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This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

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Board on Ocean Science and Policy
National Research Council
2101 Constitution Avenue,N.W.
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WILLIAM M. SACKETT, University of South Florida

NANCY G. MAYNARD, Staff Director

INTRODUCTION

In April 1982, the Department of Energy (DOE) asked the Ocean Sciences Board (now the Board on Ocean Science and Policy) of the National Research Council to review the Department's Regional Marine Research Program. The regional program consists of interdisciplinary marine research programs of the Southeast, Northeast, Northwest, and Southwest coasts of the United States.

The Ocean Sciences Board responded by organizing an ad hoc committee with terms of reference as follows:

1. To review each of the Department of Energy research programs under way for increasing the scientific understanding of the regional coastal oceanic systems and their interaction with energy activities, including transportation, drilling, and oceanic, atmospheric, and terrestrial discharges.
2. To review progress and future plans of all established regional DOE projects in terms of scientific merit and especially in the context of concerted multidisciplinary effort.
3. To advise the Department of Energy on the merit of the programs, identify gaps, and recommend priorities and options.
4. To report on committee activities to the Ocean Sciences Board.

In July 1982 committee members, experts in physical, chemical, and biological oceanography and marine geology, were asked to serve. The members, their scientific fields and organizational affiliations were as follows:

Feenan D. Jennings, Texas A&M University; chairman
Robert C. Beardsley, Woods Hole Oceanographic Institution, physical oceanography
John Goering, University of Alaska, biological oceanography
Donn Gorsline, University of Southern California, marine geology

James McCarthy, Harvard University, biological oceanography
Christopher N.K. Mooers, Naval Postgraduate School, physical oceanography
Patrick L. Parker, University of Texas, chemical oceanography
William M. Sackett, University of South Florida, chemical oceanography

Later, two more members were added--Charles H. Hewitt, Exxon Production Research, industry, and Philip E. LaMoreaux, P.E. LaMoreaux and Associates, industry--to contribute expertise represented by the National Academy of Engineering and the NRC Board on Radioactive Waste Management.

The committee reviewed the regional DOE programs in a two-day site visit to each of the four regions. At the site visits, program and project leaders made presentations on their research and plans for the future. Time was allotted also for scientific disciplinary discussions between the panel members and research investigators. Summaries of the panel reports of the visits are attached as appendixes. The summaries and the full reports which are on file and available from the Board on Ocean Science and Policy of the National Research Council were the basis for the findings and recommendations of this report.

SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

This report is focused on perceived problems in the program, however, the evidence uncovered by this review method has convinced us of the excellence of the program. Most of the research being carried out is at the forefront of coastal marine research. The scientists involved are first rate and productive as evidenced by their publication records. Indeed, much of the present understanding of the fluxes and fates of anthropogenic material in coastal waters stems from this DOE program and its predecessors.

The terms of reference called for the committee to review the progress and plans of the regional projects, advise DOE on the merits of the program, identify gaps, and recommend priorities and options. This was done for each of the regional programs. The results are discussed in the body of this report and in the appendixes.

In addition to the findings, which are applicable to each of the regional projects, we have identified issues affecting science, management, administration, and resource utilization that cuts across all regional projects and the national aspects of the program. Summaries of the conclusions and recommendations for possible ways of addressing those issues are as follows:

SCIENCE

The DOE program has aspects that give it strength, utility, and a unique scientific flavor. The program is multidisciplinary because the environmental problems to which it responds require such an approach. The program is regional because it deals with site specific environmental problems. The committee fully supports the multidisciplinary and regional nature of the Program and recognizes that advances will be made if those are retained.

Each of the regional projects has geographic and environmental factors that are unique and require scientific approaches different from the other regional projects. However, there are scientific themes that apply to all projects and are important to the continued

success of the program. The major scientific theme of DOE's Regional Oceanography Program is, and always has been, the transport of man-produced compounds through the coastal marine environment. This includes chemical characterization of these substances; physical transport by water motion; chemical transport by transformation and absorption; and biological transport by uptake, alteration and movement, and geological transport through sediment transport and sedimentation processes. We are concerned that this unifying theme is sometimes forgotten in the design of the regional projects and that, as a result, the science suffers and the strength of the arguments for adequate financial resources in DOE is weakened. It would be helpful if the DOE program managers would clearly identify this theme, and any others they consider important, for the benefit of the scientific community.

> Recommendation 1: The materials transport theme of the Regional Oceanography Program should be emphasized by DOE in reviewing and funding the development and planning of each regional project and in justifying the need for funds in its long-term plans and annual budget requests.

Numerical coastal ocean circulation modeling has developed rapidly over the past decade and is now reaching a level of scientific utility. This opportunity has been partially exploited by DOE's regional oceanography programs. Such numerical modeling offers a scientific strategy framework to help quantify coastal transports-- first physical and then chemical, biological, and geological transports--as well as helping to test conceptual ideas about transport processes in the coastal ocean. These computer models can be used in the simulation, data synthesis, and experimental planning modes.

> Recommendation 2: DOE should adopt numerical coastal ocean circulation modeling and, as appropriate, ecosystem and sediment transport modeling, as a central scientific strategy for its regional coastal oceanography programs. Interactions with programs of other agencies may be productive in this area.

MANAGEMENT

At the regional as well as the site specific level, the multidisciplinary nature of the research requires strong leadership and teamwork. This approach is needed in planning research, carrying out field and laboratory experiments, developing conceptual and theoretical models, reducing and interpreting research results and presenting the findings in a variety of publications and forums. When all of the oceanographic disciplines are involved in research programs like the regional oceanography program of DOE, it is often difficult for each of the disciplines to have an adequate voice in program development, planning, and apportioning of resources. Assignment of such responsibilities to a council that selects its own spokesman alleviates this difficulty.

> Recommendation 3: An executive council should be established in each regional program to ensure leadership and teamwork in all facets of the program. It should be chaired by a leader, agreed to by the participating scientists, who would be the spokesman and coordinator of the regional program.

In its regional program, DOE is managing complex, multidisciplinary programs whose design and makeup are primarily in the hands of the scientists proposing to do the research. This is right and proper, but an independent review of the program proposals in each region should be made to (1) help ensure the scientific excellence of each project being proposed, (2) help assure DOE program managers that each project is essential to the objectives of the program, and is not duplicative, and (3) see that any gaps, which may exist, are not detrimental to attaining the objectives of the proposed program. In the National Science Foundation, the Ocean Sciences Division uses such review panels quite successfully in reviewing the large, complex proposals of its program of coordinated ocean research experiments.

Recommendation 4: DOE should establish a panel to assist in reviewing the research proposals from the regional programs. The panel should use mail reviews from experts appropriate to each proposed project and advise DOE on the importance of each project to the goals of the proposed program.

One of the hazards of research administration in the federal government is that after a few years the professionals involved begin to lose firsthand knowledge of their science and become somewhat rigid in their thinking. Several agencies have avoided this difficulty partially by bringing bright, young scientists to Washington for periods of one to two years, either as short-term regular employees or under the Intergovernmental Personnel Act, to help manage research programs. These individuals are referred to as rotators.

Recommendation 5: DOE should bring competent younger scientists to the Department for one-to two-year periods to help manage its Regional Oceanography Program. These individuals would bring fresh ideas to the programs and help regular program managers maintain knowledge of the latest developments in their science.

ADMINISTRATION

At the national level, the overall regional program would benefit from clearly identified mechanisms for receiving advice on broad policy issues and program planning from the individuals and organizations most affected by energy-related materials introduced into coastal environments and from knowledgeable scientists not directly involved in the program. These mechanisms could provide an avenue of communication with the affected communities and help ensure that all important problem areas are identified.

