Mixing and Circulation in a Buoyant Coastal Plume

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Project Summary

Discovering the primary processes that control across-margin transport of biologically, geologically, and chemically important materials has first rank priority in ocean science. A major component of this across-margin transport is the result of freshwater inflow from rivers and estuaries into the coastal ocean. The evidence to date from model studies and field observations is that coastal Ekman circulation, especially upwelling circulation, is the most effective mixing agent. Consequently, we focus on this agent.

We offer four related hypotheses: 1) During upwelling, the offshore advection of near surface buoyancy or fresh water by the surface Ekman flux induces rapid vertical mixing of the fresh water with ambient shelf water. 2) The total mixing of plume water with ambient shelf water during upwelling wind events exceeds that for downwelling events of the same magnitude. 3) During upwelling, the mixing action is concentrated at the offshore edge of the plume. 4) The mixing dynamics there is principally a balance between offshore advection of buoyancy or fresh water by the upwelling Ekman transport and vertical diffusion between buoyant water of the plume with the saltier ambient shelf water below.

The overall objective of this project is to determine the major elements in the mixing dynamics and the circulation in a buoyant coastal plume during upwelling and downwelling circulation events. Particular objectives are: **1)** Compare mixing mechanisms during upwelling and downwelling events. **2)** Find and compare the peak levels of vertical mixing in space for both upwelling and downwelling events. **3)** Find and compare the bulk level of vertical mixing for the plume as a whole during both upwelling and downwelling events. **4)** Find the level of vertical diffusivity (K_z) during both events. **5)** Diagnose the advective-diffusive balance for buoyancy near the plume surface during both events. **6)** Advance the capability in numerical modeling of circulation and mixing in buoyant coastal plumes.

The project has three closely related elements: 1) field observations that include a moored array of instruments, purposeful dye tracing, and rapid shipboard surveys of the buoyant plume hydrographic and current fields, 2) numerical model studies of mixing processes in buoyant plumes, and 3) analysis and synthesis of the field data and model results.

We propose the use of new technology in the field work. We will conduct purposeful injection of a fluorescent dye as a tracer. It is able to measure 3-dimensional Lagrangian circulation and mixing. We will also use another new method, called the variance method, a technique for recording and processing ADCP data that yields direct measurement of turbulent Reynolds stresses and similar turbulence quantities.

The injection and subsequent dispersion of dye within the coastal circulation will be reproduced using numerical simulations. The combination of field measurements and numerical simulations allows an unprecedented opportunity to evaluate different turbulence closure schemes within the numerical model, especially as they pertain to the highly stratified flow conditions on the shelf.

The particular subject of the field and model studies is the Delaware Coastal Current. We selected this system because it is of intermediate scale among buoyant coastal discharges and because it is logistically opportune.

Broader impacts: This project will contribute to graduate level education through support of a Ph.D. student. Other graduate students will receive training in oceanographic field work. Dr. Charles Tilburg will be supported in his early career in physical oceanography. We will contribute to the full integration of Lagrangian and Eulerian measurement techniques. Our study of physical processes in buoyant coastal plumes will be beneficial to the planning and success of the up-coming CoOP program Buoyancy-Driven Transport Processes which is planned to begin interdisciplinary field studies in 2004. While our study focuses on details of physical processes, including mixing and turbulence parameterization, that program will emphasize the transport of biologically, geologically, and chemically important materials.