Chalk-Ex: Transport of Optically Active Particles From the Surface Mixed Layer

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LONG-TERM GOALS

To determine the mass balance of optically active particles within the surface boundary layer and to identify the processes responsible for particle redistribution.

OBJECTIVES

1. Perform manipulative experiments in which a known quantity of optically active particles are introduced at the surface and tracked over time and space. This approach effectively removes uncertainty in the production term of the mass balance equation.

2. Identify and quantify the relevant physical and biological processes that remove optically active particles from the mixed layer (e.g., vertical mixing, sinking, dissolution, aggregation, and grazing related "repackaging" into fecal pellets).

APPROACH

Chalk-Ex will consist of a sequence of multi-disciplinary field experiments to be done in cooperation with W. Balch and C. Pilskaln (Bigelow Lab for Ocean Sciences) and H. Dam and G. McManus (University of Connecticut). Patches of optically active particles will be created within the mixed layer by dispersal of Cretaceous chalk (CaCO3) from the stern of a research ship. Two deployments are planned during each of two cruises: November 2001 and Summer 2003. Each chalk deployment calls for ~13 tons of chalk to make a patch of approximately 2 square km. During each cruise, deployments will be made at an oligotrophic site outside the Gulf of Maine and a more eutrophic site within the Gulf of Maine. Patch evolution will be followed by making a combination of time series and spatial survey measurements over a period of about 3 days. Associated with the chalk deployments and spatial surveys (Balch), will be drifting sediment trap deployments (Pilskaln) and measurements of grazing and aggregation from in-situ samples (Dam/McManus).

The experimental approach is based on expected differences in the processes dominating CaCO3 evolution at the different sites. At the oligotrophic site, we expect grazing to be minimal and physics to dominate biology in removing particles from the mixed layer. The sinking rate of the CaCO3 particles is so slow (10 cm/d; [Honjo, 1976; Balch *et al*., 1996]) that the mass of CaCO3 in the oligotrophic patch should not decrease significantly during the course of the experiment from sinking. At the eutrophic site, we would expect easily detectable decreases in the mass of the mixed-layer patch

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due to intense grazing activity (e.g., grazing rates of 0.5–1), and repackaging this CaCO3 into fast-sinking fecal pellets. Changes in the mass of chalk in the patch should be consistent with the fluxes caught in the sediment trap, unless major dissolution occurs (which could also be associated with grazing [Harris, 1994; Milliman *et al*., 1999]).

Our part of the project will focus on two issues: (1) Tracking the patch with Lagrangian drifters and (2) Measuring temperature (T), salinity (S), and horizontal velocity (U, V) with high temporal resolution (5 min) within the upper 100 m of the water column. The first issue will be addressed by the deployment of drifters which will follow the near-surface (upper 1 m) flow and transmit their position in near real-time. The drifters will be deployed (and re-deployed as necessary) near the center of the patch. The drifter positions will be available onboard the ship during the experiment and will serve as a reference for "Lagrangian surveys" (as done, for example, during Iron-Ex I [Stanton, et al., 1998]). The second issue will be addressed by an instrumented drifter that will also be deployed near the center of the patch. This drifter will consist of a small surface buoy with 100 m of line below it. A variety of instrumentation will be attached to the buoy and the line. This drifter will be only quasi-Lagrangian and is expected to require periodic re-positioning to remain in the patch.

WORK COMPLETED

We are presently in the preparation phase for the first field experiment. Logistical details are being worked out in cooperation with the Chalk-Ex Co-PIs. We have purchased and begun testing of three surface drifters. We have designed the instrumented drifter and fabricated its principal components. We have obtained instrumentation sufficient for measuring T, S, U, V with vertical resolution of 10 m or better over the upper 100 m from the instrumented drifter.

RESULTS

Preliminary scientific results are expected following the first field deployment in November of 2001 (note that the cruise was originally proposed for July/August 2001 but was delayed due to ship scheduling problems).

IMPACT/APPLICATIONS

These experiments are designed to quantify the major loss terms for optically active particles. This knowledge is critical to understanding and predicting the evolution of the underwater optical field on horizontal scales from 1 m to 10 km, vertical scales from 1 to 100 m, and temporal scales of hours to days.

TRANSITIONS

None.

RELATED PROJECTS

We are working closely with Balch/Pilskaln and Dam/McManus to design a successful, integrated field program. A small surface buoy design developed for the REMUS AUV program was adapted for use with the instrumented drifter. Instrumentation obtained as a part of an NSF Major Research

Instrumentation grant is being used to enhance the T-only measurements originally proposed for the instrumented drifter to T/S measurements.

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PATENTS

None.