Recommendation 6: DOE should appoint a national advisory committee made up of knowledgeable scientists and individuals representing local coastal communities and regional bodies most affected by energy related materials in the coastal environment.

DOE has wisely recognized the necessity to make long-term commitments to the regional oceanography programs because of the complex and difficult nature of questions they are addressing. Because of that commitment, the researchers involved are able to undertake studies requiring repeated field experiments over a number of years and have adequate time to incorporate the results of each experiment in the design of subsequent experiments. The program not only provides the basic scientific research necessary to the development of pollutant monitoring systems by other organizations, but because of the long-term nature of the program, the data resulting from the research become monitoring systems in themselves.

Recommendation 7: DOE should continue its support of research on a long-term basis; three to six years is reasonable for the kinds of problems being addressed by DOE. Also, contract awards should be made for periods of two to three years whenever possible to reduce the time consumed in preparing and reviewing proposals.

During our reviews of the four regional programs, we concluded that communications between the DOE and the regions, and between each of the regions, should be improved. Also, we concluded that the general public and individuals and other organizations in positions both to use the results of the programs and to support them are not being adequately informed about them.

Recommendation 8: The consortium of regional executive council representatives mentioned in Recommendation 4 should work to improve communication between DOE and each of the regional programs. To improve communications about the program to the general public, each regional program should publish a popular description of its program similar to the one published by the Atlantic Southeast Region in 1981. In addition, DOE should consider publishing a similar document summarizing the overall national program. Our final recommendation to aid communication within and outside the program is that

workshops be organized to provide a forum to discuss disciplinary and interdisciplinary experimental problems and results.

RESOURCE UTILIZATION

Considering the similarity of many aspects of one regional program and another, there are times when the individual programs, as well as the collective DOE effort, would benefit from the exchange of personnel and equipment during certain phases of the research. Such exchanges could be facilitated by staggering the field activities of the programs. This could be accomplished by establishing a national consortium of representatives from each regional executive council (Recommendation 1) to assist in allocating ship time and coordinating shared use of DOE equipment, and technical and scientific talent.

Recommendation 9: The DOE program managers should organize a consortium of representatives from each regional executive council (the coordinators, in most cases) to help make the most efficient use of the limited DOE money through sharing of scientific talent, equipment and methodology, and through judicious scheduling of field programs to permit such sharing.

The use of our coastal lands, parks, and waterways for energy-related activities is accelerating each year. Both the land-sea boundary and the shelf-open ocean boundary need attention, and it is unrealistic to presume that DOE could underwrite all of the essential research in this region. Joint sponsorship with other federal and state agencies could result in more efficient use of the resources of all sponsors.

Recommendation 10: DOE should encourage and assist each regional executive council to seek support from other sources to augment certain projects that fall within the scope of both DOE and the other agencies. Care should be taken to ensure that such joint support does not weaken the program from DOE's perspective.

During our review, we came to the conclusion that present levels of funding are inadequate for the research efforts needed to attain the objective of the regional oceanography programs. While all of the programs are underfunded, increased support is needed especially in the Northwest for geology and physical oceanography, and in the Southwest where geology is very weak and physical oceanography is almost totally lacking. The committee estimates that an additional $2.0 million is needed just to address funding deficiencies in the existing regional projects. In addition, the need for regional projects in other areas such as the Gulf of Mexico and Alaska should be reexamined in the light of population growths, increased energy-related activities and of past and present research efforts in those regions by other government agencies. Costs could vary between $0.5 and $1.3 million for each additional regional project.

Recommendation 11: DOE should increase its funding support for the ongoing regional oceanography programs to overcome deficiencies in the scientific programs identified in this report. We estimate an additional $2.0 million is required. In addition, DOE should review the needs for regional programs in the Gulf of Mexico and Alaska. If needs are identified, appropriate oceanography research programs for these regions should be developed and funded. For two additional regional programs, a total of $1.0 to $2.6 million of further funding would be required.

Chapter 1

DOE RESEARCH IN OCEANOGRAPHY

HISTORY AND EVOLUTION

The DOE marine science program has historical antecedents of nearly 40 years. During this time, it sponsored basic and problem-solving research on global as well as regional problems. The major themes in the early period were the following: (1) description of the distribution of radionuclides, natural and anthropogenic, in the global ocean and in its biota and sediments; (2) identification of the fates and effects of radionuclides released in the ocean, including the pathways to man through the food web; and (3) fundamental studies of the transport processes controlling the distribution of radionuclides in the water column and sediments. As the petrochemical fuel problem became severe in the United States in the mid 1970s, marine studies supported by Energy Research and Development Agency dealt with coastal impacts of the production, transportation and utilization of energy-producing substances. The impacts of the petroleum and coal industries, of power plants and energy-related heavy industry, on the coastal ocean have continued to influence the direction of the marine research programs of DOE.

In recent years, DOE has focused its oceanographic program on coastal marine science, with specific attention being given to regional analysis of coastal ecosystems of the United States. It is this aspect of the DOE research effort that we were asked to review. Other, more global, aspects of oceanic and atmospheric science are being dealt with through other DOE programs, such as those on the seabed disposal of high-level and low-level radioactive wastes, ocean thermal energy conversion, and the long-term global effects of fossil fuel combustion.

RELATIONSHIPS TO OTHER NATIONAL OCEAN PROGRAMS

It is important to understand the role of DOE-sponsored oceanographic research within the context of that sponsored by other agencies. Some overlap exists and is,

we believe, beneficial, because interests overlap and problems are complex and interrelated. For example, DOE and the Minerals Management Service (MMS) (formerly, the Bureau of Land Management (BLM)) operations and interests are similar, both use contract or interagency agreements to obtain field data on the dispersal of man-generated materials into the ocean. However, MMS's primary interest stems from its charge to oversee the federally owned lands both off and on shore. In contrast, DOE's interest stems from its charge to oversee the development of all energy sources; historically, they focused on nuclear sources. Certainly much of the MMS-supported work supplements DOE work although they appear to mesh their efforts so duplication of effort is minimal. While DOE emphasizes mission-oriented basic research, MMS emphasizes site surveys in support of Environmental Impact Statement preparation. (Note: In the Southern California area MMS has a contract with a modeling group to produce ocean circulation models and flow measurements for the Santa Barbara Channel area and to examine the flow around structures, while DOE's efforts in this region emphasize the biological aspects of these currents.)

DOE and the Environmental Protection Agency (EPA) share concerns about the impact of man-generated materials on the marine environment--EPA primarily from a regulatory point of view covering a wide range of anthropogenic inputs, DOE restricted to the effects of energy-related materials.

While DOE and the National Oceanic and Atmospheric Administration (NOAA) have common interests in the general area of oceanographic processes, NOAA is more concerned with resource development and exploitation and management, commerce, weather and climate prediction, and fisheries research and management, and DOE studies large continental shelf regional systems where energy-related impacts can be expected.

The National Science Foundation (NSF) generally sponsors disciplinary process studies of fundamental significance to oceanography on a global basis. Occasionally, multidisciplinary studies are sponsored but on neither a regional nor a continuing basis. The Office of Naval Research (ONR) generally sponsors disciplinary oceanographic studies of broad scope with some

significance to naval operations and warfare on a global basis. Finally, the United States Geological Survey (USGS) does basic and applied research related to marine mineral resources of the continental margin.

PAST CONTRIBUTIONS OF THE DOE PROGRAM

The general quality of the marine science sponsored by DOE over the past 25 years or more has been high. A substantial fraction of the ocean scientific developments in the past two decades that have contributed directly to our understanding of flux of dissolved compounds and particulate matter in the coastal region can be traced directly to research supported by DOE and its antecedent agencies. The research currently supported by DOE in the regional programs is of equally high quality.

