′	5.717′
Port Anchor	28.921′	6.454
Stbd Anchor	29.496′	4.287

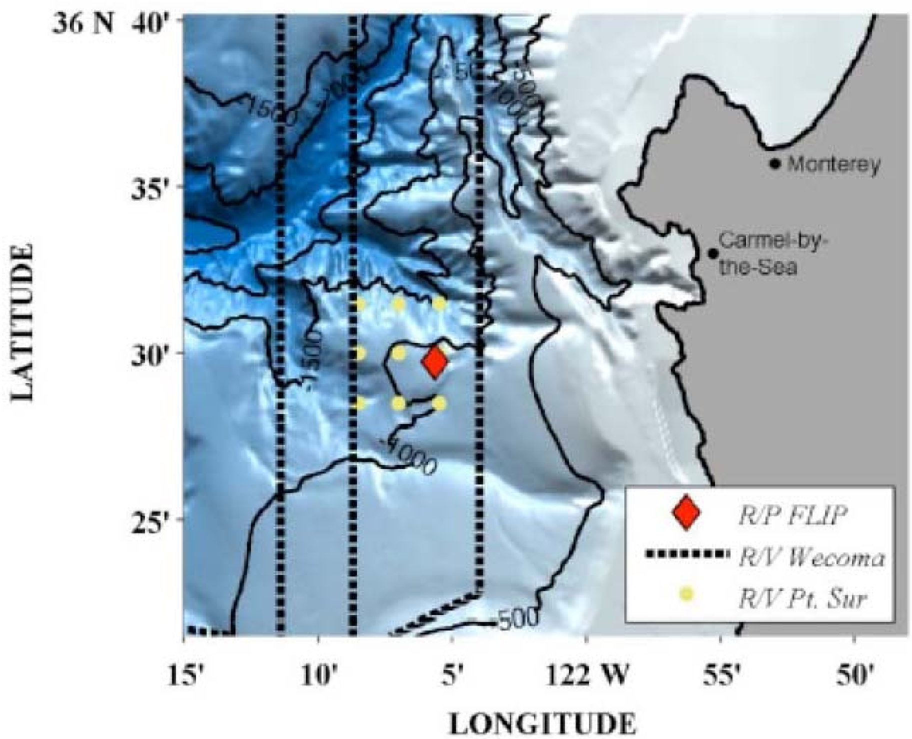

Figure 2. Location of FLIP in the context of the off-shore internal wave part of AESOP experiment.

The Deep 8 Sonar system was deployed from the port boom (figure 1). Data collection was essentially continuous from 19 Aug 1242 on. A summary of velocities for much of the cruise is shown in figure 3. The system was lowered to approximately 415m. This depth changed as the tide raised and lowered the water level, and as R/P FLIP's buoyancy changed. The sonar transmitted every 0.7 s, with 2.5-m averaging bins over-sampling the 5-m pulse length. The upwards looking sonar transmitted at 170 kHz and the downward at 140 kHz. Range was limited in the vertical by scattering in the water column. Penetration to 780 m was typical. Near-surface velocities were obscured by the surface side lobe at 80 m. During certain days, the Doppler was attenuated deeper than this by strong scattering layers that absorbed or reflected virtually all of the sound.

