Annual Report for FY 1999

P. I. Name:

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Project Proposal Title:

A Numerical Investigation of Ocean Circulation and Pelagic Fisheries around the Hawaiian Islands

1. Purpose of the Project:

This study is designed to further the understanding of the ocean circulation around the Hawaiian waters and its influence upon the regional pelagic fisheries. Several observational studies have shown the existence of the mean narrow boundary current which flows along the windward side of the Hawaiian Islands. This narrow boundary current (the North Hawaiian Ridge Current), however, has been a subject of debate ever since it was first predicted by Mysak and Magaard and observed by White in 1983. Large fluctuations with time-scales ranging from months to several years have been detected in the NHRC. One of the goals of our project is to clarify the causes of seasonal-to-interannual variability of this boundary current and to assess its influence on the movement of pelagic fish near the Hawaiian Islands.

2. Progress during FY 1999:

Our investigation during FY 1999 extended our work of previous 3 years on understanding the seasonal and interannual variability of the circulation around the Hawaiian waters. Long-term in-situ observations indicate that the North Hawaiian Ridge Current (NHRC) demonstrates significant interannual changes. As the present project is approaching the end, the focus of this year's study has been to summarize and synthesize the observational and modeling results from our investigation. Specifically, we have put together two manuscripts which described the main scientific results from this project. In addition to the work by Qiu, Koh, Lumpkin and Flament (1997), we believe that we have obtained a solid understanding on the oceanic circulation around the Hawaiian Islands. In the following, we describe briefly the majors results contained in the afore-mentioned two manuscripts.

Using a high-resolution, 2.5-layer reduced-gravity ocean model, Firing, Qiu and Miao (1999) investigated the seasonal and interannual variability in the circulation around the Hawaiian Islands, with particular emphasis on the NHRC. The numerical model simulation shows that the NHRC exists as a mean entity with a 32-year averaged transport of 2.47Sv. There is a generally good agreement between the modeled NHRC transport time series and that based on repeated ship-board ADCP measurements from 58 HOT cruises during 1988-1997. The NHRC exhibits a regime shift with a period of about 17 years. There is a significant ENSO frequency energy peak in the NHRC's power spectrum, but they are not directly linked to the ENSO events. By running a companion model with the steady wind in the equatorial region, we find that the these fluctuations are largely determined by the wind field over the interior ocean east of the Hawaii Islands. The low-frequency NHRC fluctuations are due to the mass imbalance between the inflow transport across the north line and the outflow across the south line. The time-dependent island rule is developed to understand how the mid-latitude wind variations east of the Hawaiian Islands determine the seasonal and interannual variability of the NHRC. The time-dependent linear theory can quite well estimate the the low-frequency fluctuations of the observed NHRC.

3. Plans for the next Fiscal Year:

So far, our focus of the investigation has been on the oceanic circulation on the windward side (i.e., northeast) of the Hawaiian Islands. In FY 2000, we plan to extend our modeling work and data analyses to focus on the variability of the upper ocean on the leeward side of the Hawaiian Islands. In addition, thermodynamic effects, which have been neglected thus far, will also be included. For most pelagic fish, its movement is dependent on water temperature. In the upper ocean, water temperature changes are not determined solely by conventional advection/diffusion processes modeled in our 2.5-layer model. Other thermodynamic processes must be included for a complete heat balance in the upper layer. Through the air/sea interface, solar insolation, longwave radiation, and latent and sensible heat fluxes also affect the temperature field of the upper ocean. From below subsurface colder water can be entrained into the near-surface layer due to surface wind stirring and intra-layer shear instabilities. In our effort to model the upper ocean temperature changes, we plan to include these complicated thermodynamic effects into our layered model. We expect to clarify how seasonal-to-interannual changes in the upper ocean thermal structures are related/controlled by the ocean circulation changes and whether these changes are locally forced or induced remotely by large-scale circulation changes, such as El Ninos.

4. List of papers published in refereed journals during 1999:

Firing, E., Qiu, B., and W. Miao, **1999**: Time-Dependent Island Rule and its Application to the Time-Varying North Hawaiian Ridge Current. *J. Phys. Oceanogr.*, in press.