The Northwest Region DOE investigators elucidated the physical, chemical, biological, and geological transports associated with the discharge of radionuclides by the Hanford plant into the Columbia River. They traced the pathway of radionuclides through the Columbia River discharge plume to the "mud belt" on the central Washington continental shelf and into other elements of the marine ecosystem. Additionally, they have developed an understanding of how these materials were reworked, biologically and chemically, and how sediments are resuspended and transported.

The Northwest Region DOE investigators have conducted fundamental, quantitative studies of the regional coastal marine ecosystem. For example, they have documented transient, seasonal, and interannual variability in primary productivity. Because of their inability to balance the carbon budget by considering alternative pathways, they have been led to hypothesize that particulate carbon is exported across the shelf-water slope waterfront at the shelfbreak, and is ultimately deposited in the sediments of the upper continental slope. This hypothesis serves as the basis for their present focused research program.

Southeast Region DOE investigators discovered the role of Gulf Stream meanders and spin-off eddies in providing a turbulent transport of nutrient-rich oceanic waters onto the continental shelf of the South Atlantic Bight. The consequent turbulent flux of nutrients drives

the primary productivity of that region's marine ecosystem, a fact previously attributed to nutrient fluxes from coastal wetlands.

The Southwest Region DOE investigators have played a major role in the study of petroleum and pyrogenic polynuclear aromatic hydrocarbons (PAH) in marine sediments. They have demonstrated that PAH in marine sediments are from multiple sources, including coal and wood burning, and that these sources can be identified by sediment studies. These studies have contributed significantly to our knowledge of the composition and origin of petroleum.

DOE-sponsored investigations in these regional programs and their predecessors have contributed immeasurably to an understanding of the spatial and temporal distributions of plutonium and fission products in the sea and the removal of some of them to the sediments. The vertical distribution of these radionuclides in sediments led to a breakthrough in an understanding of mixing (bioturbation) processes in sediments. In addition, DOE investigations have been at the forefront in the use of naturally occurring radionuclides (^{230}Th, ^{231}Ra, ^{210}Pb) in determining sediment deposition rates, which are vital in studies of geochemical cycling.

The DOE regional oceanographic program has provided a fundamental understanding of the kinds and numbers of micro- and macro-plants and animals that exist and the biological processes that regulate the transfer of energy and organic material between the various trophic levels in coastal regions. The program, in particular, has assembled an impressive expertise in plankton biology. The information provided by these biologists has dramatically advanced the understanding of fluxes and fates of particulate and dissolved material transported through coastal food webs.

The research theme common to the regional programs is an attempt to understand the fluxes of energy-related byproducts, both particulate and dissolved, through marine coastal systems. The various aspects of this problem currently under investigation by scientists in each of the regional programs constitute some of the most topical research in oceanography anywhere in the world, and the scientists involved are collectively attacking the truly important questions in coastal oceanography.

SPECIAL INTEREST IN RADIOACTIVITY

The special focus of DOE's oceanography program in the past and at present may well be the strongest basis for DOE's interest in the continental margins. The continental margins are the gateway to the world ocean. They bridge the primarily continental sources to the ultimate oceanic sinks. DOE's interest in tracing nuclear input to the continental shelf system requires that it study this region. In view of this fact, DOE should examine the need for regional programs in the Gulf of Mexico and in Alaska.

Chapter 2

DOE REGIONAL COASTAL OCEANOGRAPHY PROGRAMS

The DOE regional coastal oceanography program is concerned with laying a foundation of basic knowledge and understanding of the causes of problems associated with activities related to all types of energy sources--nuclear, solar, petroleum, natural gas, coal, solar, wave, wind, tidal. Nuclear activities have been the predominant concern. We recognize that both pragmatic and fundamental ocean science considerations resulted in the creation of the regional programs.

The four DOE regional coastal oceanography programs we reviewed have common features, which include the following:

- analysis of U.S. regional coastal marine ecosystems (South Atlantic Bight, Middle Atlantic Bight, Northwest Canyons and Shelves, and Southern California Basins and Borderlands);
- coordinated, multidisciplinary studies;
- long-term, continuing support of basic research;
- orientation toward field work, but with an implied commitment to quantitative ecosystems modeling, which includes a suite of physical circulation models for tidal, wind-driven, and seasonal components; and
- emphasis on understanding: (a) coastal marine ecosystem "driving forces" from continental, atmospheric, and oceanic sources, and the coastal biological response; (b) the physical, chemical, and biological transports of particulate matter and its accumulation in sediments and biota, and their subsequent movement and resuspension; (c) spatial and temporal variability of coastal marine ecosystems, especially that variability associated with atmospheric (storms) and oceanic (boundary current meanders and eddies)

perturbations (events); and (d) (with special significance) exchange processes of the coastal boundary layer, the shelfbreak boundary layer, and the bottom boundary layer.

We believe that these common characteristics of the DOE regional oceanography programs distinguish them from short-term, individual, disciplinary process studies such as those that NSF, NOAA, ONR, or EPA supports. The focus on specific United States coastal sites with energy-related problems is one of DOE's major strengths and should continue to be for at least a decade.

While all four regional programs have these common characteristics, each also has unique problems and approaches. Because of differences in their historical development, the regional groups are different in organization and program content. Recommendations are made where we believe that a more uniform program would strengthen a regional program or the overall national program. It is clear that diversity is also a strength and no attempt has been or should be made to force all regions to meet a single objective. Each regional program is described in general terms in the following section. More detailed descriptions of current programs are given in the individual site visit reports (appendixes I through IV). The order of presentation is the order in which the site visits took place.

ATLANTIC SOUTHEAST REGIONAL OCEANOGRAPHY PROGRAM

The Atlantic Southeast Program, the newest of the four regional programs, has the most concise and focused research plan. Almost all research prior to 1983 focused on the South Atlantic Bight, specifically the interaction of the Gulf Stream with mid- and outer-shelf waters. As a result, the physical, biological, and chemical consequences of Gulf Stream intrusions have been well described. The physical circulation of the area has been so well described that it serves as the basis for biological and chemical studies. The role of upwelling of deep Gulf Stream waters in the nutrient cycle of the South Atlantic has been described and shown to be of major importance. The Southeast group has recently initiated studies of the importance of river discharge and other inner-shelf processes in the transport of pollutants in this region. Chemical studies of the concentration of metals in the coastal zone have provided a model for understanding the fate of pollutants, including radionuclides, along this energy-impacted coast.

The understanding of the shelf ecosystem gained by this coordinated study serves as a model for DOE programs.

ATLANTIC NORTHEAST REGIONAL OCEANOGRAPHY PROGRAM

The Atlantic Northeast Program has both highly-focused coordinated research efforts and somewhat less coordinated but relevant individual projects. The central problem being studied by the Northeast group over the next 10 years is the transfer pathway and rate for particles moving across the shelfbreak front in the Middle Atlantic Bight area. Plankton or organic particles are the primary study objects, because pollutants would follow the same pathways. The hypothesis being tested is that the sediments of the upper continental slope are the final repository of marine organic and inorganic particles and their associated energy by-products. The group is using an extensive array of moored current meters, thermistors, fluorometers, and sediment traps to quantify the seaward

movement of particles. The research plan calls for a multidisciplinary effort involving physical oceanographers, geochemists, biological oceanographers, and modelers. The research plan is well-documented in the "DOE Northeast Ten Year Plan." The following information, summarized from that document, describes the scientific objectives of the Northeast group:

A. to define the structure, variability, general circulation and exchange of and between shelf and slope waters;

B. to determine the processes that govern the production, transformation, and fates of biogenic particles as a function of nutrient pools, grazing procedures, reasons; and

C. to estimate the source terms, horizontal and vertical fluxes of dissolved and particulate species, and partitioning between these phases across the shelf/slope front and beyond to the waters of the continental slope and upper continental rise. Fluxes across the sediment-water interface and sediment mixing rates would also be evaluated.

