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Ecological Research Division

Coastal Ocean Margins Program

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PREFACE

The marine research program supported by the Office of Energy Research, Ecological Research Division, is focused to provide scientific information on major environmental issues facing development and expansion of most energy technologies and energy policy. These issues include waste disposal, siting/operations, and possible long term effects on global systems.

The research is concentrated along the United States coastal margins where marine waters provide abundant food and resources while assimilating discharges from atmospheric, terrestrial, and aquatic sources. The program focuses on the formation and transport of particles within the waters of the continental shelf and the fate of these particles, whether on the shelf, on the slope, or in the open ocean.

The program is conducted with multidisciplinary teams of researchers who investigate water mass movements, biological productivity, and naturally forming particles, as well as contaminant transport, to develop a clear understanding of the exchanges of contaminants and other materials that take place between continental shelf and open ocean waters. Seventy-five percent of the projects are funded to university grantees and twenty-five percent to National Laboratories.

These long term studies have provided considerable insight into the dynamics of the coastal ocean margins, resulting in several publications synthesizing research. Those published in the last three years are listed below:

Angel, M. V., and R. L. Smith, eds., "Summer Upwelling on the Southeastern Continental Shelf of the U.S.A.," *Progress in Oceanography,* 19, 221-441, 1987.

Atkinson, L. P., D. W. Menzel, and K. A. Bush, eds., *Oceanography of the Southeastern United States Continental Shelf,* Coastal and Estuarine Science, 2, American Geophysical Union, Washington, D. C., 1985.

Eppley, R.W., ed., *Plankton Dynamics of the Southern California Bight,* Lecture Notes on Coastal and Estuarine Studies, 15, Springer Verlag, New York, 1986.

Landry, M. R., and B. M. Hickey, eds., *Coastal Oceanography of Washington and Oregon,* Elsevier, in press, 1989.

Walsh, J. J., ed., "Shelf Edge Exchange Processes of the Mid-Atlantic Bight," *Continental Shelf Research,* 8, 433-946, 1988.

The scientific community offers valued assistance by reviewing programs and individual projects, as well as providing indepth analysis of ongoing and proposed research in specific regions. Management and coordination of the multidisciplinary marine program is handled by a small dedicated staff. These are:

Southeast Region West Coast Shelf	William Forster, Ph.D. Ecological Research Division ER-75 Department of Energy Washington, DC 20545 (301) 353-3035
Northeast Region	George Saunders, Ph.D. Ecological Research Division ER-75 Department of Energy Washington, DC 20545 (301) 353-5348

Questions or requests for further information concerning the Ocean Margins Program sponsored by the Ecological Research Division can be directed to the staff listed above.

Helen M. McCammon, Ph.D.
Director
Ecological Research Division
Office of Energy Research

INTRODUCTION

PROGRAM HISTORY

In 1954, a Japanese fishing boat and its load of fish were contaminated by radioactive fallout from atomic bomb testing in the Pacific Ocean. The incident raised many unanswered questions. Would the radioactivity released to the ocean be transported into Japanese waters by the Kuroshio Current? Could fish taken from contaminated areas of the ocean be safely eaten? What would be the ultimate fate of the radioactivity? To assist in answering the questions, the Atomic Energy Commission (AEC), a predecessor of the Department of Energy (DOE), initiated an oceanographic research program.

The research was performed mostly by academic scientists and was based on the recommendations made by the National Academy of Sciences in its 1957 publication, "The Effects of Atomic Radiation on Oceanography and Fisheries." This report called for fundamental research on the ocean and its components and processes, particularly in seven key areas:

- Dispersion in the upper mixed layer
- Circulation in the intermediate and deep layers
- Exchange between the surface layer and deep layers
- Sedimentation processes
- Effects of the biosphere on the distribution and circulation of elements
- Uptake and retention of elements by organisms used as food for humans
- Effects of radiation on populations of marine organisms.

AEC consequently oriented its oceanographic program toward research on ocean processes. The wisdom in doing so, rather than simply monitoring the system for radioactivity, became evident in the 1970's as fallout concerns subsided, while impacts of nuclear power plants and other energy activities began to dominate agency priorities.

Study of the process-related issues was facilitated by the nature of the contaminant. Radionuclides decay at fixed rates and oceanographers were able to use a number of radionuclides to follow and time the processes occurring in the ocean. This was a major breakthrough that has become increasingly significant in determining biogeochemical cycling and water mass movements.

Thus, the initial program provided both the framework and the tools for analyzing other energy-derived contaminants; its insights and methods could also be used for understanding impacts from industrial and agricultural sources.

Over time, the AEC/DOE research was moved to the shallow coastal waters, where the potential for problems related to energy issues was much greater than in the deep oceans. To unravel the complexities of shelf analysis, regional research teams — made up of biological, chemical, and physical oceanographers — were created. Using this interdisciplinary approach, and frequently working in collaboration with other agencies, the Department of Energy is furthering our understanding of the processes affecting the cycling and behavior of energy-introduced contaminants in the coastal zone.

SIGNIFICANCE OF OCEANOGRAPHIC STUDY TO DOE POLICIES AND PROGRAMS

Energy and Weapons Issues

The marine waters surrounding the U.S. provide food and resources on the one hand while assimilating discharges from various sources on the other. Different energy-related technologies can have similar impacts on the marine system, such as causing shifts in marine populations due to nutrient changes, disruption of breeding areas, and the like. The functioning and dynamics of the marine system need to be studied to understand which impacts can cause serious or long lasting injury and which ones can be assimilated with minimum perturbation and to develop technologies to forestall or reduce serious damage. Furthermore, understanding these processes could aid in technological development of innovative energy sources derived from the ocean system.

At present, the ocean is being used as a repository of low level radioactive wastes by numerous countries. While the U.S. stopped this practice many years ago, concerns surface periodically about the isolation of the wastes disposed of decades ago. The continuing research program on the ocean margins identifies the major sinks and reservoirs of different materials, including radionuclides and the paths by which humans might be exposed. The same studies reveal that significant input of natural radionuclides are brought on to the shelf from deep ocean upwelling. An analysis of the isotope ratios provides the key to deciphering the source of the radionuclides.

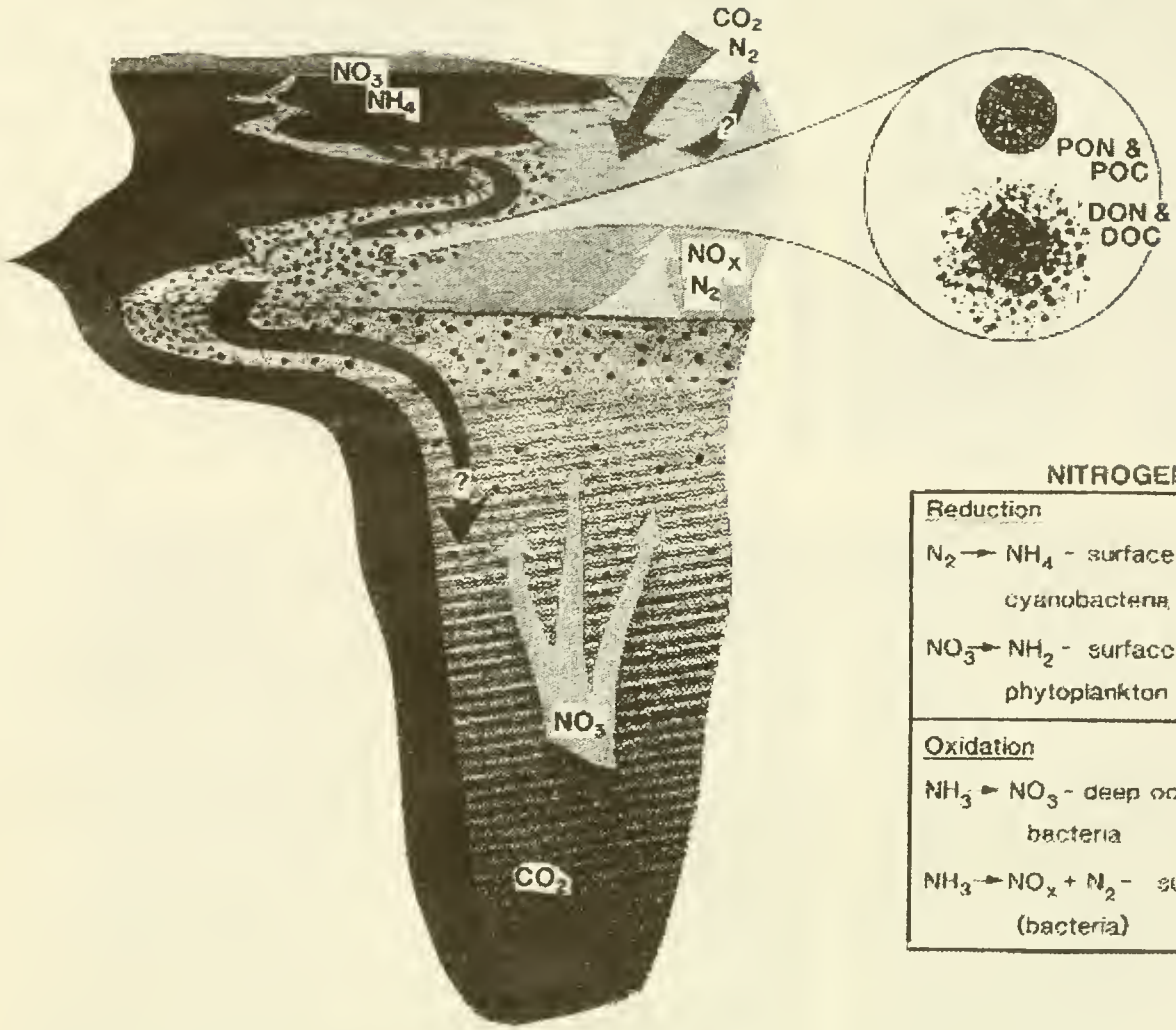
Transportation routes of oil and liquified gas have become congested near major coastal metropolitan areas. Although accidents are rare, basic information on dynamics of coastal ecosystems is crucial in minimizing or containing accidents when they do occur. The best time for research is before an accident occurs so that maximum scientific knowledge can be used to mitigate effects of accidents. The same basic information can also be used to evaluate environmental concerns in areas targeted for petroleum exploration.

