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FINAL REPORT**DOE Grant No. DE-FG02-87ER60555**

Grantee: The Trustees of Columbia University in the City of New York

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Pierre E. Biscaye and Robert F. Anderson**Principal Investigators**Project Title: Transport and Transfer Rates in the Waters of the
Continental Shelf and Slope: SEEP

The subject grant covered work done on and in conjunction with the second part of the SEEP (Shelf Edge Exchange Processes) Program. The first field experiment, done under a previous grant, took place in 1983-1984 in the waters of the continental shelf and slope south of Long Island and New England-- the Middle Atlantic Bight (MAB). The second experiment, done under the subject grant, took place from February 1988 to May 1989 in the waters of the continental shelf and slope south of the Delmarva Peninsula in conjunction with DOE-funded scientists from 5 other institutions.

The first part of the grant (1987-1988) was occupied with planning the field experiment, the second part (1988-1989) with the field experiment itself, and the third part (1989-1991) with analysis of samples, reduction of data and initial writing up of the results for publication. Because the program ended at the end of 1991 before the results were published (see below), the grant was extended twice for a year each time (on a no-additional-cost basis) and finally ended 31 December 1993.

The overall SEEP Program, which began in 1980 or 1981, had as its goal the testing of a hypothesis with respect to the fate of particulate matter formed in and introduced into the waters of the continental shelf adjacent to the northern east coast of the U.S.A., i.e., the MAB. The original hypothesis was that a large proportion of the particles in general, and of the particulate organic carbon (POC) in particular, was exported from the shelf, across the shelf/slope break and front, into the waters of, and, to some degree, deposited in the sediments of the continental slope. This hypothesis was based on budgets of organic carbon and lead-210 that did not account for a large proportion of those species in the waters or sediments of the shelf, and on a carbon-rich band of sediments centered on the slope at ~1,000 m water depth. The results of the first SEEP experiment, south of New England and Long Island (SEEP-I) suggested, but did not prove, that there was only a relatively small proportion of the carbon which was exported from the shelf to the slope. The objective of the second experiment -- SEEP-II -- done under the subject grant, was to tighten the experiment in terms of the kinds of data collected, and to focus it more on the shelf and only the upper slope, where shelf-derived particles were thought to be deposited. ┘

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(Acct. Nos. 0-22721, 0-22722)
(Expired 31 December 1993)
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The field experiment lasted 15 months and involved three deployments/recoveries of ten mooring and ten cruises. Biscaye was overall coordinator of the field experiment for all investigators, was responsible for the mooring program, and was Chief Scientist on eight of the ten cruises. Anderson was Chief Scientist for one cruise. In terms of the kinds of instruments deployed and samples collected, our specific responsibilities were the sediment traps and the sediment sampling program. Seventeen 0.07 sq. m. sediment traps (plus two 1.0 sq. m. traps) were deployed on seven of the ten moorings in a three-dimensional array -- actually four-dimensional array, since the traps collected a time series sequence of samples. We recovered >500 trap samples, each representing a sampling of the vertical flux of particles of from 8 to 21 days. We recovered about a dozen each gravity cores and box cores from the slope sediments, and many grab samples from the sandier sediments of the shelf.

Analytical work commenced on the SEEP-II samples in June 1988, as soon as the samples from the first recovery of the moorings and sediment trap samples, and the first sediment cores were brought back to the lab. A major effort was required in the preparation of the sediment trap samples for analysis, because each one had to have the "swimmers" (live zooplankton that swam into the traps, as opposed to falling in passively with all the other sinking detritus) picked out by hand under the microscope. For the >500 sediment trap samples recovered from SEEP-II, this effort took from 2-3 man years of intensive, careful work under a microscope. The final sample was picked for swimmers in September 1991, only three months before the grant was originally supposed to end. Analyses of all kinds -- organic carbon and nitrogen, calcium carbonate, opaline silica, lead-210, etc. were carried out as samples were picked over the course of the project from 1988 to 1991.

The results of the SEEP II study overwhelmingly show that the hypothesis of export of a large proportion of the MAB shelf primary productivity is untenable. All the observational data suggest that, although a small fraction of carbon is exported across shelf/slope break and through the front to the slope depocenter, the principal fate of shelf carbon is, in fact, oxidation on the shelf. The estimate from our data of the proportion of primary production that is exported is <1%. About half of that percentage that escapes is labile carbon and is remineralized on the surface slope sediments quickly (of the order of a year). The other half, however, consists of old (hundreds of years), refractory carbon, a large part of which accumulates in the sediments of the slope depocenter without further degradation. The reason for the organic-rich depocenter is thus not so much the high flux of unused shelf carbon, as it is the refractory nature of what accumulates in the sediments there. That small portion that does escape the shelf to the slope water and depocenter appears to increase from the northern to the southern MAB.

Our research also demonstrated that the behavior of natural species of heavy metal radionuclides is anomalous in the MAB compared to elsewhere in the world oceans. In contrast to the behavior of ^{210}Pb , deposition rates of ^{230}Th , ^{231}Pa and ^{10}Be exceed their local rates of supply, in some cases by more than an order of magnitude. The pattern of enhanced deposition follows the order $\text{Be} > \text{Th} > \text{Pa} > \text{Pb}$, whereas the expected order would be $\text{Be} > \text{Pb} > \text{Pa} > \text{Th}$. We postulate export from the region of fine grained manganese-rich particles to explain at least some of the anomalies.

As a means of tying the SEEP Program research to other similar programs in the world, our collaboration and participation in the French ECOMARGE Program (ECOSystem des MARGES continentales) was encouraged by DOE. ECOMARGE is extremely similar to SEEP in its objectives and approaches to studying the problem of the transport of particles (especially organic carbon) from the continents to the open ocean. As a result of this collaboration, Biscaye was one of the Guest Editors of the special issue of Continental Shelf Research in which the results of the first ECOMARGE experiment in the Mediterranean were reported. We actually participated in several cruises and moored instrumental aspects of the second experiment, ECOFER, in the Bay of Biscay (Atlantic coast of France). Some of the publications listed below arise from that collaboration.

The major results of the SEEP-II experiment are being published in a special issue of *Deep-Sea Research II (Topical Studies in Oceanography)* and will be out in 1994. Anderson and Biscaye are senior authors on four of the papers, and junior authors on another four papers out of the 19 total in the special volume. The publications listed below are all of those published under support of the subject grant.

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