The driving force of this program is the need to provide a scientific basis for dealing with the energy-related materials which are being produced in the highly populated Northeast. Many of these materials are discharged into coastal waters. The core of the program is to be able to predict their movement and fate.

PACIFIC NORTHWEST COASTAL OCEANOGRAPHY PROGRAM

The Pacific Northwest Program is the oldest of the four DOE programs reviewed. Radionuclide transport, uptake, and reactivity were subjects of much of the early work. The current projects together constitute a program to study the coastal ecosystem. The purpose of the program's biological studies is to provide a fundamental understanding of the processes governing the communities of organisms in the water column, on the seabed, and in the surf zone of the region. Of special concern is the identification of the natural variability in the production, distribution, and numbers of organisms.

Sustained effort is being made to discover the factors and processes that regulate biological production and give rise to the natural variability. Research sites include the surf-zone, mid-shelf sediments, and the water column. Projects on bacteria, phytoplankton, surf-zone plants and animals, models, zooplankton, fecal transport, and animal/sediment relationships are active. Reasonable progress is being made, but coordinated research involving chemistry and physics directly with biology will be more productive in the future.

Efforts are under way to characterize chemically the organic and inorganic inputs from the Columbia River and to study the sinking dynamics of particles and determine their chemical constituents. Petroleum and non-petroleum hydrocarbons are being characterized and a source sought. Plutonium and lead are being used as radiotracers to provide a time frame for local transport processes. The chemical research is well developed and can be quickly integrated into future programs.

The physical oceanography program has two components, circulation and sediment transport. Valuable insights into submarine canyon circulation off Washington have been made. Work on shelf circulation, especially in association with coastal upwelling and coastal-trapped wave propagation, is very useful for coastal ecosystem modeling. The group plans to continue investigations of sediment dispersal via submarine canyons and to reinitiate basic studies of mid-shelf sediment transport dynamics under the Columbia River plume.

SOUTHWEST REGIONAL OCEANOGRAPHY PROGRAM

The Southwest Regional Program has focused primarily on oceanic food-chain dynamics and in recent years, the biological oceanography of the Southern California Bight. The biology of the water column has been well-studied and the scientific group has wide experience in the distribution and abundance of diverse marine life including bacteria, phytoplankton, micro-zooplankton, zooplankton, and larval fish. This program has introduced many new isotopic, chemical, and biochemical techniques into biological oceanography.

Chemical and geochemical research is fairly broad within the Pacific Southwest Program (PSW). Organic geochemistry, including petroleum pollution, natural gas and petroleum generation, and stable isotope ratio variations, are well developed and productive. The group has made several significant advances in nutrient chemistry and sea water chemistry of selected elements in the ocean environment.

The PSW Program is currently planning to study coastal transport processes in the deep basins off Southern California. The goal of this work is to understand the transport of energy-related material to and from the basins and to evaluate the vertical transport or sinking of material. Preliminary work has been done to construct a carbon budget for the basin. The relationship between pollutants and organic particles (sinking or not) has been identified as a major problem for this highly-populated coastline.

Chapter 3

PROBLEMS AND OPPORTUNITIES

During the course of our review, we considered both the administrative and scientific aspects of DOE's Regional Oceanography Program. Each of the regional programs has a great deal in common with the others. They are all concerned with the introduction of materials into the ocean environment from energy-associated activities; the physical transport of those materials in the water column; their modification by chemical and biological processes; their uptake by organisms and particles; and their ultimate removal from the coastal waters by sedimentary processes, physical transport into the deep sea, or return to man through the food chain.

This commonality and the fact that an understanding of the total process requires the active participation and cooperation of scientists from each of the ocean science disciplines--physics, chemistry, biology and geology--plus consideration of the social, political, and legal aspects of the problem, has led us to a number of recommendations for improving both the regional components and the national program.

ADMINISTRATIVE ASPECTS

At the regional level, the interdisciplinary nature of the research requires strong teamwork. This approach is needed in planning research, carrying out field and laboratory experiments, developing conceptual and quantitative models, reducing and interpreting research results, and presenting the findings in a variety of publications and forums. We believe the best way to ensure such teamwork is to establish an executive council in each region, chaired by a leader, agreed upon by the participating scientists, who would be the spokesman and coordinator of the regional program.

At the national level, the DOE administrators and program managers have supported a research program which has resulted in an outstanding publication record of the scientists. However, we have identified several administrative procedures that we believe would

strengthen the program, especially in the face of funding levels only marginally adequate to meet DOE's objectives in its Regional Oceanography Program. Our recommendations concerning those procedures follow:

NATIONAL PLANNING AND REVIEW

DOE should appoint an advisory committee made up of knowledgeable scientists and individuals representing coastal communities and regional bodies most affected by energy-related materials in the marine environment. The advisory committee would assist DOE in planning the broad policies and perspectives of the program and help ensure that all important problem areas are identified.

In addition, a review panel should be established to assist the DOE program managers in reviewing research proposals from the regions. The review panel should use mail reviews of experts on the individual disciplinary parts of the proposals. The review panel would assist the DOE program managers in ensuring appropriate disciplinary balance and interaction within each regional program. It would also help ensure that each task in a proposal is essential to meeting the objectives of the program and that no critical areas of needed research are overlooked.

MANAGEMENT

DOE program managers should organize a consortium of representatives from each regional executive council (the coordinator in most cases) to help make the most efficient use of limited DOE money through sharing of scientific talent, equipment, and methodology, and through judicious scheduling of field programs to permit such sharing. For example, in some cases it would benefit individual programs and DOE collectively to exchange personnel and equipment during certain phases of research. This could be facilitated by staggering the field efforts of the different programs. The consortium could allocate the collective ship time rather than leaving each program with the difficult task of deciding how much money to allocate for ship use and how much for other needs. This sort of central administration could extend also to the use of DOE equipment, such as current

meters, sediment traps, and moored fluorometers. The reduction in overall costs would help the regional programs regain some of the purchasing power and flexibility to seek new initiatives they have lost in recent years.

Also, DOE should consider using rotators, who would be brought into Washington under the Intergovernmental Personnel Act, to help manage the programs. The use of bright, young scientists in this manner would bring new ideas and methods to the program.

DOE should also recognize that it has teams of scientists with outstanding expertise in a variety of oceanic processes available to it. Recognition and utilization of these teams in the regional programs would ensure cross fertilization of ideas and provide an important source of competence. The following teams are available now:

- 0 bottom boundary layer and sediment transport dynamics
- 0 coastal boundary layers
- 0 circulation studies
  - current measurements
  - physical and chemical hydrography
  - particle fluxes
- 0 plankton biology

Concerning duration of projects, DOE should continue to support research on a long-term basis: three-to-six years is reasonable for attacking the kinds of problems addressed by DOE. Of course, as programs evolve, it will be necessary to drop some investigators from the program and add new ones as understanding of oceanic processes evolves. Also, contract awards should be made for a two-to-three-year period wherever possible to reduce the time consumed in preparing and reviewing proposals.

COMMUNICATIONS

While reviewing the four regional programs, we concluded that communications between DOE and the programs, and between each of the regions, should be improved. We concluded that the general public and individuals and other organizations in positions to both use the results

of the programs and support them are not being adequately informed about them.

Establishing a consortium of regional executive councils as recommended above would do much to ensure communication between DOE and the regional programs. In addition, each regional program should publish a booklet similar to the one produced by the Atlantic Southeast Region in 1981. The DOE should consider publishing a similar document summarizing the overall national program. Workshops involving principal investigators from all regions should be organized to provide a forum to discuss scientific and experimental problems and results on both a disciplinary and an interdisciplinary basis. Many of the processes being studied are common to all four regions.