By focusing on processes, DOE's Coastal Ocean Margins Program provides information on existing and unanticipated energy- and defense-related issues. For example, the Southeast Regional Program initiated in 1975 was aimed at determining the effects of floating nuclear power plants in the coastal region. While these plants were never developed, because of the fundamental nature of the program's research, it has provided important scientific input into environmental evaluations on the extent of contaminant river discharges into the South Atlantic Bight, disposal of nuclear-powered submarine reactors off the continental shelf, and drilling for oil on the Blake Plateau. It has served other – sadder – purposes, too, when this research provided the necessary information about oceanic currents to pinpoint the location of the Challenger booster rocket.

Global Change

Energy- and weapons-related problems are not the only targets for the DOE oceanographic program. A major energy policy issue facing the U.S. is that of global change. In this regard, DOE's program provides input to at least two areas of biogeochemical cycling (figure 1).

Given the present concern over carbon dioxide (CO_2) and other trace gases discharged from energy generation, the trade-offs among fossil fuel, renewable resources, conservation, and nuclear power need to be reevaluated. While much emphasis is focused on the buildup of these gases in the atmosphere, there is 60 times more CO_2 in the ocean than in the atmosphere. Furthermore, the single greatest unknown in carbon cycling and CO_2 atmospheric buildup is the role of the oceans in absorbing or buffering the CO_2 and other carbon compounds.



NITROGEN	CARBON
Reduction $N_2 \rightarrow NH_4$ - surface ocean cyanobacteria $NO_3 \rightarrow NH_2$ - surface ocean phytoplankton	Reduction $CO_2 \rightarrow (CH_2O)_n$ - surface ocean photosynthesis - (produces O_2) $CO_2 \rightarrow CH_4$ - sediments bacteria
Oxidation $NH_3 \rightarrow NO_3$ - deep ocean bacteria $NH_3 \rightarrow NO_x + N_2$ - surface ocean (bacteria)	Oxidation $(CH_2O)_n \rightarrow CO_2$ - entire ocean heterotrophs - (removes O_2)

FIGURE 1 MARINE CARBON AND NITROGEN CYCLE.

Phytoplankton productivity is an order of magnitude greater on continental margins than in the open ocean (table 1). The DOE program findings assist in determining how much and when carbon is taken up over the shelf areas during phytoplankton production. Where does the carbon go: is it respired or eaten, or is it removed through burial or transport into the open ocean? The program helps identify the role of organisms in the dynamics of CO_2 cycling into and out of the ocean.

Nitrogen cycling is also a significant concern. Nitrogen oxides are important in the chemistry of ozone formation and dissipation in the atmosphere, and nitrogen from the ocean may contribute to these processes. Other forms of nitrogen serve as a valuable nutrient for phytoplankton and bacterial growth. Much of this nitrogen comes from deep water upwelling, but closer to shore, it may come from agricultural runoff. Nitrogen flux from coastal ocean margins can be quantitatively determined for U.S. coastal areas by the three regional programs, and it is possible to extrapolate the information through comparison with other continental shelves.

Although this marine program is only a small part of DOE's total contribution in comprehending global systems, it does provide crucial input for a basic understanding of the role of carbon, nitrogen, phosphorus, and other elements in oceanographic systems. Without this information, atmospheric CO_2 buildup and the greenhouse effect cannot be deciphered. The program also provides data on contaminant dispersion along the U.S. continental shelves and into the open ocean. Thus, as new issues surface, this program — because of its focus on fundamental processes — is most effective for providing a scientific base for issue evaluation.

TABLE 1
ESTIMATES OF PRIMARY PRODUCTION IN THE MARINE ECOSYSTEM

Ecosystem	Area ($\times 10^6 km^2$)	(%)	Gross Primary Production ($g\ C\ m^{-2} yr^{-1}$)	Total Gross Production ($g\ C\ yr^{-1} \times 10^{14}$)	(%)
open ocean	326	90.3	50	163	80.7
coastal zone	34.0	9.5	100	34	16.7
coral reefs	0.4	0.1	1000	4.0	2.0
upwelling zone	0.4	0.1	300	1.2	0.6
	361			202.2	

Total primary production for the biosphere (terrestrial and aquatic) is estimated at $\sim 500 \times 10^{14}$ g C y^{-1}). Therefore marine ecosystems account for ~40% of the total annual carbon fixed on the planet.

COASTAL OCEAN MARGINS PROGRAM

Goal

DOE's Coastal Ocean Margins Program is providing a better definition of three different major marine coastal systems in the Northeast, the Southeast, and the Southwest. The program is developing improved understanding of marine transport and better identification of the origin of fate of marine system contaminants derived from energy activities or other sources. Specifically, the goal of the Coastal Ocean Margins Program is to understand the transport of materials — both natural and human-derived — within coastal regions and between coastal and open ocean areas.

Rationale

The coastal oceans are the first line receptacle for gathering discharges from rivers and estuaries and are important in materials exchange among the atmosphere, open ocean, and continents. Because the coastal oceans have high levels of nutrients and physically driven erosional processes, they contain much higher concentrations of particles, both inert and those derived from biological productivity. These particles can actively sorb dissolved inorganic and organic chemicals and contaminants from the water and become the major vehicles of transport of natural and human-derived materials in the oceans. Increased biogenic production, due to high-nutrient inputs to the coastal region, may mitigate some toxic substances by sorbing them to make large particles that are deposited in sediments or transported from the shore by oceanographic exchange processes. The increased phytoplankton production also may mitigate atmospheric CO_2 levels by accelerating the uptake of CO_2 into the ocean. We are only now beginning to understand in what forms and by what pathways contaminant-carrying particles are dispersed around the world's oceans, and whether materials are isolated by burial in shallow or deep sediments, dispersed through biological food chains, or decomposed and redissolved to be diffused broadly into the ocean.

Although the same fundamental processes are involved in biogenic production, transport, and decomposition on the continental shelves, circulation along the coastal margins generally is controlled by coastline shape, flow of water from rivers and estuaries, wind force and direction, and bottom topography. On the ocean side of the shelf, exchanges are complex and controlled by massive boundary currents such as the Gulf Stream along the East Coast and the California Current off the West Coast. The distribution and intensity of ocean processes thus are different for each geography or region. For this reason, the Coastal Ocean Margins Program is subdivided into three major regions: the Northeast, Southeast, and Southwest Coasts of the United States.

The three regional programs share a set of general objectives against which the range of geographical differences are compared. These objectives are:

- To determine movement of water masses and their chemistry on the coastal shelf and slope so as to identify how dissolved and particulate materials are transported and distributed
- To quantify amounts and determine rates of biological and geochemical particle transformations that take place on the continental margins
- To determine the productivity of living organisms (phytoplankton, bacteria, zooplankton) over temporal and spatial scales and the fate of these organic particles both on and off the shelf.

Research Plan and Current Program

Within the Coastal Ocean Margins Program, regionally directed studies are being conducted to define currents, upwelling events, coastal boundary layers, eddy diffusion, flushing rates, and sediment transport. Through the use of biogeochemical tracers, the nature and extent of estuarine and atmospheric inputs of energy- and weapons-related materials to coastal marine waters are being determined. Fluxes of particulate matter, dissolved organic and inorganic compounds, and nutrients within water masses and between boundary layers (e.g., nearshore waters versus deep water, sediment/water interfaces) are being derived.

Researchers are conducting integrated studies of physical, chemical, and biological oceanography to determine the correlation of primary productivity levels and particle formation. They are doing so by taking advantage of the unique properties of naturally occurring and artificial radionuclides and stable isotopes to provide insight into how fast materials in the ocean are turning over and what are the major sinks and distribution patterns.

The program has been divided into three coastal ocean margins which are physiographically and dynamically different. The first is the Shelf Edge Exchange Processes (SEEP) Program in the Northeast, extending from New England to Cape Hatteras; the second is the South Atlantic Bight (SAB) Program, extending from Cape Hatteras to Florida; and the third is the California Basins Study (CaBS) in the deep basins off the Southwest Coast. Researchers in each geographic region exchange data for maximum use of information from different disciplines; they share facilities and shiptime for maximum cost effectiveness. These studies are closely coordinated with programs conducted by other agencies and are often carried out with their cooperation and support. Institutions participating in each of the regional programs and levels of funding for each are presented in table 2.

TABLE 2
COASTAL OCEAN MARGINS PROGRAM, FY 1988

Region	Institutions in Program	Budget ($ in thousands)
NORTHEAST		**$ 2,681**
Shelf Edge Exchange Processes (SEEP)	Brookhaven National Laboratory	
	Lamont-Doherty Geological Observatory	
	National Aeronautics and Space Administration	
	North Carolina State University	
	Old Dominion University	
	University of South Florida	
	Woods Hole Oceanographic Institution	
	Yale University	
SOUTHEAST		**$ 1,355**
South Atlantic Bight (SAB)	Oak Ridge National Laboratory	
	Old Dominion University	
	Skidaway Institute of Oceanography	
	University of Georgia	
	University of Miami	
SOUTHWEST		**$ 1,586**
California Basins Study (CaBS)	Lawrence Livermore National Laboratory	
	Oregon State University	
	Skidaway Institute of Oceanography	
	University of California-Los Angeles	
	Scripps Institute of Oceanography	
	University of Hawaii	
	University of Southern California	
	University of Washington	
TOTAL:		$ 5,622

OVERVIEW OF REGIONAL PROGRAMS

Northeast: Shelf Edge Exchange Processes

Statement of Problem

Within the Northeast coastal region, there are over 200 fossil fuel and 20 nuclear power plants, 4 liquified natural gas facilities, 12 large oil refineries, and 2 offshore oil lease areas, as well as major facilities for nuclear submarines at Norfolk, Virginia; New London, Connecticut; and Portsmouth, New Hampshire. About 34,000 containers of radioactive wastes (including the pressure vessel of the nuclear submarine *Seawolf* reactor) were discarded off the Northeast Coast between 1951 and 1967. In 1963, the nuclear submarine *Thresher* was lost 300 kilometers off Boston. The 1966 collision of the oil tankers *Texaco Massachusetts* and *Alva Cape* led to their explosion in New York Harbor; the *Argo Merchant* broke up on Nantucket Shoals in 1976. This history clearly shows that significant planned and unplanned events will continue to occur here. A strong, continuing research provides the knowledge needed to cope with these events and mitigate their impacts.

