Diapycnal Mixing in a Coastal Regime – AESOP

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Grant # N00014-15-1-0362

LONG-TERM GOALS

To identify the major processes producing mixing in the upper ocean and to understand their dynamics sufficiently well to permit accurate parameterization of mixing for use in numerical models.

OBJECTIVES

These measurements during August 2006 were the first attempt we know of to survey a coastal domain with sufficient coverage to assess how mixing levels vary across the domain. Previous measurements have been concentrated in sub-regions, often revealing particular mixing processes, but insufficient to guide modelers in how to represent mixing over the whole domain of a regional model.

APPROACH

To obtain spatial coverage, we ran lines of microstructure profiles that were 5-10 km long (Fig. 1). To observe the primary temporal variability, each line was run repeatedly for 12.5 hours, the period of the 'twice-daily' tide, and some lines were rerun at a different phase of the monthly tidal period. Our planned lines were modified as we went and began to understand the patterns of tidal currents and mixing in the bay. The mixing measurements were supplemented by the powerful Doppler Sonars installed on R/V Revelle by Rob Pinkel at Scripps and by a 300 kHz ADCP on the bottom the the bay.

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **30 SEP 2007**	2. REPORT TYPE **Annual**	3. DATES COVERED **00-00-2007 to 00-00-2007**

4. TITLE AND SUBTITLE **Diapycnal Mixing In A Coastal Regime - AESOP**	5a. CONTRACT NUMBER
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **University of Washington,Applied Physics Laboratory,1013 NE 40th St.,Seattle,WA,98105**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
code 1 only

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**6**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

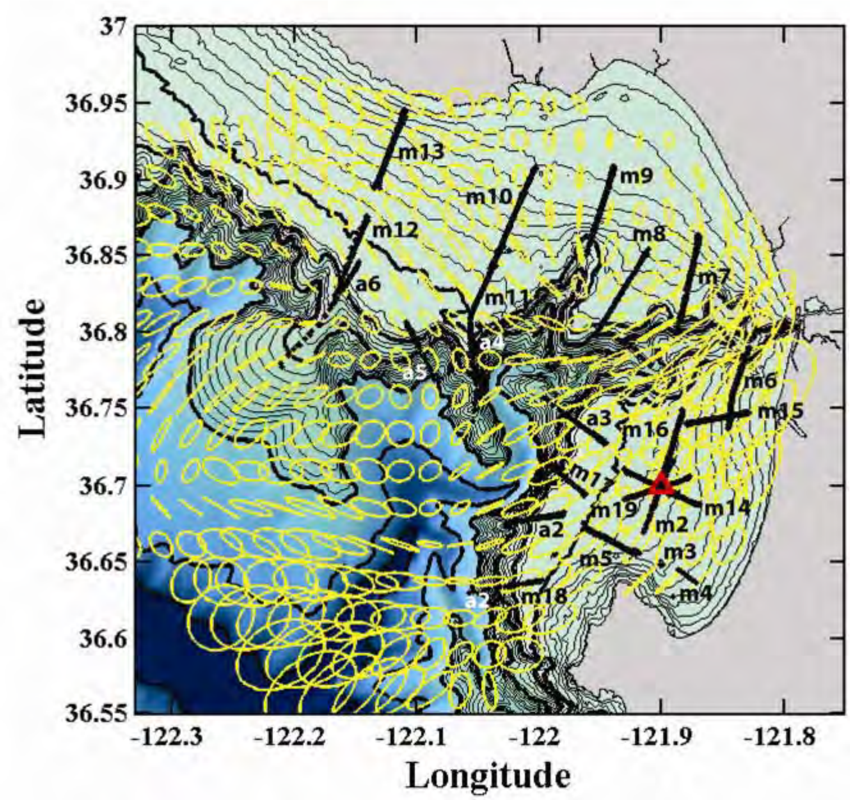

Fig. 1 Bathymetry of Monterey Bay overlaid with tidal ellipses (yellow), tracks of microstructure sampling (black) and the position of a 300 kHz ADCP set on the bottom (red). Tracks taken with the Advanced Microstructure Profiler (AMP) are labeled with 'a' and those with the Modular Microstructure Profiler (MMP) with 'm'. The tidal ellipses were supplied by Leslie Rosenfeld of the Naval Postgraduate School (Rosenfeld et al., 2006)

WORK COMPLETED

The data have been reduced, and we are in the midst of scientific analysis.

RESULTS

The bottom-mounted ADCP record shows that the internal tide had a constantly shifting modal structure (Fig. 2) dominated by the first mode but with important contributions from modes 2-5. Identifable peaks match the inertial frequency, f, and tidal lines K1, M2, S2, M3 and M4 (Fig. 3), though the record is too short to distinguish M2 and S2. Empirical Orthogonal Function (EOF) analysis shows vertical structures approximating internal wave modes with the relative mix of amplitudes constantly shifting.