At a time when use of our coastal lands, ports, and waterways for energy-related activities is increasing rapidly, a strong research program to ascertain the nature and magnitude of impacts of these activities must be initiated. Both the land-sea boundary and the shelf-open ocean boundary need attention. It is unrealistic to presume that DOE could underwrite all of the essential research on these topics. The scientists supported by the regional programs often have obtained support from other sources to augment certain projects. Support from other agencies should be encouraged, but the base of support from DOE must be substantial enough to remain dominant and to ensure appropriate focus of the program.

FUNDING LEVEL AND SCOPE

We recognize the budgetary constraints faced by DOE in the present economic climate, but we would be remiss if we failed to comment on the inadequacy of current levels of funding for the research effort needed to meet the objectives of the regional oceanography programs.

Funds for each of the ongoing regional programs are inadequate, especially in the Northwest Region, where increased support is needed for geology and physical oceanography, and even more so in the Southwest Region, where geological studies are very weak and physics is almost totally lacking. The committee estimates that an additional $2.0 million per annum will be needed to correct these deficiencies.

Furthermore, the need for regional oceanography projects in other geographic areas, such as the Gulf of Mexico and Alaska, should be examined by DOE in the light of population growth, increased energy-related activities, and the research programs of other agencies. If the needs are identified, appropriate oceanographic research programs should be developed and funded. Costs are estimated at $0.5 to $1.3 million per new region.

PHYSICAL SCIENCE OPPORTUNITIES

Physical transports play a major role in linking sources and sinks associated with energy-related materials introduced into the coastal ocean. They take place through mean and transient advection and through turbulent diffusion processes. Physical transport variability occurs on a wide range of space and time scales which can be understood and modeled in terms of contributing and dominant processes. In the interior of the water column, physical transport is dominated by advection, while turbulent diffusion is relatively more important in the surface, bottom, shore (coastal), and shelfbreak turbulent boundary layers. Some of the key advection processes, and their approximate space and time scales relevant to coastal transports are summarized below:

process	space (km)	time (days)
tides		
surface	100 to 1,000	1/2 to 1
internal	100	1/2 to 1
wind-driven transient circulation	100 to 1,000	2 to 20
boundary current meanders & mesoscale eddies	50 top 300	10 to 30
air-sea transfer of heat, mass & momentum	10 to 1,000	0.1 to 1
seasonal atmospheric forcing	1,000	365
interannual variations in atmospheric forcing	1,000	>365
river run-off	10 to 100	10 to 1,000
gravity waves		
surface	10^{-3} to 10^{-1}	10^{-4}
internal	1 to 10	10^{-2} to 10^{-1}

The above table provides some background for appreciating the importance of long (multi-year), rapidly sampled ($\leq$ 1 hr) time series of physical variables (velocity, pressure, temperature, salinity, winds, etc.) at several locations in coastal regions of concern. From such observations, insight is provided into the natural variability of physical transports. Similarly, synoptic (spacial) maps of key variables help to provide understanding of the spatial structure of physical transport processes and their subsequent time evolution. Modern instrumentation makes feasible such time series and synoptic mapping measurements.

Numerical modeling of space-time variable physical transport in the coastal ocean has shown considerable

progress in recent years. Such modeling serves to provide insights into the important physical processes in a region and to help test conceptual ideas, to help synthesize inevitably limited field observations, to identify the need for critical measurements, and to make sensitivity and simulation studies. Numerical models also provide a quantitative framework useful for relating biological, chemical, and geological transports to physical transport. There is a great opportunity here for DOE to assert scientific leadership in evolving this scientific strategy, which would be intrinsically interesting and would produce important results that could be used directly by the strongly applied agencies involved in coastal ocean pollution monitoring and environmental impact assessment.

A challenging aspect to observing and modeling physical transport processes is the influence of special bathymetric provinces in the coastal ocean. For example, the effect on circulation and turbulent mixing of coastal capes and bays, submarine banks and basins, submarine canyons and capes, and estuarine, riverine, and coastal lagoon interactions with the shelf waters are only partially understood. Yet these bathymetric provinces often play a critical role in the pathways for the exchange of materials. Hence, there is a special scientific opportunity for DOE programs to elucidate the influence on physical transports of such bathymetric anomalies as they occur and have a predominant influence in the various coastal regions.

GEOLOGICAL SCIENCE OPPORTUNITIES

Studies of the fate of radioelements or any substance introduced into the ocean must include consideration of the sediments since these are the ultimate sink for most substances depending on the degree of partitioning and the rates or fluxes between water and substrate. Organisms are a primary factor since they either serve as collectors and carry elements to the bottom as parts of either organic matter or hard parts, or in the process of reworking and mixing sediments may aid in release or uptake of elements in the surficial sediments.

Another factor must be the general geological setting for a given margin. In the examples of the east and west coasts of the United States these basic differences are extreme since the former is a passive margin and the latter is an active margin in the tectonic sense. Morphology, which reflects tectonic conditions, is different; the east coast margin is one of broad shelves, slopes, and rises while the west coast margin is typified by narrow shelves, steep slopes, and marginal trenches or borderlands.

Coastal drainages differ; east coast streams are low-gradient, low-discharge sources of dominantly fine sediments, which characteristically are dumped into estuaries. West coast streams are of steep-gradient, seasonally high input of relatively coarse grained sediments, which deliver loads directly to the open ocean shelves. Thus the problem and opportunities differ on each coast and between regions on each coast.

We can summarize the opportunities as follows with the appropriate region identified for each:

1. The Southeastern Region will be concentrating research on the inner-shelf zone in which fine sediments are actively accumulating and shifting in response to wave and tide. A problem of interest is the question of net sediment flow. Is the flux towards the estuaries from both ocean and river, or is it periodically directed to sea?

The fine sediments are carriers for metals, and ions will exchange depending on the chemistry of the depositional environment, saline or fresh water. This question is still controversial and a detailed oceanographic-biologic-sedimentologic sampling program can provide answers to its question.

2. The Northeastern and Northwestern regions share some aspects of the same intriguing sedimentologic problem. Both have central-shelf mud belts that are dynamic deposits through which fine sediments seasonally or at other frequencies cycle from river discharge to offshore slope or submarine canyon depositional sites. The rate of this flux and the factors that control the flux are basic questions for both regions since, again, the fine sediments are important carriers for introduced radioelements, metals in general, and organic compounds.

All of these may be absorbed on the active clay surface depending on chemical environment.

3. The Southwest Region is one in which the depositional centers are marginal deep basins. Some of these are anoxic and provide essentially continuous depositional records in which the primary seasonal laminations are preserved making possible long-term analysis of the variation in content of introduced elements or compounds that find a sink in the accumulating basinal sediments. This region is one in which concentrated episodes of sediment delivery occur at decade or generational intervals. This contrasts with annual events in the other regions.

4. A major fault in many geochemical studies is that they are typically "one-dimensional." No analysis is made of the associated sediment texture, fabrics, and sedimentary structures. Yet many element concentration gradients are primarily texturally controlled and specifically related to the clay content of a given sediment. Additionally, sediment structures yield information of the degree of post-depositional reworking or of the primary depositional mechanism which may be more or less continuous particle infall or may be a rapid mass depositional event from mass movement or strong high-concentration flows.

5. The sedimentary class of greatest concern in these studies are the fine particles of silt and clay. Clay minerology is an important control on the exchange properties of clays. All of these particle size classes are carried as suspension load in the ocean and thus the physical oceanography drives the sediment dispersal and recycling system. It is evident that the sampling of the suspended load must be done in close conjunction with the water sampling and circulation studies.