Program Description

The first phase of the Shelf Edge Exchange Processes (SEEP-I) field program began in 1983-84, when a multidisciplinary team of physical, geochemical, and biological oceanographers set out to test the theory that significant export of biogenic and mineral particles from the shelf occurs, with a subsequent series of geochemical reactions taking place in an organic depocenter on the shelf slope. The first transect to test this theory was located at the north end of the Mid-Atlantic Bight running south from Martha's Vineyard.

The field analysis showed that while there was export of particles from the shelf, it was not nearly as much as postulated. Further, no significant depocenter was found. Data suggested that some of the particles produced on the shelf were consumed there. It was theorized, however, that since the shelf also narrows southward, more water — and therefore more particles — should be exported off the shelf as one proceeded southward along the shelf. The maximum export of particles and water should occur near Cape Hatteras, where it would become entrained into the Gulf Stream and swept far into the North Atlantic (figure 2).

SEEP-II, initiated in February 1988, focuses on shelf exchange of particles at the latitude of Delaware and Maryland. This phase will determine if the absolute flux of particles across the shelf is greater in this geographic region of the Mid-Atlantic Bight than in the northern region. A greater deposition of organic matter on the shelf slope is expected and is being evaluated. Current vectors and planktonic distributions will be determined; subtleties of shelf exchange and biological transformations will be analyzed so as to estimate transport and deposition on the slope. In addition, SEEP-II will evaluate further transport of chemicals from the mid-slope to the interior oceans via redox systems. The field program will operate for 16 months through two spring bloom periods. It will describe seasonal and short-term events important in shelf-edge exchange processes for a western boundary circulation regime of the Atlantic Ocean.

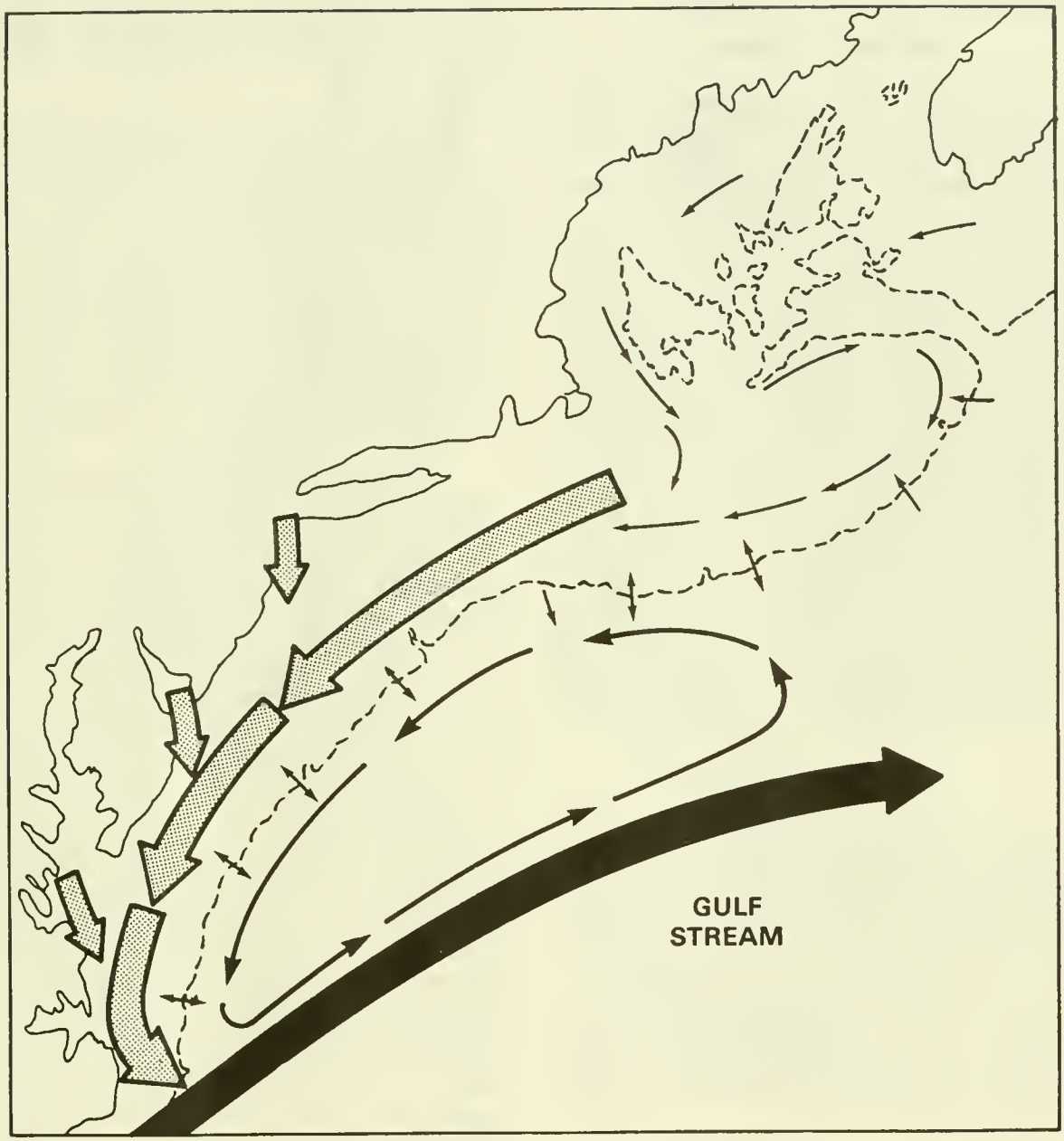


FIGURE 2 SCHEMATIC DIAGRAM OF THE MID-ATLANTIC BIGHT. EXCHANGES AND FLUXES.

Southeast: South Atlantic Bight

Statement of Problem

The SAB regional marine program was initiated in 1975 in response to the need to understand more about physical and biological oceanography processes near shore, where potential impacts of floating nuclear plants would be greatest. Although by the mid-seventies, the possibility of such facilities had diminished, new pressures were building for onshore domestic energy development; these also could affect coastal ecology. At that time, within the Savannah River watershed alone, there were major nuclear fabrication facilities of DOE's Savannah River Plant and three operating and two planned nuclear power plants. Now, there are 32 operating nuclear reactors in the 8 States of the Southeastern Region. In addition, Savannah is a major terminal for liquified natural gas and is 1 of the top 10 U.S. shipping terminals for coal exports. The region also has several home ports for nuclear submarines; offshore, there are several planned leases for oil and gas exploration. Before the consequences of these diverse defense- and energy-related activities on the marine environment can be assessed, a better understanding of the natural variability of circulation patterns and biological systems is needed.

Program Description

The general objectives of the present South Atlantic Bight program are to quantify the inputs and production, transformations and fluxes of particulates and associated energy-related byproducts within the bight. (See figure 3 for a schematic diagram of the SAB.) The ultimate end product of this research will be to develop predictive mathematical models of the dynamics of these particulates with special reference to defining the routes, rates, and reservoirs for carbon, nitrogen, associated energy-related organics, trace elements, and radionuclides.

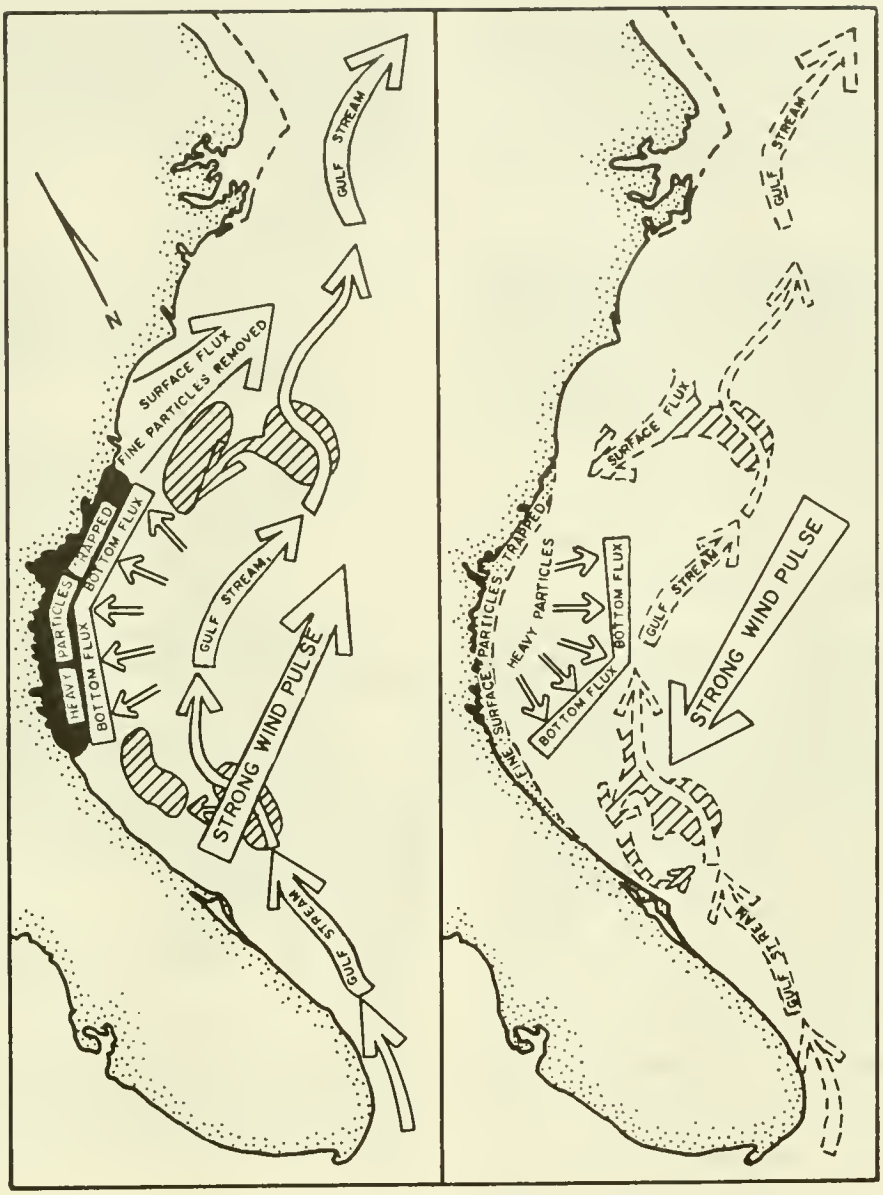
The current SAB program is made up of 10 principal investigators from 5 institutions all focusing on determining the ultimate fate of materials injected into the SAB system. The program's most recent studies were the Spring Removal Experiment (SPREX) of 1985 and the Fall Removal Experiment (FLEX) of 1987:

