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13. ABSTRACT *(Maximum 200 words)*

The objective of this proposal was to complete the analysis and manuscripts of the CTD data collected in the Gulf of California. The most important accomplishment of the present reporting period has been completion, submission for publication to Deep Sea Research and acceptance, subject to minor modifications requested by a referee, of a paper by Ph.D. student Juan Rodrigues-Sero and M.C. Hendershott describing fine structure in the Gulf of California. The title is "Vertical Temperature Gradient Finestructure Spectra in the Gulf of California." We have also made significant progress on a manuscript with A. de Leon and A. BadanDangon, of CICESE (Ensenada, Mexico) in which ADCP data collected in the northern Gulf of California in January 1990 are processed to extract the tidal velocity field there. The initial reduction of observations is complete, but we wish to include in the publication a comparison with tidal model results to be provided by researchers at CICESE and then to re-analyze the data using the model fields as a basis set rather than simple polynomials in the space coordinates.

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Final Technical Report on "Analysis of Data from Finestructure and Circulation Studies in the Gulf of California"

M. C. Hendershott

The most important accomplishment of the present reporting period has been completion, submission for publication to Deep Sea Research and acceptance, subject to minor modifications requested by a referee, of a paper by PhD student Juan Rodrigues-Sero and M. C. Hendershott describing fine structure in the Gulf of California. The title and abstract are

Vertical Temperature Gradient Finestructure Spectra in the Gulf of California

Juan A. Rodrigues-Sero, Myrl C. Hendershott

ABSTRACT

Vertical temperature gradient finestructure in the upper kilometer of the water column in the Gulf of California was studied by making CTD vertical yoyos lasting a semidiurnal period at locations ranging from the center of Guaymas Basin (tens of km from coasts and thousands of m deep) to the shallow sills (a few hundred m deep) that separate Guaymas Basin from the shallow northern Gulf. Spring tide vertical temperature gradient spectra (VTGS) observed at these locations show internal wave levels (defined below) that rise from near open ocean values in central Guaymas Basin to values about 20 times open ocean values very near the sills. The spring tide internal wave level in northern Guaymas basin varies from near open ocean values at neap tides to several times open ocean values at spring tides. Spring tide VTGS in central Guaymas Basin closely resemble open ocean spectra, being nearly flat at the lowest wavenumbers $k < O(0.1$ cpm) and then falling off as k^{-1} before beginning to rise abruptly around $k \approx O(2$ cpm) -- about the limit of resolution attainable with the CTD. Further towards the sills the transition between the k^{-1} falloff and the subsequent rise towards higher wavenumbers is ever more gradual and occurs at ever smaller wavenumbers; right at the sills the spectra rise towards high wavenumbers over the entire resolved wavenumber range. Neap tide VTGS levels in north central Guaymas basin are a half or a third of spring tide levels; neap spectral shapes there resemble spring spectral shapes further southward from the sills.

The differences in shape between different Gulf VTGS and between Gulf and open ocean VTGS are accountable for in a composite model of ocean vertical gradient spectra which connects the Garret-Munk internal wave spectra (flat at low wavenumbers k) with the Kolmogoroff and Obukhov Universal spectra (varying as $k^{1/3}$ at high wavenumber) through an intervening saturated internal wave region (varying as k^{-1} between an internal wave saturation wavenumber k_R and a higher wavenumber k_{OZ} corresponding to the largest vertical scale at which overturning can occur). The composite spectral model is largely conventional, the new ingredients are (1) use of Gregg's (1989) suggestion that kinetic energy dissipation ε has the simple dependance N^2E^2 on local Vaisala frequency N and Garret-Munk internal wave level E, and (2) care with constants in patching the spectra

together. In the Gulf of California, where stratification is primarily determined by temperature, the resulting VTGS $F_{TZ}(k)$ vary with local mean vertical temperature gradient T_{oz} and with E as:

$$F_{TZ}(k) \approx T_{oz}^2 \qquad k^* < k < k_R, \qquad (1)$$

$$F_{TZ}(k) \approx T_{oz}^2/k \qquad k_R < k < k_O \qquad (2)$$

$$F_{TZ}(k) \approx E^{4/3}\, T_{oz}^{5/3}\, k^{1/3} \qquad k_{OZ} < k, \qquad (3)$$

$$k_R \approx E^{-1}, \qquad k_{OZ} \approx E^{-1}\, Toz^{1/4}, \qquad (4,5)$$

in which k* is a wavenumber corresponding to a low mode internal wave vertical scale.

The scaling (1, 2, 4) with with T_{oz} and with E (estimated from the low wavenumber part of the spectra) successfully collapses all the Gulf VTGS, spring and neap, that appear to have an approximately flat internal wave region followed by a k^{-1} saturated internal wave region. This not only extends range of internal wave level over which the scaling (1, 2, 4) has been verified beyond the normal open ocean range, but also shows that the spectra can adjust their level by a factor of two or three over several days without changing their shapes away from the (presumably) steady shape idealized in (1, 2, 4). The scaling (2, 3, 5) pulls the Gulf VTGS in the vicinity of k_{OZ} towards collapse, but not far enough.

A further consequence of the composite spectral model is an estimate of internal wave induced diapycnal diffusivity K_V of heat or salt. In the open ocean this estimate yields $K_V \approx 0.15$ cm2/s, but in the high internal wave energy region just south of the sills it yields $K_V \approx 60$ cm2/s. This is roughly half the value that would be required to completely account for spring-neap changes in vertical profiles of temperature recently observed in this part of the Gulf.

The other important accomplishment of the present review period has been progress on a manuscript with A. de Leon and A. BadanDangon, of CICESE (Ensenada, Mexico) in which ADCP data collected in the northern Gulf of California in January 1990 are processed to extract the tidal velocity field there. The methods employed are very similar to those of Candela et al (JGR) but the results show that the cruise track can have an important effect on the extent to which spatial detail can be mapped from ADCP profiles taken along it. The initial reduction of observations is complete, but we wish to include in the publication a comparison with tidal model results to be provided by researchers at CICESE and then to reanalyze the data using the model fields as a basis set rather than simple polynomials in the space coordinates.