6. Benthic populations are a primary mixer of deposited surficial sediments. Study of the sediment substrate must be done hand in hand with benthic biological studies. The fine particulates are actively screened and aggregated by planktonic organisms that filter or screen the water for food particles, capturing mineral particles in the process. These aggregation processes are the principal reason for the rapid fall out of even fine sediments from margin waters, and thus planktonic sampling designs must include provisions for

sampling of fine ambient suspended load as well as rapidly through-falling aggregates of fine particles. Therefore both sediment trap, and point large volume water sampling will be necessary to adequately characterize the fluxes of particulates to the bottom.

7. Mass budgets of fine particulates must be developed in each region in order to adequately evaluate the fluxes of all parts of the ocean margin system. The integration of physical, biological, and chemical studies with sedimentologic studies provides an ideal framework for producing answers to some basic questions concerning the rates and pathways of fine particulates as they pass from source to ultimate depositional sink. These opportunities should not be missed, nor can quantitative answers be given unless all parts of the system are included.

BIOLOGICAL SCIENCE OPPORTUNITIES

The DOE needs quantitative information relative to the biological transport of chemical elements and compounds through coastal food webs if the impacts of energy-associated pollutants on food webs of importance to man are to be assessed. The biological research needed to assess these impacts will vary regionally and perhaps can best be prioritized by numerical modeling. Several examples of important general biological research areas, which the review panel has identified, are as follows:

1. Many opportunities exist for researching the role of individual trophic-level water column and benthic micro- and macro-organisms in transporting natural materials and pollutants through coastal food webs that impact man.

2. The DOE regional oceanographic program provides an opportunity to study nutrient cycling and trophic-level production processes associated with important transient processes in coastal systems (e.g., coastal upwelling, turbulent tidal and wind mixing, freshwater discharge, resuspension, and transport of sediments).

3. The relative toxicity of certain pollutants and various natural materials delivered or intensified in concentrations by man's activities to coastal systems is required, and the DOE Regional Oceanographic Program provides the opportunity to examine the toxicity and the important biological, chemical, and physical processes that regulate the transfer of such materials through coastal food webs of interest to man.

4. Outside current DOE regional programs, few opportunities exist for acquiring the time and space scale biological and interdisciplinary oceanographic data needed to assess the natural variability of biological, chemical, and physical processes in coastal environments. These programs have provided the opportunity to acquire the information needed to distinguish natural system biological variability from man-caused effects. Few other agency research programs afford scientists with the opportunity to acquire their data on the correct temporal and spatial scales that are required to assess mans impact on coastal environments.

CHEMICAL-GEOCHEMICAL SCIENCE OPPORTUNITIES

The opportunities for chemical-geochemical research derive from the need to understand and assess the releases, transport, and fate of energy by-products. The relative proportions of various energy by-products differ from region to region. For example, there is a large and traceable tritium release in the Southeastern Region, whereas petroleum hydrocarbons are the most important by-product in the Southwest Region and perhaps in the Gulf of Mexico and Alaska. All regions have contributions from nuclear power plants and pyrogenic products from coal and oil-fired power plants. In petroleum producing regions, i.e., the Southwest and Gulf Coast regions, inorganic constituents from drilling activities may also be important. While some problems can be solved by purely chemical studies, many of them require an understanding of physical transport and biological transfer mechanisms.

One of the major research opportunities for regional studies is to identify and quantify the source of materials that are potential pollutants in coastal waters. Nuclear materials from power plant and ship releases merit study. Pyrogenic hydrocarbon releases from coal are significant sources in some regions. Petroleum hydrocarbons are potential pollutants in all regions.

Specific studies need to be done on the following:

- the chemical nature and mechanisms of decomposition or loss of simple aromatic and polynuclear aromatic hydrocarbons
- the level of and transport pathway of plutonium in coastal systems
- the role of particles in the transport of chemical pollutant away from land and into marine sediments
- the interactions of organic matter with inorganic substances such as metals with humic organic matter and
- the determination of whether organic residues are transported in a different manner and at different rates from inorganic and radionuclide energy by-products.

It is clear that energy by-products or potential pollutants cannot be studied as isolated substances. The geochemical cycles of natural, but related elements and compounds must be studied in order to even estimate the impact of man-released substances.

Continued advantage should be taken of the continuity provided in allowing the inventory of energy by-product distribution on long-term temporal and spatial bases.

In summary, the need to understand the transport of energy by-products in coastal waters can be matched to key research opportunities. These opportunities overlap biology, chemistry, geology, and physics so that they are well answered by multidisciplinary, regional marine programs.

APPENDIX I: SOUTHEAST REGIONAL PROGRAM SITE VISIT REPORT SUMMARY

National Academy of Sciences Committee to Review Department of Energy Regional Oceanography Program, September 21-22, 1982, Savannah, Georgia.

Committee members attending were Bob Beardsley, John Goering, Donn Gorsline, Feenan Jennings, Chris Mooers, Par Parker and Bill Sackett. Bill Forster, Department of Energy, also attended. Committee members absent were: Jim McCarthy, Charles Hewitt, and Philip LaMaoreaux.

The site visit involved presentations to the committee by the principle inviestigators of the Southeast Regional Oceanographic Program in the results of their invistigations to date and the plans for further research during the coming two-to-five years. In addition, individual Committee members met with individual principal investigators in their respective scientific disciplines to learn more about the details of each project.

The following are the principal investigators present at the meeting:

D. Menzel, Skidaway, program coordinator
J. Blanton, Skidaway, physical oceanography/meteorology
L. Atkinson - Skidaway, hydrography/nutrient chemistry
T. Lee, University of Miami, physical oceanography
L. Pietrasfesa, North Carolina State University, physical oceanography
H. Windom, Skidaway, trace element geochemistry
D. Hayes, Oak Ridge National Laboratories, transuranics and tritium
L. Pomeroy, University of Georgia, microbiology
J.A. Yoder, Skidaway, phytoplankton
G. Panhoffer, Skidaway, zooplankton

From the committee's viewpoint the site visit was very successful. The presentations were well done and Dave Menzel's arrangements for the visit were just fine

in all respects. We are grateful to him and the program scientists who participated in the presentations and discussions.

The purpose of this memorandum is to summarize the findings, conclusions and recommendations of the Committee concerning the DOE Southeast Regional Oceanographic Program following our site visit.

A summary of all of our views is presented in the following paragraphs. The details will be found in the individual team member reports on file in NAS Board on Ocean Science and Policy:

1. The Southeast Program is well designed to understand most of the major physical, chemical and biological processes which must be known if the impacts of energy-associated pollutants on this shelf are to be assessed.

2. The scientific content and productivity of the program are excellent. The individual investigators are all highly competent, and the strong interactions between physical, chemical and biological scientists is impressive. The monograph now in review will be a major contribution to oceanography.

3. The balance of efforts between scientific disciplines appears both very good and appropriate for the program thus far. But a shift toward benthic biological studies and geology will be needed now that the emphasis is shifting to waters nearer the coast.

4. The operational aspects of the program are outstanding. The committee was impressed by the team's decision to attack the difficult physical oceanography early during the program in order to provide a suitable knowledge of circulation of the region. Their decision to now move inshore is appropriate and laudable. And their successful efforts to acquire ancillary funding from other Federal Government agencies to strengthen their research has been a real asset. Dave Menzel's leadership as scientific coordinator has been outstanding.

5. No significant deficiencies in the science of any of the individual projects was noted. Some suggestions for strengthening several of the projects are presented in the detailed site visit reports in the BOSP files.