- SPREX: A study of cross-shelf transport of materials during meteorological/hydrographic regimes prevalent during spring months.
- FLEX: A study of cross-shelf transport of materials during meteorological/hydrographic conditions prevalent during the fall.

Because the SAB program has been ongoing for more than a dozen years, major syntheses publications have been completed. Past studies have demonstrated that major transport processes on the outer-middle shelf are driven by fluctuations in the flow of the Gulf Stream and wind events. On the inner shelf, transport is controlled by wind events, tidal exchanges, and the presence of low-density water from river runoff. Transport usually is parallel to the shore line, except when deflected offshore by shore line irregularities (e.g., capes, bottom topography, or prevailing winds).

When the Gulf Stream moves in an offshore direction, significant amounts of upwelled water and included materials intrude onto the continental shelf about every 2 weeks. When the intruded waters remain on the shelf for 3 days or more, large blooms of phytoplankton and zooplankton populations occur. The zooplankton which develop in this short time period are dominated by gelatinous, asexually reproducing forms. More advanced forms — e.g., crustacea — dominate with longer residence times. These plant and animal populations rapidly scavenge the nutrients and other elements from the water column, converting them to particulate forms. The settling particles enrich the sediments, primarily in the capes and other areas of topographic irregularities. During the summer, when shelf waters are thermally stratified, the high levels of primary production induced by these intrusions are not visible in surface waters. Because this subsurface feature (probably common to areas influenced by western boundary currents) was not recognized in the past, total primary production--and hence the transport and fate of particles in such areas--has been greatly underestimated. An accurate estimate of this dispersal of particles is critical in the dispersal of energy-related by-products in the region.

Nearshore, a coastal frontal zone inhibits the cross-shelf transport of material from the inner continental shelf. The inner front is characterized by water with reduced salinity, large amounts of particulate matter, and high biological production. Trace elements — and other material recycled between the sediments and water column — and their net transport out of the inner shelf are currently being studied. The exchange of material between this inner and outer continental shelf is controlled by the effects of wind and water density on frontal zone currents.



IN STREAM PRODUCTION

FINE PARTICLES

HEAVY PARTICLES

SURFACE FLUX

BOTTOM FLUX

FIGURE 3. SCHEMATIC DIAGRAM OF THE SOUTH ATLANTIC BIGHT.

Northward wind stress, common in spring and summer, spreads the coastal front seaward; southward stress, common in the autumn and winter, confines the front to a narrow band along the coast. Under the latter conditions, material may be advected to Cape Canaveral and subsequently deflected into the Gulf Stream.

This knowledge base on SAB particle dynamics is the beginning of a general conceptual model that ultimately will provide DOE with a predictive capability for quantitatively assessing SAB's capacity for assimilating energy-related by-products. This information will enable decisionmakers to maintain the delicate marine ecological balance while continuing to satisfy national energy requirements.

Southwest: California Basins Study

Statement of Problem

The geologic and oceanographic setting of the West Coast margin is different from that of the East Coast because it is a zone of crustal plate collision, whereas the East Coast is a more passive zone with less tectonic activity. The West Coast area, frequently referred to as the California Bight, offers some important advantages for determining the fate of injected pollutants. The region has a network of deep-sea basins close to shore. (See figure 4 for a schematic showing the deep basins adjacent to the coast and the ocean currents flowing through them.) These basins act as extremely efficient traps for coastal sediment. The deep waters in many of the basins are nearly free of oxygen; sediment records consequently are well preserved. Water circulation is restricted by the walls and sills which define basin boundaries, by adjacent land masses, and by reduced local wind effects due to coastal mountain topography. General circulation is restricted by an eastern (rather than a western) boundary current.

These characteristics also affect biological environments, in that colder waters move south along California and coastal upwelling is a major process. In contrast, on the East Coast, warm waters move poleward and current mixing recharges surface water nutrient budgets.

Sediment particles enter the coastal zone from river input, major waste discharges, biological production in the water column, and atmospheric infall. River discharge enters the margin from the northern sector rivers. Sediment contribution is seasonal; it also can be influenced by longer climatic cycles. Over the past century, more than half of the sediment contribution has come in four or five major flood events at roughly 20-year intervals. On a long-term average, land-derived sediment from the rivers constitutes approximately 80 percent of the total California borderland particulate budget.

CaBS' objectives are:

- To quantify the production, transformation, and flux of organic matter and energy-related byproducts within the Santa Monica-San Pedro Basins
- To evaluate the current patterns and water movements which transport particles and dissolved materials within the Basin and resuspend and transport particles from the Basin margins and bottom
- To measure terrestrial particulate and dissolved inputs to the Basin
- To measure net accumulation and burial rates of sediment and sediment-associated radionuclides, organics, and elements
- To develop models of the dynamics of organic matter in the Santa Monica-San Pedro Basins.

Program Description

The California Basins Study is a coordinated, multidisciplinary effort to examine and understand the production, transport, and ultimate fate of biogenic particulates and energy-related products associated with them in the nearshore ocean basins off Southern California.

Particle sources include anthropogenic and other terrestrial inputs as well as planktonic growth. The CaBS program has emphasized understanding planktonic cycling in the near-surface euphotic zone, vertical particle fluxes, and benthic metabolism and burial rates.

This study has used the closed nature of the Santa Monica-San Pedro Basin off Los Angeles as a convenient regional feature which constrains the movement of near-bottom particulate material, thereby allowing budgets in a closed-basin system to be determined (figure 4). One strength of this program is the comparison of methods used to measure the various particle-associated processes. Results are

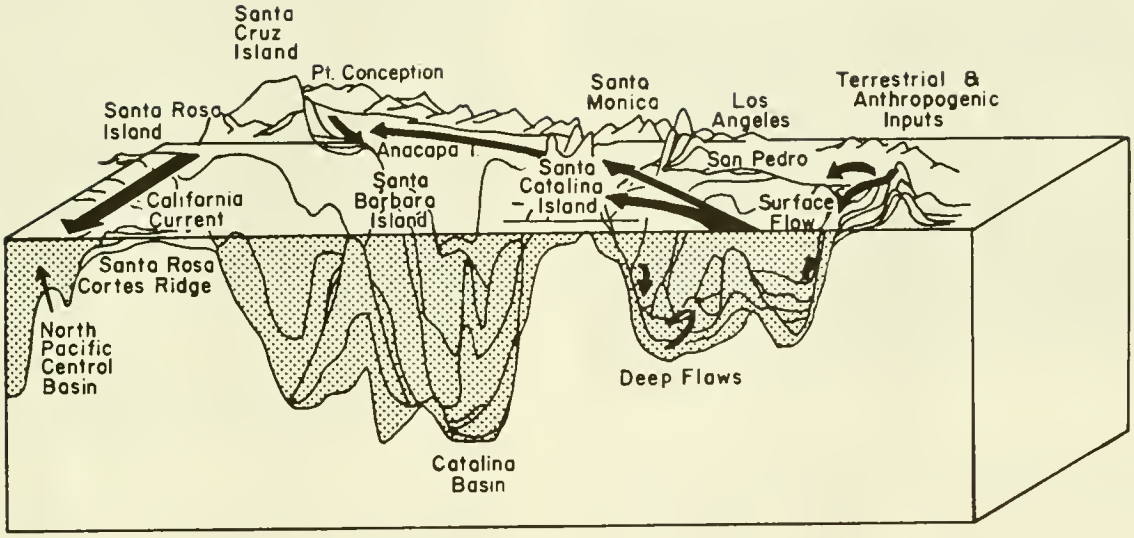


FIGURE 4. SCHEMATIC VIEW OF THE SOUTH CALIFORNIA BASINS AND CONTINENTAL BORDERLAND.

providing information on amount of anthropogenic inputs to the offshore basin, the direction of currents carrying the materials, and the rate of sedimentation of the materials in the basin.

In the past 3 years, the program has accomplished several important objectives. The dynamics of the coastal current systems have been mapped on a temporal basis, describing for the first time details of the northward motion of the easterly current, the surface eddy system, and the anticlockwise motion of the below sill currents in the basin. Fluxes of dissolved and particulate radionuclides involving $^{239/240}Pu$, ^{137}CS, $^{234/238}Th$, and ^{210}Pb have allowed the quantitative determination of the advective lateral motions and depositional vertical motions in the bight.