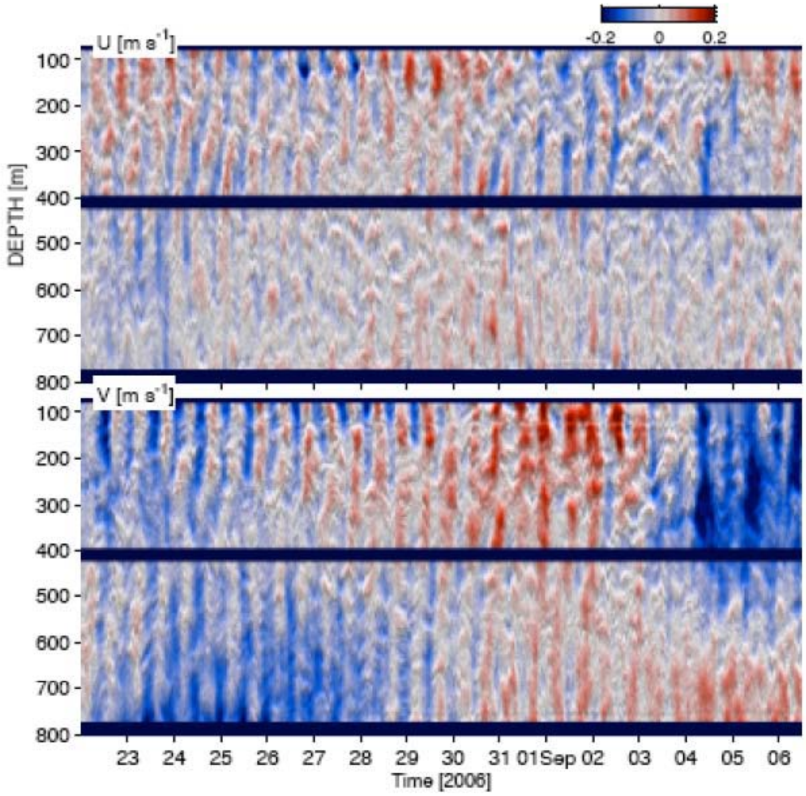

Figure 3. Velocity from 22 Aug until 6 Sep. Shading indicates vertical shear.

The Fast CTD was deployed on 20 Aug. The unit had seen heavy use on a cruise 1.5 months previous and had developed some problems that required attention. These were sorted out by 22 Aug, with smooth operation after that time. The only stoppages were for a computer malfunction, and when we inadvertently sampled the bottom. The bottom sampling required a few minutes out of the water to clear the conductivity cell, but no damage was done. The Fast CTD consisted of a SBE 49 CTD unit augmented by an SBE 7 micro conductivity cell. The unit was dropped between 2 and 5 m/s and was brought back up at faster speeds. A full drop from the surface to 920 m took almost exactly 9 minutes. This fast sampling rate greatly exceeded the buoyancy frequency at all but the shallowest depths. The purpose of such rapid sampling is to merge the Doppler and CTD measurements such that the time evolution of the velocity and shear fields could be monitored in a reference frame that moved vertically with isopycnals This worked quite well for this data set.

RESULTS

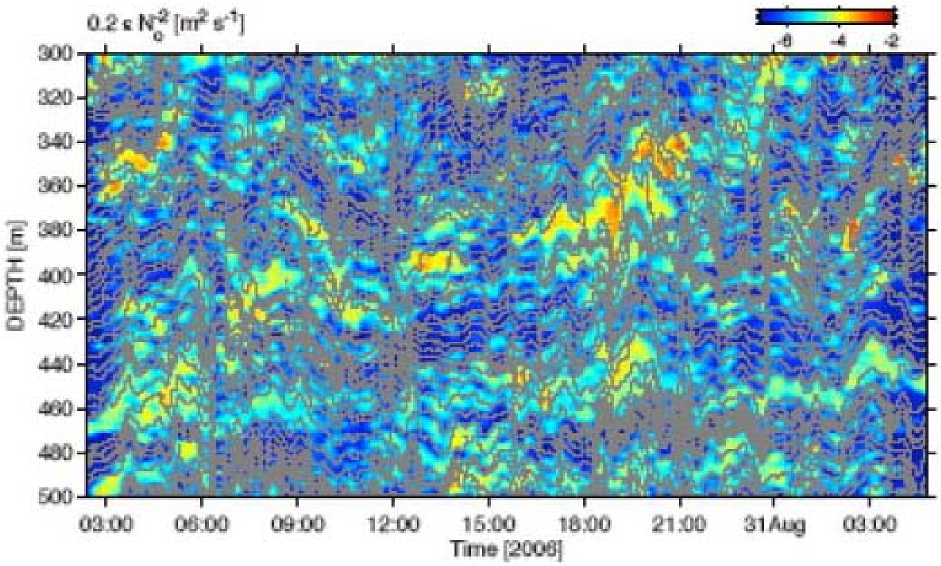

Figure 4. A depth-time map of turbulent dissipation obtained from the Fast CTD. Isopycnal surfaces are given in black. From this time-evolving display, we can investigate the antecedent conditions that lead eventually to overturning.

On 30 Aug we switched to an abridged CTD drop range from 300 to 500 m. These drops were made at a lower drop speed of 1 ms_1. The goal of this sampling mode was to get high-resolution statistics near the depth of the sonar, where the horizontal beam separation would not complicate interpretation of shear statistics. Dropping slowly allowed better CTD resolution, leading to more accurate overturn estimates. Preliminary analysis indicates a combination of dissipation sources, both high shear and high strain playing a role, Figure 4.