6. In conclusion, the committee makes a number of recommendations for strengthening the program as it now begins to move into its next phase. These are summarized as follows:

a) As planned by the Southeast Regional Team, the nearshore region of the shelf should now receive major program emphasis. In this connection, water column, benthic and water-sediment studies should be emphasized. Geological studies will be necessary.

b) As this shift in emphasis takes place, a post doctoral program should be initiated to fill the needs in organic geochemistry, benthic biology, physical modeling, and especially in geology-sedimentology.

c) Stronger modeling programs in physical, chemical and biological studies should be undertaken, with an ecosystem model as a goal.

d) The longer term research objectives should be better defined, prioritized and scheduled on the calendar, even if very approximately.

e) The public relations booklet should be updated, made more accurate and informative, and widely distributed.

APPENDIX II: NORTHEAST REGIONAL PROGRAM SITE VISIT REPORT SUMMARY

National Academy of Sciences Committee to Review Department of Energy Regional Oceanographic Program, October 28-29, 1982, Long Island, New York.

Committee members attending were Bob Beardsley, John Goering, Donn Gorsline, Feenan Jennings, Jim McCarthy, Chris Mooers, Pat Parker and Bill Sackett. Bill Forster, Department of Energy, also attended. Committee members not attending were Charles Hewitt and Philip LaMoreaux.

The site visit involved presentations to the committee by the principal investigators of the Northeast Program on the results of their research to date and on their plans for a joint research effort on Shelf Edge Exchange Processes (SEEP) which will guide the Northeast Regional Program during the next ten years. In addition to the presentations, time was available for discussions on a disciplinary basis between the individual members of the committee and the individual principal investigators. In addition Pat Parker, Bill Sackett and Freenan Jennings met with Derek Spencer of Woods Hole on the evening of October 27th to discuss his subprogram.

From the committee's viewpoint, the site visit was very successful. We are particularly grateful to Pierre Biscaye for organizing the presentations in exemplary fashion and to John Walsh for hosting the visit. The presentations and the investigators who made them are as follows:

General & Biological	Walsh
Physical	Csanady
Geochemical	Biscaye

<u>Processes Associated with Water Masses</u>

Hydrography - Frontal Structures	Gordon Houghton Hopkins
Hydrographic Tracers	Fairbanks Csanady Ou

Processes Associated with Particulate Matter

Primary Productivity/Sediment Pigments	Falkowski
Pigment Fluxes and Diagenesis (water column)	Marra
Nutrients	Whitledge
Moored Fluorometers	Wirick
Zooplankton	Smith
	Stepien
Bacterial process	Ducklow
Particle fluxes	Rowe
Tracers - Water column	
Radionuclides	Li
	Bacon
	Livingston
	Turekian (Cochran)
Organics	Bopp
Tracers - Sediments	
Radionuclides	Sholkovitz
	Cochran
	Biscaye
SEEP Summary	
Physical	Gordon
Geochemical	Bacon
Biological	Walsh

The purpose of this memorandum is to summarize the findings, conclusions, and recommendations of the committee concerning the DOE Northeast Regional Oceanographic Program, following the October 28-29, 1982 site visit.

The committee's findings, comments and recommendations are summarized as follows:

1. The energy produced or transported into the U.S. North Atlantic Coastal Region to serve the needs of it 45 million inhabitants results in a stress on the coastal environment which must be evaluated and minimized to ensure that the quality of the ecosystem is maintained.

The DOE Northeast Regional Oceanography program is designed to provide this understanding.

2. The principal investigators in the Program have good stature in the scientific community and represent both breadth and depth in their expertise and capabilities. They have excellent publication records.

3. The Shelf Edge Exchange Processes (SEEP) Experiment is still in the early stages of development (The principal investigators have only met once as a group to discuss it.) The DOE should not commit itself to support of SEEP 2 or 3 until SEEP 1 has been completed and the principal investigators have demonstrated that they can work together effectively, beneficially and productively.

4. The design of SEEP-1 should be carefully considered from a number of viewpoints:

a) The physical program is relatively strong in mid-water column mass and circulation studies, but it is relatively weak in surface and bottom boundary layer dynamics.

b) The near bottom passage of nepheloid layers should be observed. It seems important to arrange sediment traps to cover the near-bottom path from the central shelf (the "mud belt") to the shelf edge and from there to the bottom seaward of the shelfbreak.

c) It may be possible to extend available DOE funds and equipment for SEEP-1 by enlisting participation of exiting National Data Buoy Center platforms and Coast Guard lighthouse installations for the meteorological network.

d) The modeling aspects of SEEP-1 should be strengthened. A more significant circulation modeling component should be developed, perhaps using exiting models such as the Mellor and Blumberg Model of the Mid-Atlantic Bight and an atmospheric forcing analysis subprogram. In addition, the commitment to work toward a conceptual ecosystem and abiotic transport model should be increased. Quantitative ecosystem modeling should be more fully explored.

5. With regard to the balance of disciplinary expertise in the Program several points should be made.

a) The transport of material in the bottom boundary layer is very important as are the processes responsible for resuspension and reworking of sediments on the bottom. The assistance of a sedimentologist will be required in the SEEP series of experiments.

b) The biological effort should be expanded to fill at least two large gaps in the current effort: benthic metabolism and nutrient cycling. The first will be important in determining the residence time of organic carbon that reaches the bottom. As indicated in the Walsh et al. hypothesis regarding the fate of organic particles produced over the shelf, a complete understanding of this phenomenon requires quantitative knowledge of the path of nitrogen in this system.

6. The management structure of the program is still diffuse and ill-defined in spite of the participation by first class scientists. The present leadership is provided on a laboratory basis which may ultimately prove destructive to the program. The committee recommends establishment of an Executive Committee structured along disciplinary lines. They should have the responsibility and authority to set goals, change direction, coordinate multi-disciplinary studies, and alter the principal investigator set.

7. Finally, the DOE should make arrangements to coordinate the work of the Northeast Regional Oceanography Program with the work of the other DOE Regional Oceanography Programs, especially the Southeast Region for the purpose of:

a) The temporary use of instruments and equipment from other regional programs;

b) The exchange of ideas, models and analytical techniques; and

c) The arrangement of periodic scientific communications (planning and interpretation) on an intra-regional basis and on a national basis.

APPENDIX III: NORTHWEST REGIONAL PROGRAM SITE VISIT REPORT SUMMARY

National Acadamy of Sciences Committee to Review Department of Energy Regional Oceanographic Program, December 2-3, 1982, Seattle, Washington.

Committee members attending were John Goering, Donn Gorsline, Philip LaMoreaux, Jim McCarthy, Chris Mooers, Pat Parker, and Bill Sackett. Bill Forster, Department of Energy, also attended. Committee members not attending were Bob Beardsley, Feenan Jennings and Charles Hewitt.

Presentations on the Northwest Regional Program and the investigators who made them are listed as follows:

Introduction and Overview	Anderson
Contract Presentations	
Physical Oceanography/Sediment Transport	Hickey
Chemistry	Carpenter
Biology	Landry
Research Perspectives	Landry
Investigator Presentations	
Physical Circulation	Hickey
Surf Zone Model	Winter
Surf Zone Biology	Lewin
Factor Analysis/Bacteria	Perry
Phytoplankton/Nutrients	Dortch
Methods/Models	Banse
Zooplankton	Landry
Fecal Transport	Lorenzen
Chemistry	Carpenter
Animal/Sediments	Jumars
Sediment Transport	Nowell
Sediment Transport	Smith

1. The Northwest Regional Oceanographic Program, the oldest of all DOE programs, has had success in addressing scientific problems relevant to DOE's objectives, perhaps most notably the earlier Columbia River plume radionuclide transport studies and the mid-shelf sediment transport dynamic studies.

2. The current program consists of a multidisciplinary group of about twelve scientists involved in a cooperative program in which there is modest interaction. This was apparent from the presentations and from the lack of co-authorship on publications. The research projects described by about half the participants were basic studies not necessarily directed to the Northwest region. The sharing of ship time once a year was the most evident element of cooperation.