Research biologists have been able to determine with remarkably good precision the productivity within the basin, including new production and the mass balance of carbon imported, exported, and deposited. From the deployment of three different types of sediment traps, the flux of organic particles based on carbon and nitrogen has been very closely related to the production and decomposition flux. It has been shown that the major grazing activity of phytoplankton occurs by micro-(not macro-) zooplankton. These smaller animals repackage far more organic material than the large animals do. It has been estimated that bacteria could utilize up to 80 percent of the new production of photosynthetic carbon and nitrogen. The sedimenting and dissolved carbon and nitrogen may largely represent microzooplankton feces and adsorbed bacterial cells, but not phytoplankton cells. Lastly, ^{14}C measurements suggest that 5 to 10 percent of sedimenting organic particles may be derived from fossil carbon.

The complex sediment deposits in the Santa Monica Basin show evidence of turbidity flows and some re-entrainment of surface sediments. The area of oxygen-free sediment has expanded since 1850 and now covers most of the sea floor of the deep basin. This is partly due to the enrichment of the surface waters by sewage outfalls and nutrient-enriched (agricultural) river runoff. The contribution of sewage particles to the bottom sediments has been estimated at between 1 and 5 percent, based on organic or trace metal indicators. The contribution of various sources of carbon to the total sediment carbon balance has been quantified. At the same time, measurements were obtained on the rates of *in situ* respiration and nutrient recycling processes occurring in the surface sediments, and these agree with the deposition rates calculated in the studies cited above.

COORDINATION WITH OTHER AGENCIES AND GOVERNMENTS

Interagency Collaboration

DOE coordinates its marine program with other agencies at both the Headquarters and regional levels. At Headquarters, the program is integrated into the U.S. Global Ocean Science Program (GOSP) as part of the Ocean Margins task outlined in the GOSP 1987 report. It is similarly part of the global change crosscut being developed by the Committee on Earth Sciences and chaired by the Office of Science and Technology Policy. The crosscut will provide an overall picture of Federal activities in global change.

DOE's Coastal Ocean Margins Program provides key research on the input and interaction of continental margins with the open ocean system in the Western and Eastern Coastal regions of the U.S.; this information is provided to the National Science Foundation (NSF) in connection with the Global Ocean Flux Study (GOFS). Other interagency collaboration includes the Federal Plan for Ocean Pollution chaired by the National Oceanic and Atmospheric Administration (NOAA) and the Panel for International Programs and Intergovernmental Cooperation in Ocean Affairs chaired by the Department of State.

Active research scientists and program managers at NSF, NOAA, Office of Naval Research, and the National Aeronautics and Space Administration have participated in panel reviews of regional DOE studies; this has provided close coordination and research opportunities between the DOE program and those of other agencies. In the field, scientists funded by other agencies have been drawn to the nucleus of the three regional DOE multidisciplinary studies; this has been of mutual benefit to all concerned because of the resulting expanded and comprehensive data base. Besides researchers funded by the aforementioned agencies, scientists working for or supported by the U.S. Geological Survey, Department of the Interior/Minerals Management Service, Environmental Protection Agency, State of California, and Canadian Government have interacted with--and subsequently broadened the scope of--the DOE Coastal Ocean Margins Program.

International Collaboration

To determine cross-shelf transport in the Eastern Atlantic Ocean, the Western Mediterranean Sea, and off the coast of Mauritania underlying the Sahara Dust Plume, Spain, France, and Israel have invited collaboration and exchange with scientists in DOE's Coastal Ocean Margins Program.

Similarly, an active exchange program is in place for Japanese scientists and U.S. researchers to compare the dynamics of the Kuroshio Current and the continental shelf of Japan with the Gulf Stream interaction and the U.S. continental margin. This will contribute to the development of global understanding of the dynamics of such currents with the ocean margins.

FUTURE DIRECTIONS: THE CONTINENTAL OCEAN MARGINS FLUX STUDY

Several DOE-sponsored investigators also are involved in planning for the Global Ocean Flux Study, a major national oceanographic program, with the National Science Foundation as lead Federal agency. The GOFS planning document defines the program's overall goal as "understanding the processes controlling marine biogeochemical cycling at regional, basin-wide, and global spatial scales, and at time scales from interannual to decadal." This goal cannot be achieved without substantial effort in analyzing continental margin processes, since these control important phases of the global cycle. Recent work shows that continental shelf processes are intimately coupled with processes over the continental slope and with boundary currents such as the Gulf Stream and California Current. Taken together, these "continental margin processes" thus are important elements of many global-scale phenomena. The GOFS program has been initiated with a coordinated international series of open ocean studies in the Atlantic and the Pacific Oceans. The Continental Margins part of the program will be defined in a workshop in early 1989. In early 1991, DOE will announce in the Federal Register notice of our intent to support COMFS-type research in 1992.

The Continental Ocean Margins Flux Study Goals and Objectives

The Continental Ocean Margins Flux Study (COMFS) is DOE's program within the framework of the overall GOFS project. COMFS is based on DOE's Coastal Ocean Margins Program, which can be seen as the major contributor in understanding the dynamics between the continental margins and the open ocean in the elucidation of biogeochemical cycling in the marine system. The COMFS goal is to understand the role of margin processes in the global biogeochemical cycle; this is a subset of the much broader GOFS program. Specific objectives of COMFS are:

- To identify sources and sinks of substances important to global biogeochemical cycles within the continental margins
- To quantify and model the fluxes of these materials between the continental margins and ocean interiors
- To identify and quantify rates of biological and geochemical transformations of importance to the global cycle which take place on the continental margins.

The COMFS Plan

The initiation of a concerted effort to understand global scale fluxes from the continental margins to the deep ocean is a natural outgrowth of DOE-supported regional marine research. COMFS will apply research team strengths and focuses to an interagency and international program addressing national and global issues.

Under COMFS, the two East Coast programs will be combined and focused on whether the main route of material removal is at major topographic features such as Cape Hatteras and Cape Canaveral. Joint experiments with other agencies will focus on the Capes to test the hypothesis that they are the major discharge points along the East Coast. Biological productivity in slope water will be investigated, quantified, and related to nutrient supply, and material export from this region by the Gulf Stream will be determined.

CaBS will be extended to encompass all deep basins from San Diego to Point Conception and to reach seaward for a distance of 200 km across the California Current system. Where previous emphasis was on vertical transport and deposition, COMFS studies will concentrate on horizontal transport rates. Thus, COMFS research will examine important questions such as carbon export from the shelf into an eastern boundary current system and sources, routes, and rates of nutrient supply and sedimentation and of oxygen depletion in coastal basins in a global context. A major effort will be the interdisciplinary modeling of the carbon, oxygen, and nutrient cycles of this West Coast continental margin.

To gain insight into the complex processes governing particle fluxes over continental margins, COMFS will construct next-generation models of nutrient supply, primary production and utilization, and flux. These will be related to observations over continental margins to answer such questions as what fraction of locally produced carbon is retained in continental slope sediments and what fraction of the massive nutrient supply by upwelling along both East and West Coasts is utilized in the shelf-slope region.

The detailed studies off the U.S. coasts will be compared with other prototype locations such as equatorial continental margins, polar margins, and coasts subject to massive freshwater input such as the Alaska Shelf, East China Sea, and Brazilian Shelf. A worldwide budget of carbon and nutrients for the various continental margins will be developed by an interagency GOFS team and the fluxes to the deep ocean will be quantified to provide the boundary conditions for a global ocean flux model.

Instrumentation Development

With DOE's support, our grantees have developed innovative instruments that have provided new insights into oceanographic processes. For example, DOE has taken the lead in developing a moored fluorometer, a delayed double flash fluorometer capable of measuring primary productivity in realtime; an attachment to the acoustic Doppler current profiling system for estimating zooplankton biomass *in situ* when determining currents; and moored oxygen sensors that have provided insight into the coupling between oxidation and reduction reactions on the continental shelf. In addition, DOE has applied realtime satellite thermal and color imagery in studying primary productivity in boundary current upwelling events.

Beyond these, there is a large potential for increasing our understanding through such instruments as moored nutrient sensors, automated particle analyzers, high precision optical emission spectrometers, and towed conductivity, temperature, and density (CTD) systems. The development of such new instrumentation for enhanced research on global ocean studies is essential for better, more effective understanding of oceanographic processes.

The COMFS program is designed to provide significant contributions in understanding biogeochemical cycles both in ocean systems and in the overall global picture. A draft plan of the COMFS program may be obtained by writing to the Ecological Research Division at the address given in the Preface.

APPENDIX 1: Legislative Authority

Legislative Authority

The following legislation authorizes support for a research program in oceanography:

- PL 585, the Atomic Energy Act of 1946, authorized conduct of research and development activities relating to the use of fissionable and radioactive materials for medical, biological, and health purposes and for the protection of health during research and development activities.

- PL 83-703, the Atomic Energy Act of 1954, as amended, expanded the authority of the AEC to arrange for the protection of health and promotion of safety during research and production activities and for the preservation and enhancement of a viable environment.

- PL 93-577, the Federal Non-Nuclear Energy Research and Development Act of 1974, authorized initiation of a comprehensive non-nuclear energy research, development, and demonstration program to include the environmental and social consequences of various technologies.

- PL 95-91, the Department of Energy Organization Act of 1977, provided for incorporation of national environmental protection goals in the formulation and implementation of energy programs to advance the goals of restoring, protecting, and enhancing environmental quality in the pursuit of energy development.

APPENDIX 2: Northeast Abstracts

Coastal Productivity

Falkowski, P.G.