At time the modes combine to produce vertical bands of elevated shear variance that coincide with bands of elevated turbulent dissipation (Fig. 4). We are not aware of previous reports of similar structures and did not observe bands like this in time series on the New England continental shelf during the Coastal Mixing and Optics (CMO) field work.

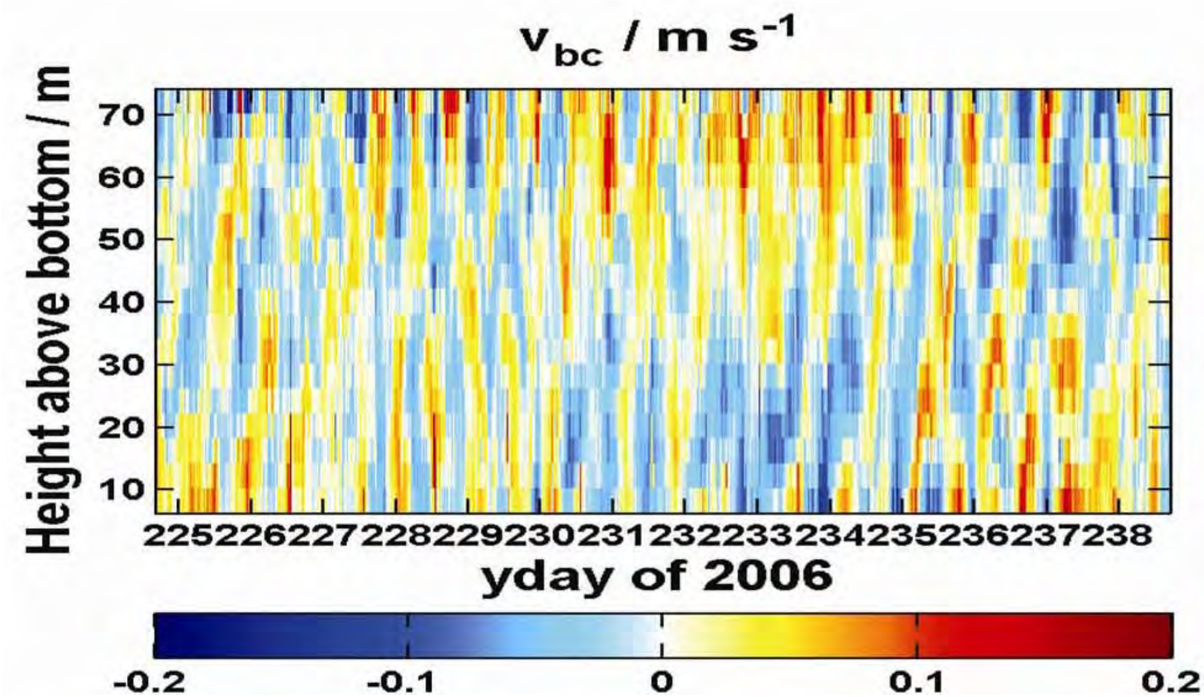

Fig. 2. Baroclinic north/south velocity measured with the bottom-mounted Workhorse 300 kHz ADCP The horizontal axis is elapsed days during 2006. The current exhibits a strongly modal nature that evolved during the fortnight.

Vertical bands of elevated dissipation also appear in the AESOP data; the example in Fig. 4 is one of the weaker ones. These coincide with intense vertical bands of acoustic backscatter observed with our DT-X BioSonics system using 120 kHz and 200 kHz transducers and with the ship's 12 kHz Knudsen echo sounder. Francisco Chavez (personal communication, 2007) and colleagues at the Monterey Bay Aquarium Research Institute (MBARI) believe that the acoustic images were produced by schools of anchovies. Some of these produced dissipation rates between 10-6 and 10-5 W/kg, the largest values observed in the bay.