The Phased Array Doppler Sonar was deployed as an ancillary instrument. The data will be analyzed by Jerry Smith. Two consecutive frames from a movie of backscatter intensity (left) and radial surface velocity (right), 2 seconds apart, are shown in figure 4. The typical NW swell is seen clearly in both signal. This is from a time where conditions were favorable for the measurement. The useful range of surface-velocity measurements varies widely, from just a few hundred meters in calm conditions to well over a kilometer when winds exceed about 6 m/s. In AESOP , a diurnal pattern emerges: even in weak winds, the useful range increases in the evening at about 8 pm (local time), but devolves an hour or two later into noisy velocity estimates, even though the intensity still indicates long ranges with good (acoustic)signal. We hypothesize this results from upward migrating zooplankton arriving first (yielding good velocity statistics), followed by predators that introduce large velocity variability.

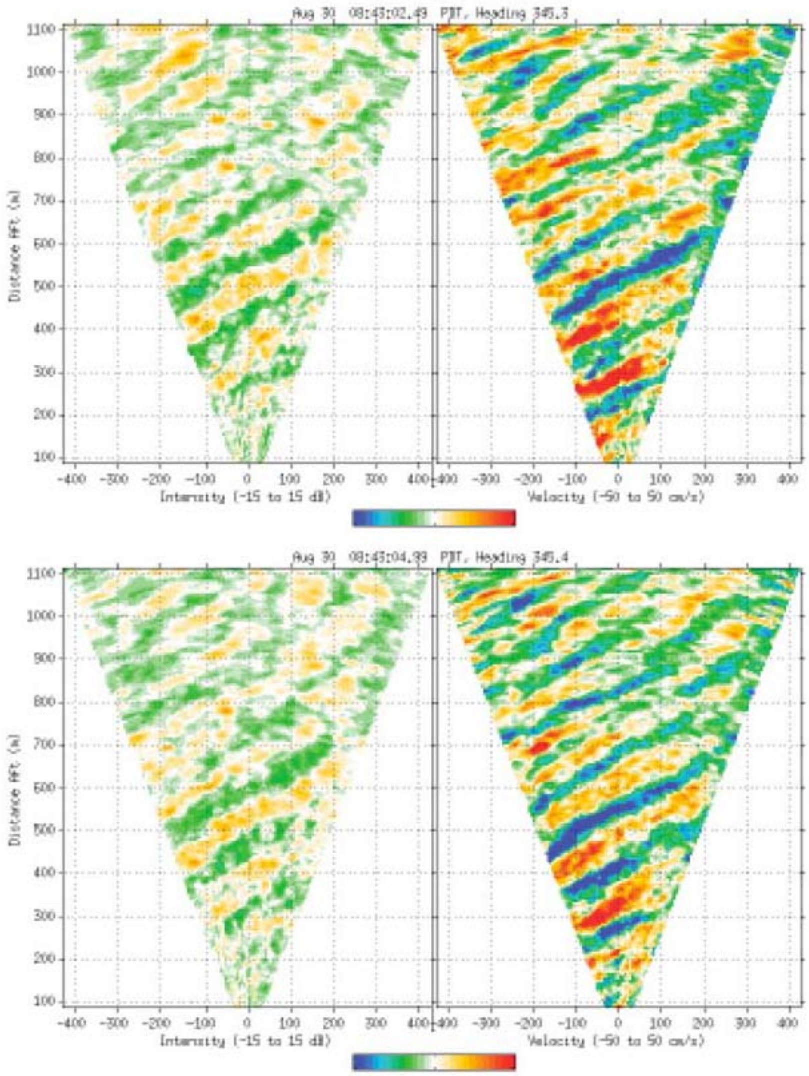

Figure 5. Two snapshots, 2 s apart of surface wave properties from the Phased Array Doppler Sonar.

We hope to analyze wave group statistics (among other things). While temporal wave group characteristics have been studied some in the past, these data provide the opportunity to examine spatial group coherence, both in the along and across-propagation directions.

IMPACT / APPLICATIONS

The data provide an unusually close look at a complex coastal site. We look forward to merging our depth-time view of the region with the (x-z) view obtained from the moving ships in the experiment.

RELATED PROJECTS

The refinements of the Fast CTD will be continued, in preparation for use in the coming SCS-07 Experiment in the South China Sea.