$200,000

Brookhaven National Laboratory

Department of Applied Science

C: 516-282-2961; F: 666-2961 *

Effects of energy-related pollutants on ecosystems of the Northeast Continental Shelf cannot be assessed or predicted without an understanding of the production and fate of phytoplankton. Phytoplankton, because of their high productivity, play a central role in the flux of organic matter and pollutants. This project focuses on processes that govern the production and fate of phytoplankton in coastal plumes and continental shelf environments. The approach is multi-disciplinary, involving shipboard observations, remote sensing, and moored instruments. The work, called Shelf Edge Exchange Processes (SEEP) Program, is concerned with exchange processes across the shelf that result in deposition of organic material on the upper slope. Field and laboratory studies are under way to provide basic information on the effects of light energy and nutrients on phytoplankton growth and this information will be used to develop a unified field theory of the structure and function of coastal ecosystems. The continental shelf of the Northeast Atlantic Coast is a biologically rich and complex environment subject to increased anthropogenic perturbations of an energy-related nature. This project focuses on the natural variability of coastal ecosystems, to develop a comprehensive theory describing the regulation of primary production in coastal ecosystems impacted by runoff from major estuarine systems. The natural variability of the Northeast Continental Shelf will be studied sufficiently to allow anthropogenic perturbations to be placed in a perspective required for rational management strategy.

* "C" indicates the commercial telephone number, while "F" refers to the number for the Federal Telephone System (FTS).

Ship Charter

Falkowski, P.G.

$320,000

Brookhaven National Laboratory

Department of Applied Science

C: 516-282-2961; F: 666-2961

Research vessels are required for multi-disciplinary studies of coastal oceanography by DOE contractors in the Northeast for a start of the Shelf Edge Exchange Processes (SEEP) II Program experiment in FY '88 to '89. This research includes projects on primary productivity, food chain dynamics, and coastal transport and diffusion. Vessel requirements are based on the nature, location, and timing of the scientific work to be conducted. The well-equipped major vessels of the University National Oceanography Laboratory System (UNOLS) meet these requirements and have been effectively utilized. In addition, cooperative use of National Oceanic and Atmospheric Administration (NOAA) vessels has proven feasible and advantageous to both agencies. The ship charter budget has been used for the Northeast collaborative SEEP-I experiment with the deployment of current meters and sediment trap arrays, collection of hydrography data, and geochemical sampling on two cruises. In addition, a biological cruise was undertaken to deploy floating sediment traps and fecal pellet collectors, and to collect water samples for primary productivity and microbiological activity. The principal biological field data collection of SEEP-I from February to April and a turnaround of the current-meter deployments and geochemical sampling were accomplished during the spring of 1984. In FY '85, focus was on retrieving the physical and sediment trap moorings and collecting box cores and hydrographic measurements. FY '86 to '89 focus is on the SEEP-II field program.

Coastal Transport and Diffusion

Flagg, C.N.

$212,000

Brookhaven National Laboratory

Department of Applied Science

C: 516-282-3128; F: 666-3128

The project objective is to understand the processes of transport and diffusion with emphasis on their control over the environmental effects of energy-related activities in the Mid-Atlantic Continental Shelf region. These processes must be understood because of their direct effect on the movement of pollutants and other materials and because of the critical role they play in the dynamics of shelf ecosystems. The approach involves field observations, data analysis, and numerical modeling. Historically, the research is divided into five components: (1) coastal boundary layer, (2) shelf circulation, (3) water mass analysis, (4) water property dispersion, and (5) air-sea interaction. The Coastal Boundary Transect (COBOLT) Program observations were completed by the end of FY'78 with processing and analysis extending through FY'83. The Spar Buoy Oceanographic Telemetry System (SBOTS I) was used in a five-mooring array for Mesoscale Experiment (MESEX I), with analysis extending through FY'83. FY'83 and '84 marked the beginning of the Shelf Edge Exchange Processes I (SEEP-I) field program, a multi-institutional examination of off-shelf fluxes of material. More recent activities include: (1) analysis of data collected during SEEP-I, and fabrication and testing of a bottom-mounted acoustic current profiler for use in the SEEP-III field program; (2) several publications describing the water property distributions in the Mid-Atlantic Bight (MAB) and the Gulf of Maine/Georges Bank region, and the dynamics of the MAB; and (3) dynamics of the MAB and outer continental shelf. Focus is on advection and diffusion processes on the continental shelf and the between the continental shelf and slope waters.

Food Chain Dynamics

Smith, S.L.

$398,000

Brookhaven National Laboratory

Department of Applied Science

C: 516-282-7697; F: 666-7697;

C: 516-282-2835; F: 666-2835

The food chain dynamics project provides information on the transfer of energy and material among various pelagic and benthic trophic levels and on factors that alter the pathways or rates of these transfers. Intensive ecosystem studies, coordinated with laboratory experimentation, provide the base for predictive models and evaluation of potential effects of human activity in the coastal environment. Study of the food chains uses an integrated field program of biological rate measurements, standing stock estimates, and remote sensing to infer the cycling and transfer of pollutants and organic material to higher trophic levels. Earlier studies suggest that the spring bloom phytoplankton is not consumed, but based on our recent test of this hypothesis, we find that all rates of processes, including accumulation, if calculated on a time (seasonal) and space-adjusted basis, are greater on the shelf than on the slope. If the test of the export hypothesis is constrained only to the area of Shelf Edge Exchange Processes (SEEP) Program experiments, there is little evidence in favor of accepting the hypothesis because during summer-stratified conditions animal consumption exceeds plant production (i.e., shelf food chains are more or less closed systems). The implication is that the energy-related by-products (pollutants) that enter food chains on the shelf will not be dispersed into the deep sea if the transport relies on fluxes of biogenic particles. Rapid recycling of organic material on the shelf is evidenced in the low-oxygen events in the New York Bight apex during the summer. The assimilative capacity of coastal ecosystems is dependent on cycling and fate of pollutants by food chains if physical export is minor.

Moored Sensing Systems

Wirick, C.

$155,000

Brookhaven National Laboratory

Department of Applied Science

C: 516-282-3063; F: 666-3063

This project involves deploying fluorometers across the shelf break in the Mid-Atlantic Bight for a period of several months. High-frequency time series of fluorescence will be obtained. Data will be analyzed in conjunction with transmissometers, sediment traps, zooplankton grazing, wind events, and other dynamics to estimate the short-term vectors of motion of chlorophyll and phaeopigments. The fluorometric measurements should provide statistically significant results concerning (1) the seasonality of the standing stock of phytoplankton, (2) the importance of storms in resuspending and transporting phytoplankton, and (3) the transport of phytoplankton across the shelf-slope front.

Transport and Transfer Rates in Waters of the Continental Shelf

Biscaye, P.E.

$637,000

Columbia University

Lamont-Doherty Geological Observatory

C: 914-359-2900

Energy-related pollutants are expected to have maximum impacts on our coastal zones, where the amount of water for dilution is limited, but where the productivity of food for man is highest. The project objective is to understand and quantify processes that transport pollutants and remove them from, or put them into, the pathways leading back to man. Studies include: (1) processes associated with suspended solids; (2) processes associated with sediments as sinks and sources; and (3) spreading of water characteristics and species in solution, to determine sources of continental shelf waters and the processes changing their contaminants.

Continental Shelf Processes Affecting the Oceanography of South Atlantic Bight

Pietrafesa, L.J.

$169,000

North Carolina State University

Department of Marine, Earth, and Atmospheric Sciences

C: 919-737-3721

The objective of this project is to identify, characterize, and quantify physical processes important to the flux of chlorophyll on the Mid-Atlantic Bight shelf, the flux of particulate matter across the shelf, and the resuspension of bottom sediments and particles. Current meter data will be used to establish scales of variability along shore. Spatial and temporal variability of the shelf-slope front are determined using current meter and thermistor strings. Chlorophyll flux estimates are determined by integration of current meter and fluorometer data.

Boundary Processes in the Nutrient-Bearing Stratum of the North Atlantic

Csanady, G.T.

$151,000

Old Dominion University

Department of Oceanography

C: 804-440-4285

The project objective is understanding (1) the physical basis of the North Atlantic nutrient cycle (i.e., circulation, mass balance, and nutrient regeneration in the nutrient-bearing upper thermocline layers) and (2) the role in the cycle of physical processes at the continental margin off North America. Key margin processes under study are shelf-edge exchange, deposition over the continental slope, and upwelling under the western boundary current. Work involves (1) modeling circulation in the isopycnal layers of the upper thermocline from subduction through western boundary current transport, (2) modeling shelf-edge exchange and western boundary upwelling, and (3) model-observation comparison and analysis and interpretation of data collected in the Shelf Edge Exchange Processes (SEEP) Program experimental series. This work is part of the coordinated interdisciplinary studies on continental margin processes important in the global biogeochemical cycle.

Collection and Simulation Analysis of Moored Fluorometer Time Series from the Mid-Atlantic and South Atlantic Bights

Walsh, J.J.

$150,000

University of South Florida

Department of Marine Science

C: 813-893-9164

The objective of this project is to determine the quantity of marine primary production and energy-related particles derived from the land boundary, the fraction of this material retained in the inner shelf, and the fraction exported to the open sea, including the time scales for the processes in the Mid-Atlantic and South Atlantic Bights. The approach uses a basic model that will be enhanced by new physical and biological submodels and in which Eulerian measurements may be transformed into a Lagrangian field.

Distribution of Some Chemical Elements Between Dissolved and Particulate Phases in the Ocean

Bacon, M.P.

$153,000

Woods Hole Oceanographic Institution

Department of Chemistry

C: 617-548-1400

The project objective is to develop a quantitative understanding of how the oceans assimilate chemical substances added to them by measuring natural radioactive nuclides. We are testing the hypothesis that upper continental slope sediments constitute a major sink for undesirable by-products of human activities that enter the ocean. The geochemical objectives are (1) to test the hypothesis by using various procedures to estimate the fluxes of materials to the upper slope sediments and accumulations therein and (2) to better understand the geochemical transport and exchange that control the fluxes and rates of accumulation. Field operations conducted south of Nantucket Shoals and Georges Bank have been completed and sample analysis is in progress. Initial results suggest accumulation of ^{210}Pb, ^{230}Th, and ^{231}Pa.

Fate of Nuclides in Natural Water Systems

Turekian, K.K.

