PROJECT SUMMARY

Impact of Nonlinear Barotropic Tides in the North Pacific - D. Luther, U. H.

Overview. The daily surface tides in the ocean, forced by gravitational perturbations arising from the motions of Earth and its Moon, exert a profound influence on the biology, chemistry, geology and circulation in both pelagic and coastal environments. As more accurate models of the tides have been developed, it has been realized that non-linear interactions among the tides in the shallow seas and continental shelves (which are all forced by the pelagic tides) result in a flow of energy back into the open ocean, but at altered frequencies and wavelengths. The impact of this energy flux can have significant consequences not only for modeling the diurnal and semi-diurnal tides themselves, but for the energetics of phenomena dependent on the tides such as abyssal mixing. The potential impacts of the flux of coastal nonlinear tide energy into the pelagic ocean suggest many avenues for research. Two are proposed here. First is how much the coastal non-linear tides "contaminate" what is generally considered to be the linear diurnal and semi-diurnal tides in the pelagic ocean. Second is the question of whether the flux of coastal nonlinear tide energy dominates the entire suite of surface gravity wave motions in the pelagic ocean at periods shorter than the tides, even as short as 15 minutes, a possibility that has ramifications both for the ocean's energy budget and other geophysical phenomena (e.g., Earth's "seismic hum"; fragmentation of ice shelves) that are now known to depend on these waves.

The broad objectives here are to elucidate, using observational tools, (i) the nature (e.g., amplitude, structure) of the pelagic, barotropic, nonlinear tides, especially within the diurnal and semi-diurnal tide bands; (ii) the specific source locations for the energy in the pelagic, barotropic, nonlinear tides; (iii) the flow of energy from the principal, linear barotropic tides to gravity waves in other frequency bands; (iv) the nature (e.g., isotropic or not) and sources of the gravity wave energy at periods of 15 minutes to 2 hrs. To accomplish these objectives, analyses are proposed of existing long (> 1 year) bottom pressure records in the North Pacific that well observe these waves and tides. The methodologies include least squares harmonic analysis and a variety of auto- and cross-spectral techniques, some borrowed from seismology.

Intellectual Merit. Evidence presented in the Project Description already indicates the non-trivial impact of pelagic non-linear tides both within the diurnal and semi-diurnal bands of gravitationally-forced tides and within the shorter-period gravity waves (even periods as short as 15 minutes). These phenomena suggest a significantly different flow of tidal energy through the oceans than currently believed, with consequences for tide modeling, mixing dynamics, etc.

Broader Impacts. ***Benefits to Other Scientific Disciplines.*** Accurate ocean tide models are being demanded by earth scientists studying Earth's internal properties. Their observations of deformation under periodic ocean tide loading have become more accurate with GPS, demanding ever more accurate tide models. The work to be accomplished under this proposal will ultimately result in improved open ocean tide models. Furthermore, better knowledge of the origins and radiational patterns of the shorter-period gravity waves will improve seismological models of the "Earth's hum" which are also used to reveal properties of Earth's interior.

Education. As standard tidal analyses are now trivially accomplished with computer programs, comprehension of the complexities and subtleties of both the gravitational and radiational tidal forcing, and the ocean's responses, is waning among physical oceanography students, even as interest in the interaction of tides with the general circulation is waxing. A Ph.D.-track student will be funded under this proposal. During that student's tenure, she/he will be tutored in all aspects of the ocean's tides.