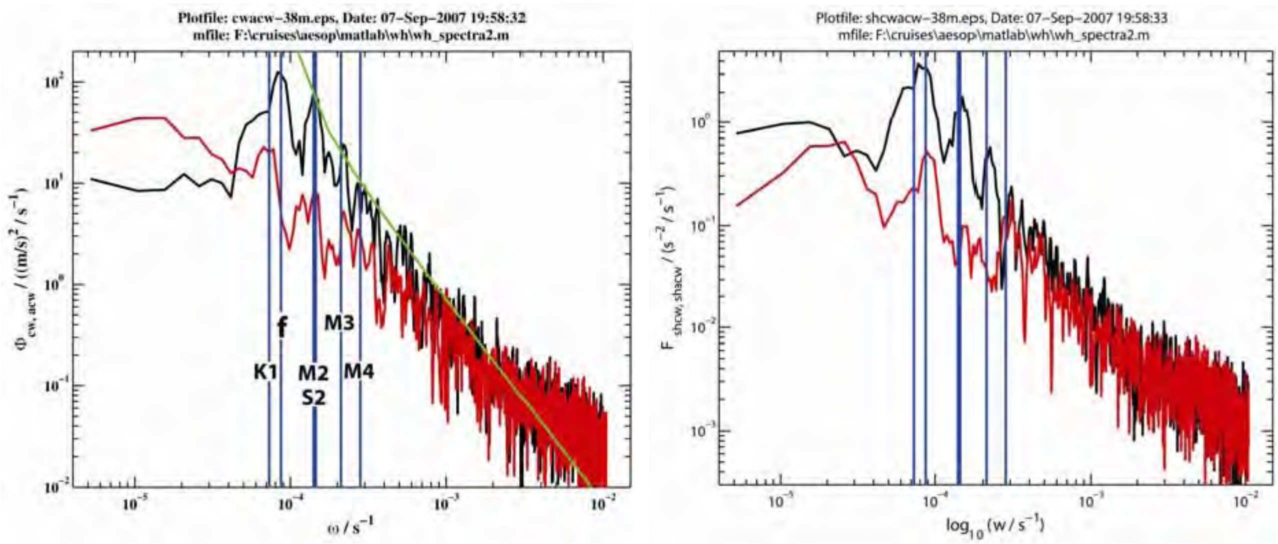

Fig. 3. Spectra of velocity (left) and shear (right) for the Workhorse bin 38 m above the bottom. Clockwise (anti-cyclonic) and Anti-clockwise (cyclonic) components are black and red. Vertical blue lines mark frequencies of K1, M2-S2, M3 and M4 tidal constituents as well as the near-inertial frequency, f. The data record is too short to separate M2 and S2. The green line is the modification of the Garrett-Munk internal wave continuum spectrum by Levine (2002). About 80% of the shear variance is in the discrete spectral lines.

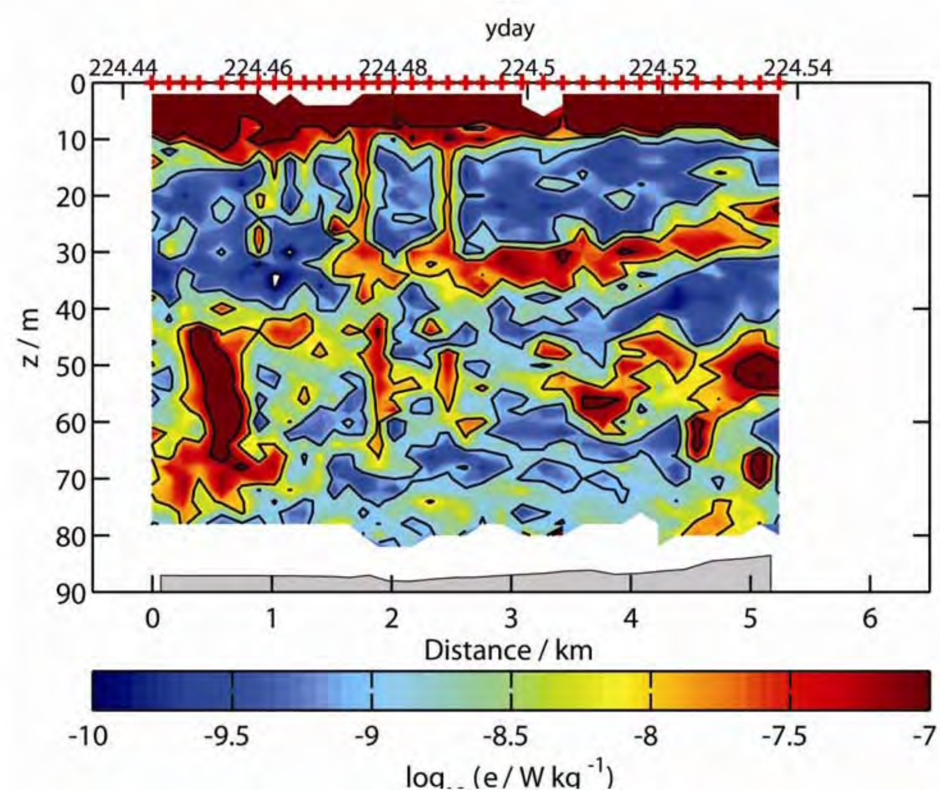

Fig. 4. Logarithm of the rate of turbulent dissipation along track m2 in Fig. 1 versus depth. Both the persistent horizontal banding and the vertical lines of elevated dissipation are unique. The former reflects banding of the shear variance produced by the internal tide modes and the former appears to have been produced by the rich biological activity in the bay.

REFERENCES

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