$101,000

Yale University

Department of Geology and Geophysics

C: 203-432-3186

The behavior of natural radionuclides in precipitation, soil profiles, and groundwaters provides valuable clues to the behavior of nuclides released during the exploitation of energy resources. The influence of water on the behavior of nuclides in soil profiles and groundwaters affects the transport of nuclides to the coastal zone by rivers. Climatic regimes and related geomorphic processes have changed markedly over the past thousands of years because of glacial cycles. This research focuses on the chronology of groundwaters and soils. Continued study of the carbon cycle (through ^{14}C analysis) in soil profiles, stream detritus, and coastal sediments will provide insight into some aspects of the increased use of fossil fuels (which release carbon dioxide) and accelerated land use for agriculture and silviculture.

Aircraft Remote Sensing in the SEEP-II Investigations--1988

Hoge, F.E.

$35,000

National Aeronautics and Space Administration

Goddard Space Flight Center, Wallops, Va.

C: 802-524-1000-1567; F: 889-1567

Transects will be flown over and beyond the geography of interest to the SEEP-II Program and the FLEX Program in the South Atlantic Bight in conjunction with the deployment and ship schedule for these programs. Active and passive color measurements will be made using a pulsed laser transmitter to stimulate Raman backscatter as well as fluorescence from chlorophyll and phycoerythrin pigments contained in phytoplankton. Fluorescence from dissolved organic matter will also be determined. These measurements will be correlated with certain shipboard measurements. The data will be used to infer details of phytoplankton distribution that cannot be obtained from shipboard measurements and to improve ocean color algorithms in general.

APPENDIX 3 : Southeast Abstracts

Radionuclides in the Coastal Zone

Olsen, C.R.

$45,000

Oak Ridge National Laboratory

Environmental Sciences Division

C: 615-576-0505; F: 626-0505 *

The project objective is to identify, trace, and quantify the environmental and biogeochemical processes that affect the fate of particles, radionuclides, contaminants, and trace substances in aquatic systems, through measurements of the distribution of natural and anthropogenic radionuclides. Our approach involves cooperative efforts with other coastal zone scientists. The results enable predictions of the physical transport, chemical behavior, biological availability, and potential effects on coastal ecosystems of radionuclides and (by analogy) other contaminants or trace substances introduced into river-estuarine and coastal zones in association with energy development and waste disposal. This research is necessary for eliminating uncertainty associated with extrapolating numerical simulations and laboratory data to natural environments.

Production and Turnover of Suspended Organic Detritus in the Coastal Water of the Southeastern Continental Shelf

Pomeroy, L.R.

$89,000

University of Georgia

Institute of Ecology

C: 404-542-3415

This project concerns the production and turnover of suspended organic particulate matter in the coastal water of the Southeastern Continental Shelf. Organic matter is associated with clays in large particles in which the organic matter is the matrix. Organic matter is produced and removed by the combined activities of plankton, micro-organisms, and benthos. In collaboration with other scientists, key processes that contribute to the budget for the production and removal of suspended organic detritus in the coastal water are examined. Turnover time of suspended particles will be compared with rates of movement of water and suspended sediment load along and across the continental shelf.

* "C" indicates the commercial telephone number, while "F" refers to the number for the Federal Telephone System (FTS).

Measurement of Gulf Stream and Wind-Induced Shelf Circulation in the South Atlantic Bight

Lee, T.W.

$173,000

University of Miami

Rosenthal School of Marine and Atmospheric Sciences

C: 305-361-4057

Transport and dispersal of materials entering the inner shelf zone with river discharge is not well understood. Climatological data, satellite imagery, and numerical modeling results indicate a northeast transport alongshore and possible offshore exchange south of Cape Fear during the spring and summer when maximum runoff and northward winds prevail. Interdisciplinary analyses have been conducted to investigate the transport processes in the shelf region between Cape Fear and Savannah. Analyses focus on the coupling mechanisms between inner and outer shelf waters, with emphasis on the modes and rates of shelf water removal. The effect of the Gulf Stream induced circulation in the vicinity of the Charleston Bump on shelf water removal and the associated biological responses are being investigated.

Continental Shelf Processes Affecting the Oceanography of the South Atlantic Bight

Atkinson, L.P.

$155,000

Old Dominion University

Department of Oceanography

C: 804-440-4285

The objectives of this project are (1) to identify the physical processes responsible for the general circulation of water in the South Atlantic Bight and of associated chemicals and particles; and (2) to determine the variables controlling processes that affect the distribution of temperature, salinity, buoyancy, and dissolved constituents. The shoreline, nearshore fronts, Gulf Stream position, topographic irregularities, and wind are important in driving circulation patterns and the coupling between offshore and nearshore water.

Nearshore Transport Processes Affecting the Dilution and Fate of Energy-Related Contaminants

Blanton, J.O.

$210,000

Skidaway Institute of Oceanography

C: 912-356-2457

This project is analyzing physical transport processes on the inner shelf of the southeastern U.S. Numerical hydrodynamical models are used to study the dynamics of inner shelf circulation. Mechanisms for exchange of material from inlet to inlet are assessed using numerical models and data from Lagrangian drifters. We analyze (1) the degree to which cross-shelf pressure gradients predict alongshore currents under stratified conditions and (2) the mechanisms by which material is removed offshore from the inner shelf.

Nutrient Recycling on the Southeastern U.S. Continental Shelf

Hanson, R.B.

$80,000

Skidaway Institute of Oceanography

C: 912-356-2468

The project objective is to understand essential components of nitrogen cycling in Southeastern Continental Shelf waters. In collaboration with other scientists, studies concern the coherence among physical flow fields, the coupling of nitrogen regeneration to phytoplankton production, and the coupling of benthic and pelagic processes. Regeneration of inorganic nitrogen in the water column and from the sediments, and the spatial and temporal variation of these processes is analyzed.

Flux of Energy and Essential Elements Through the Pelagic Portion of the Continental Shelf Ecosystem

Verity, P.; Yoder, J.

$77,000

Skidaway Institute of Oceanography

C: 912-356-2473

This project analyzes the coupling between motion of water and phytoplankton productivity and related processes in the water column of the Southeastern Continental Shelf. Research is conducted in the inner shelf and involves analysis of rates of (1) biological and chemical processes important to the carbon and nitrogen cycle and (2) cross-shelf removal of material from the inner shore.

Trace Metal Geochemistry of South Atlantic Bight

Windom, H.L.

$118,000

Skidaway Institute of Oceanography

C: 912-356-2490

Recent studies in nearshore regions of the South Atlantic Bight indicate that sediments are an important temporary and/or permanent repository for trace elements supplied by rivers and tidal exchange with inshore and offshore waters. We are determining the sources of trace elements and their distribution in nearshore sediments as well as the dominant sedimentary phases that influence their fate. Stable depositional areas and their rates of sedimentation are being evaluated. We are analyzing (1) changes in chemical composition caused by exchange of nearshore and estuarine water, (2) the rate of trace metal and nutrient loss from the water column to nearshore sediments, (3) the importance of living and nonliving particles in controlling the transformation and the fate of trace metals, and (4) the importance of cross-shelf removal of particles.

Coordination: Southeast Continental Shelf Studies

Menzel, D.W.

$230,000

Skidaway Institute of Oceanography

Department of Research

C: 912-356-2480

Focus is on coordinating services for DOE-supported oceanographic research on the Southeast Atlantic Continental Shelf. Coordination activities include (1) conducting, reporting, and planning meetings; (2) synthesizing accumulated results; (3) coordinating the design and implementation of short- and long-term research; (4) scheduling and coordinating the use of research vessels; and (5) maintaining and operating oceanographic sensors on the Savannah navigational light tower.

Biological Processes in the Water Column of the South Atlantic Bight: Zooplankton Responses

Paffenhofer, G.A.

$85,000

Skidaway Institute of Oceanography

Department of Research

C: 912-356-2489

The project objective is to quantify biological processes involving metazoan zooplankton in the nearshore zone of the Southeastern Continental Shelf. These processes are (1) the rates at which living and nonliving particles are ingested; (2) growth, reproduction, excretion, and excrementation rates of abundant metazoan zooplankton taxa; and (3) zooplankton production rates. To obtain information on the latter, we will also determine metazoan zooplankton abundances in the water column. Data resulting from these studies are necessary to quantify the rates of cycling and fate of dissolved and particulate materials in the nearshore zone, which is the objective of the Biotransformation Program (BIOTRANS), the cooperative multi-investigator program in the nearshore zone. In addition, we have participated with other investigators in the Fall Removal Experiment (FLEX) in the fall of 1987. We will also analyze samples from the Spring Removal Experiment (SPREX), which was completed in April 1985.

APPENDIX 4: Southwest Abstracts

Studies of Coastal Processing Using Radioactive Tracers

Noshkin, V.E., Jr.

$50,000

Lawrence Livermore National Laboratory

Environmental Sciences Division

C: 415-422-0931; F: 532-0931 *

This work is part of the coordinated DOE California Basins Study (CaBS) research program. We will use manmade and naturally occurring radioactive tracers to assess circulation routes of dissolved and particulate materials in the water column and to assess rates and processes depositing (and possibly remobilizing) materials to bottom sediments, and redistributing them within sediments of basins in the Southern California Bight. We will collect water, particles, and sediment samples to measure concentrations of fallout-delivered ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Am, ^{90}Sr, ^{137}Cs, and natural ^{210}Pb, thereby determining the supply routes and fluxes of these tracers to the basins and continental slope area. We will investigate: (1) the role of upwelling as a mechanism that transports oceanic tracers in coastal zones; (2) particle-scavenging reactions involved in the transport of these tracers, to determine whether they are element-specific, biological, or abiotic in nature; (3) the effects of upwelling and advective transport on altering the vertical distribution of manmade tracers in the water column; (4) sedimentation rates of particles to different offshore regions; (5) fluxes of specific tracers to the bottom sediments; and (6) redistribution processes in the sediment columns (physical and biological mixing, and pore-water diffusion). These studies will help establish a base of knowledge necessary to evaluate the present and future energy development impacts on Pacific coastal regions.