3. The current program has clearly lacked focus, however such focus may be provided in the future by possible programs to explore the Juan de Fuca upwelling center/eddy and to study the transport of mid-shelf fine sediments off Washington. (The Program did not present a clear set of scientific objectives or experimental designs for either study.)

4. There is insufficient awareness, coordination, and cooperation between the Northwest Regional DOE continental shelf studies and the oceanographic studies being conducted by other Federal Agencies such as NOAA (PMEL and NMFS) and NSF in the Northwest region.

5. Most of the deficiencies identified by the Panel appear to stem from the lack of adequate leadership at the regional level and from lack of adequate guidelines from DOE at the national level. The regrettable lack of knowledge of energy-related activities in the Northwest demonstrated a further example of leadership shortfall.

6. The Committee makes the following general recommendations:

a) The Program should focus its efforts on two new studies discussed by a number of principal investigators during the site visit.

One study involves the summertime upwelling/eddy phenomenon adjacent to the mouth of the Strait of Juan de Fuca. An understanding of the circulation, sediment transport, and biological and chemical distributions in this location is extremely important, as this will probably be the region most impacted by future energy-related activities.

The other study involves an update and extension of earlier work on the transport of mid-shelf fine sediments off Washington to obtain a more quantitative understanding. These sediments carry much of the particulate matter discharged by the Columbia River and through the Strait of Juan de Fuca. The midshelf silt beds are the centerline of the major bottom fishery for the West Coast and underlie substantial pelagic fisheries as well, thus constituting likely pathways for the concentration of byproducts returned to man.

Both of the studies require the participation of physicists, chemists, biologists and geologists in the planning and conduct of field work, and in the analysis and interpretation of the resulting data. They provide excellent opportunities at the planning level to ensure that the needs of each discipline are identified and that the needs are met in the most effective way.

Both studies also involve processes which are both perculiar to, and common to, each of the scientific disciplines. A quantitative ecosystem model would be desirable to provide the scientific bases for the studies. In the absence of such a model, it may be necessary for the physical component to take the lead responsibility for the design of the studies, with appropriate guidance from the other disciplines. Also, there should be a better linkage to the needs for studying particulate and dissolved chemical fluxes, sediment transport, and organism-sediment interactions. For example, the biological work, and particularly the sediment trap work, should be brought together with the physical work to provide a coordinated approach from the water surface to the substrate.

b) The use of more modern instrumentation, and the inclusion of additional or different scientific expertise, are recommended. The Committee believes that the principal investegator set will need to be restructured to undertake the types of studies outlined above.

c) The management structure of the Northwest regional program should be changed. An executive committee should be constituted with disciplinary representation. This committee should have the responsibility and authority to set goals, change direction, coordinate multidisciplinary studies within

the Program and with other agency sponsored research in the region, and alter the principle investigator set. As a result, it should provide for more adequate scientific communication and coordination.

d) Finally, DOE should make arrangements to coordinate the work of the Northwest Regional Program with the work of the other DOE regional programs, especially the Southwest Regional Program, for (1) the temporary use of instruments and equipment from other regional programs; (2) the exchange of ideas, models and analytical techniques; and (3) the arrangement of periodic scientific communications (planning and interpretation) on an inter-regional basis and on a national basis.

APPENDIX IV: SOUTHWEST REGIONAL PROGRAM SITE VISIT REPORT SUMMARY

National Academy of Sciences Committee to Review Department of Energy Regional Oceanographic Program, January 12-14, 1983, La Jolla, California.

Committee members attending were Bob Beardsley, John Goering, Donn Gorsling, Charles Hewitt, Jim McCarthy, Chris Mooers, Pat Parker, and Bill Sackett. Also attending were Bill Forster, Department of Energy and Dick Vetter, National Academy of Sciences. Committee members absent were Feenan Jennings and Philip LaMoreaux.

The site visit was conducted according to the format used at the three earlier reviews. Dick Eppley, Scripps Institutuion of Oceanography (SIO), served as group coordinator and opened the meeting with an overview which stressed the recent "Southern California Bight Studies." This was followed by individual presentations by the principal investigators listed below. Each principal investigator described his research, his relationship to the overall program and directions for future research. After these presentations, panel members met with small groups of program scientists based on scientific disciplines. In a final open session, progress and plans for a "Southern California Deep Basin Study" were presented by the following investigators:

M. M. Mullin, SIO, larval fish, zooplankton
J. R. Beers, SIO, microzooplankton
F. Azam, SIO, bacteria in food webs
A. F. Carlucci, SIO, bacteria and mineralization processes
R. W. Eppley, SIO, phytoplankton
C. R. Booth, SIO, instruments
P. M. Williams, SIO, chemistry
G. A. Jackson, SIO, physical modeling
E. Goldberg, SIO, chemistry & energy by-products
I. R. Kaplan, UCLA, hydrocarbons & stable isotopes
V. Noshkin, LLL, radionuclides
F. Harrison, LLL, metal toxicity

All presentations were well prepared and informative.

The following committee summary and recommendations are based on the scientific presentations, group and individual discussions, and the written evaluations from the committee membership:

1. The Southwest Regional Program is composed of scientists who are leaders in their fields. Their individual research has been excellent and their productivity first rate. The program has at times been highly organized and generally focused on food-chain dynamics. The PSW group is presently proposing a major study of coastal transport processes in the deep basins off Southern California. These basins located just beyond the very narrow continental shelf in this region are, with regard to particle flux questions, important geomorphic features not occurring in the other three continental margin regions where existing DOE programs are focused. The proximity of these basins to major urban centers, the large coastal and atmospheric import of energy-related byproducts, and the restricted exchange of deep water and sediment are particularly important features: the material that sinks below the sill depths will be exposed to a different physical, chemical, and biological environments and will have a very different fate than that of material deposited on the oxygenated benthic boundary layer of other shelf and slope sediments. The fundamental question to be addressed is whether any of these energy-related byproducts and other pollutants are mobilized in the sediment, incorporated in the marine food web, and returned to man.

The committee judged this Deep Basin Study to be potentially excellent in terms of basic scientific merit, relevance to DOE, and in physical location. DOE clearly needs to understand the oceanic influence and the fates of energy by-products from the Southern California region.

2. The present scientific group is strong in plankton biology and geochemistry/chemistry but deficient in physical oceanography and geological science. Since the transport of material into and out of the deep basins by both water column advection and sediment transport must be understood as an integral part of the proposed study, new scientific staff in physical oceanography and marine geology must be added to the group.

3. The management of new programs, like the proposed Deep Basin Study, should be vested in an executive committee representing all major scientific disciplines. The chairman of the Executive Committee should serve as the focus for principal investigator input, for internal review, for contact with DOE, for contact with the other regional DOE programs as well as the usual coordination activities. The committee feels that this higher level of managerial activity is necessary to strengthen the scientific focus and level of organization and coordination within the Southwest Program and should be supported by DOE.

4. The level of support which DOE provides the group accounts for roughly 25% of their total budget. State and other Federal Government grants account for the balance. The committee feels that DOE should increase the level of support if new and exciting programs like the Deep Basin Study are to be successful. This additional funding is needed to increase the basic support level of the existing scientific staff and also attract new investigators in other disciplines, like physical oceanography, marine geology, and benthic biology.

5. The Southwest Program review brought into sharp relief a situation which exists to some extent in all four DOE regional programs. This can be stated in two sentences. First, DOE is faced with environmental problems of a magnitude such that large, organized, multidisciplinary research programs must be fielded to deal with them successfully. Second, there are other problems which are best solved through the efforts of single investigators. The committee recognizes the value of both of these modes of research and urges DOE to continue support of both modes.