Program of Mineralization and Cycling in Marine Systems

Venketesan, I.; Kaplan, I.R.

$152,000

University of California

Institute of Geophysics and Planetary Physics

C: 213-825-1805

Changes in various organic substances that settle to the sea floor are examined. Activities include: (1) evaluating the relative flux of marine photosynthetic carbon to the sea floor versus the importance of terrigenous plant material; (2) determining the rate of decomposition of sedimenting organic matter in the water column; (3) examining the organic matter covering the sediment surface, because this area contains actively metabolizing bacterial forms; and (4) measuring biogenically active organic substances, such as amino acids, sugars, and low molecular weight acids, in pore water and sediments. In conjunction with estimates of inorganic components, controls and rates of organic decomposition in sediments can be estimated

*"C" indicates the commercial telephone numbers, while "F" refers to the numbers for the Federal Telephone System (FTS).

Role of Bacteria in Organic Matter Fluxes in the Southern California Coastal Zone

Azam, F.; Carlucci, A.F.

$100,000

University of California/San Diego

Scripps Institution of Oceanography

C: 619-452-3196; C: 619-452-3195

This project will evaluate the role of bacteria in the cycling of matter in seawater, whether the organic matter is dissolved, particulate, produced *in situ,* or terrestrially derived. The assessment will be made by measuring (1) fluxes of dissolved and particulate matter into bacterioplankton, (2) mineralization rates of organic matter, (3) growth rates of heterotrophic bacterioplankton, and (4) growth of bacteria on particles and in the free state.

Primary Production, Nutrients, and Oxygen in the Southern California Bight: Contribution to the Carbon, Nitrogen, and Oxygen Budgets

Eppley, R.W.

$100,000

University of California/San Diego

Scripps Institution of Oceanography

C: 619-534-2338

This project will determine (1) the spatial and temporal variation in planktonic primary production; (2) the sinking flux of particulate biogenic carbon to depth; and (3) the calibration of satellite chlorophyll images in order to calculate primary production synoptically over a larger area than can be done from ships. The objective is (1) to develop a mass balance for carbon and nitrogen in basins of the California Bight, and (2) to provide a basis for evaluating supply and decomposition rates of organic matter and the distribution of these processes in the basins.

Density and Nutrient Fields Measurements at Openings to a Marine Basin and Model of Fluxes Within the Basin

Jackson, G.A.

$114,000

University of California/San Diego

Scripps Institution of Oceanography

C: 619-534-2923

This project is part of a larger program to study the production, cycling, and fate of organic matter produced around a relatively isolated deep coastal basin in the California Bight. Using an isolated area such as a basin allows changes in water properties to be related to *in situ* processes. There are two components: (1) to measure density, nutrient, and oxygen fields in the vicinity of basin sills, to establish exchange rates of basin waters with surrounding waters; and (2) to develop a physical-chemical-biological model to integrate field measurements made by other scientists in the program. Such models will describe coherence of flux rates in the system, test the completeness of the basin description, and serve as a basis for more complex analyses.

Provision of Research Ship Use for Sampling Work at Sea

Shor, G.G., Jr.

$212,000

University of California/San Diego

Scripps Institution of Oceanography

C: 619-534-2853

The project objective is to provide ship services for the California Basins Study program in mineralization and cycling in marine systems.

Sources and Composition of Organic Materials in Waters and Sediments of the Southern California Coastal Zone

Williams, P.M.

$107,000

University of California/San Diego

Scripps Institution of Oceanography

C: 619-452-2929

The project objective is to determine the sources, composition, and fate of naturally occurring organic substances in shelf, slope, and basin waters and in sediments of the California Bight coastal zone. The isotopic and chemical characteristics of the sedimentary, dissolved, and suspended and sinking particulate organic phases are analyzed. It is expected to determine (1) the relative fluxes of terrestrially and marine-derived organic substances to the coastal waters and sediments; (2) whether the qualitative and quantitative changes in the composition of various organic phases reflect specific biochemical processes occurring in the sediments and water column; (3) whether changes in isotopic ratios can be used to interpret the magnitude of terrestrial versus marine contributions; and (4) whether radiocarbon dating of organic phases is useful for interpreting organic processing.

Utilization, Cycling, and Vertical Transport of Particulate Organic Matter in the Marine Coastal Environment

Landry, M.R.

$107,000

University of Hawaii

Department of Oceanography

C: 808-948-7776

The project objective is to elucidate the roles of planktonic animals and protozoa in (1) the utilization of surface-produced particulate organic matter (POM) and (2) the transport and cycling of POM through the water column overlying the Santa Monica Basin. We use sediment traps to quantify the rates of flux of phytoplankton pigments, carbon, nitrogen, and biogenic silica. We conduct experimental studies on shipboard to assess process rates of various components of the grazer community, including the gut fluorescence technique for macrozooplankton and the dilution, metabolic inhibitors, and fluorescently labeled bacteria techniques for planktonic ciliates and flagellates. Many of the organisms characterized as macrozooplankton on the basis of size function similarly to microzooplankton by producing slowly settling fecal debris, versus rapidly settling pellets as generally assumed for macrozooplankton. Such debris is subject to metabolism and degradation within the euphotic zone. The daily flux of phytoplankton from the euphotic zone is in the range of 20 to 40 percent of daily production as measured by ^{14}C and approximately 10 percent of particulate carbon, implying a particle residence time of 10 days.

The Role of Zooplankton and Micronekton in the Cycling and Remineralization of Chemical Materials in the Southern California Bight

Small, L.F.; Huh, C.

$138,000

Oregon State University

College of Oceanography

C: 503-754-2991

The project objective is to understand the transport mechanisms and mass balance distribution of certain metabolically active and inactive elements and compounds in a deep basin. This will be accomplished by estimating the role of zooplankton and micronekton stocks in the fractionating of ingested particulate matter into dissolved, rapidly recycling materials, and into larger fecal pellets which are transformed in transit through the water column. We will evaluate the role of zooplankton in transferring inorganic chemicals through the water column relative to other sedimentation processes. Analysis of trace metals and radionuclides in the water, suspended particles, zooplankton fecal pellets, sediment trap material, and bottom sediments will suggest sources, transport and recycling pathways, removal flux, and residence times in the basin.

Flux and Recycling of Bioactive Substances in Surface Sediments of Deep Basins Off Southern California

Jahnke, R.

$59,000

Skidaway Institute of Oceanography

C: 619-452-2598

The project objectives are to develop an understanding of the processes responsible for the recycling of biogenic debris in the surface sediments of the Santa Monica Basin and to quantitatively determine the rate at which dissolved components are exchanged across the sea floor-bottom water boundary. During the first 18 months of this project, pore water, sediment, and *in situ* benthic chamber data were collected for assessment of recycling and diagenetic processes occurring in the surface sediments. An attempt to summarize these measurements and compare them to other carbon-cycling rates estimated by other investigators in this project suggested that surface sediments were a major site for biogenic recycling in the basin.

Sedimentological Analysis and Shipboard Coring Support for DOE Southern California Basin Study

Gorsline, D.S.

$24,000

University of Southern California

Department of Geological Sciences

C: 213-743-2920

The project objective is to provide sedimentological background data on the cores collected for study by other investigators in the California Basins Study (CaBS). Sedimentological analyses will provide background information on the marine geological setting, long-term depositional budgets, and the dominant processes affecting various parts of the Santa Monica Basin. Laboratory work involves textural analysis, radiographic analysis, and chemical analysis for carbonate and total organic carbon.

Circulation and Particulate Fluxes in the Southern California Bight

Hickey, B.M.

$299,000

University of Washington

School of Oceanography

C: 206-543-4737

This project will determine the general circulation in the Santa Monica-San Pedro shelf/slope/basin region, including patterns and forcing mechanisms. It will also describe particle dynamics in this region, i.e., the relative importance of horizontal advection, wave/current resuspension processes, submarine canyons, and intermediate-depth nepheloid layers in redistributing particles, on time-scales of hours to years.

APPENDIX 5: Support Grants

Partial Support for the National Academy of Sciences' Ocean Science Board

Perry, J.S.

$15,000

National Academy of Sciences

C: 202-334-3517 *

The National Academy of Sciences, through the Ocean Sciences Board of the National Research Council, proposes policy and identifies major problems concerning ocean science. Support is provided by the Office of Naval Research, the National Science Foundation, the National Oceanographic and Atmospheric Administration, the Department of Energy, the Environmental Protection Agency, the U.S. Geological Survey, the Bureau of Land Management, the U.S. Coast Guard, the National Aeronautics and Space Administration, and the Department of State.

Partial Support for the National Academy of Sciences' National Research Council Committee on Global Change

Perry, J.S.

$10,000

National Academy of Sciences

C: 202-334-3517

This project involves energy research and development to accurately reflect global studies of earth-system processes. The Committee on Global Change is a focal point for plans and communications related to the emerging International Geosphere-Biosphere Program (IGBP). The Committee will provide scientific guidance and leadership to the government on important national and international multi-disciplinary problems involving the earth system (ocean, biota, space, and solid earth).

*"C" indicates commercial telephone numbers.

Partial Support of the University National Oceanographic Laboratory System (UNOLS) Office

West, R.W.

$6,000

National Science Foundation

C: 202-357-7837

The University National Oceanographic Laboratory System (UNOLS), an association of 17 academic institutions, was established in 1971 by the National Science Foundation as a coordinating and planning mechanism for oceanographic facilities operated by those institutions. Thirty-one other academic institutions participate in UNOLS as associate members. The UNOLS office is the focal point for planning, coordinating, and reporting of all UNOLS activities and is supported by six Federal agencies. It provides administrative staff services, and prepares and disseminates ship schedules, user requirements, analyses of annual ship use, committee reports, new marine regulations, and other related information.

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