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PACIFIC MARINE ENVIRONMENTAL LABORATORY
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PREFACE

During FY-75 both the emphasis and the scope of Pacific Marine Environmental Laboratory (PMEL) were changed. The principal focus for current activities has become the development of programs associated with environmental impact assessment. Complementary research on various fundamental processes is continuing in order that there is sound background not only for these immediate assessments but also for future needs.

Stated in a generic sense, there are many questions associated with an activity that is planned to occur somewhere in the marine environment. The questions relate to the potential impact of this activity on the marine environment. Stated in a more specific sense, there are questions raised by the possible development of oil and gas on the outer continental shelf, by the possible increase in tanker traffic through the Puget Sound system, by the increased municipal waste discharged into Puget Sound, and by the planned mining of the deep ocean floor for manganese nodules. In each case, the impact of these activities is unknown and some estimates of kind and magnitude must be made.

Beginning early in FY-75 the existing PMEL staff prepared several proposals for work in the area of environmental impact assessment, and these efforts resulted in a marked increase in funds available to the Laboratory. A number of additions to the staff have been made, including a reasonable filling out of the formerly limited supporting staff.

In addition, the increased diversity of the program resulted in a decision to restructure the internal organization of the Laboratory. The former estuarine research effort was divided into three components: Modeling and Simulation Studies (MASS), Studies of Coastal and Nearshore Environment (SCENE), and Marine Life and Geochemical Studies (MARLAGS).

Section II of this report is organized according to the new project structure even though it was not formally established until the very end of FY-75.

At the close of the year, PMEL had a total of 78 employees (56 FTP) of which 68 are in Seattle and 10 are in Honolulu. A larger proportion of our staff is without graduate degrees this year than last year (19% Ph.D., 17% Masters, 36% bachelors, 28% other), reflecting the increase in support personnel.

We end the year located at four places in Seattle--the Showboat Apartments, the University of Washington Department of Oceanography, and Building 68 and the former control tower at Sand Point--and at the Hawaii Institute of Geophysics facility at the University of Hawaii. Short-term planning is underway for the development of interim laboratory and shop space at Sand Point, and longer range plans are being made for ultimate location of the Laboratory at the NOAA facility planned to be completed at Sand Point by 1979-80.

A. DEEP OCEAN MINING ENVIRONMENTAL STUDY (DOMES)

The DOMES project is concerned with potential environmental problems expected from the deep-ocean mining of manganese nodules (which also contain reserves of copper, nickel, and cobalt). The principal goal of DOMES is to identify these problems early enough to allow a timely response to the requirements of the National Environmental Policy Act with respect either to Law of the Sea negotiations or to domestic legislation concerning mining operations in international waters. In addition, the identification of these problems will aid in the development of guidelines for designing the equipment and devising the operational techniques for the future mining industry.

DOMES FY-75 Activities

Although the official beginning of the project will be in FY-76, work this year took place in three areas: planning, operations, and data workup.

Planning

In April 1975, a draft Technical Development Plan (TDP) was published. It describes the marine environment of the area potentially to be mined, and it discusses the way each type of mining system being developed by industry will encroach on the marine environment at and around the mining sites. The TDP examines the probable encroachment and develops relevant environmental impact questions. A "straw man" technical plan was devised on the basis of these questions. It includes 27 contract-size work units in specific areas of research such as zooplankton, phytoplankton, and water chemistry.

Following the release of the TDP, a workshop was held in Washington, D. C., on April 29 and 30 to obtain information for use in preparing DOMES requests for proposals. Representatives of universities, environmental groups, governmental agencies, and the mining industry attended. At the suggestion of the deep-ocean mining industry, the three sites chosen for investigation are typical and representative of bottom conditions in the areas potentially to be mined (fig. 1). They are:

Site	Location
A	8°27'N, 150°47'W
B	11°42'N, 138°24'W
C	15°N, 126°W

In May 1975, a letter was sent to universities aimed at securing proposals mainly for studies of the upper water column in order to permit an early FY-76 investigation of parameters known to be time-variable. Proposals selected for funding concerned phytoplankton and primary productivity, temporal and spatial distributions of zooplankton, DOMES Phase I Nutrient Program, the distribution and composition of suspended particulate matter, dispersion of waste sediments, documentation of historical cases of benthic smothering, supporting physical oceanographic measurements, and a review of existing information on fishes in and adjacent to the DOMES area.

Operations

Field operations took place from April 15 to June 6 within a 2-degree square centered near 15°N, 126°W from the NOAA Ship OCEANOGRAPHER. Personnel were from Lamont-Doherty Geological Observatory, City University of New York, U.S. Geological Survey, and NOAA's Pacific Marine Environmental

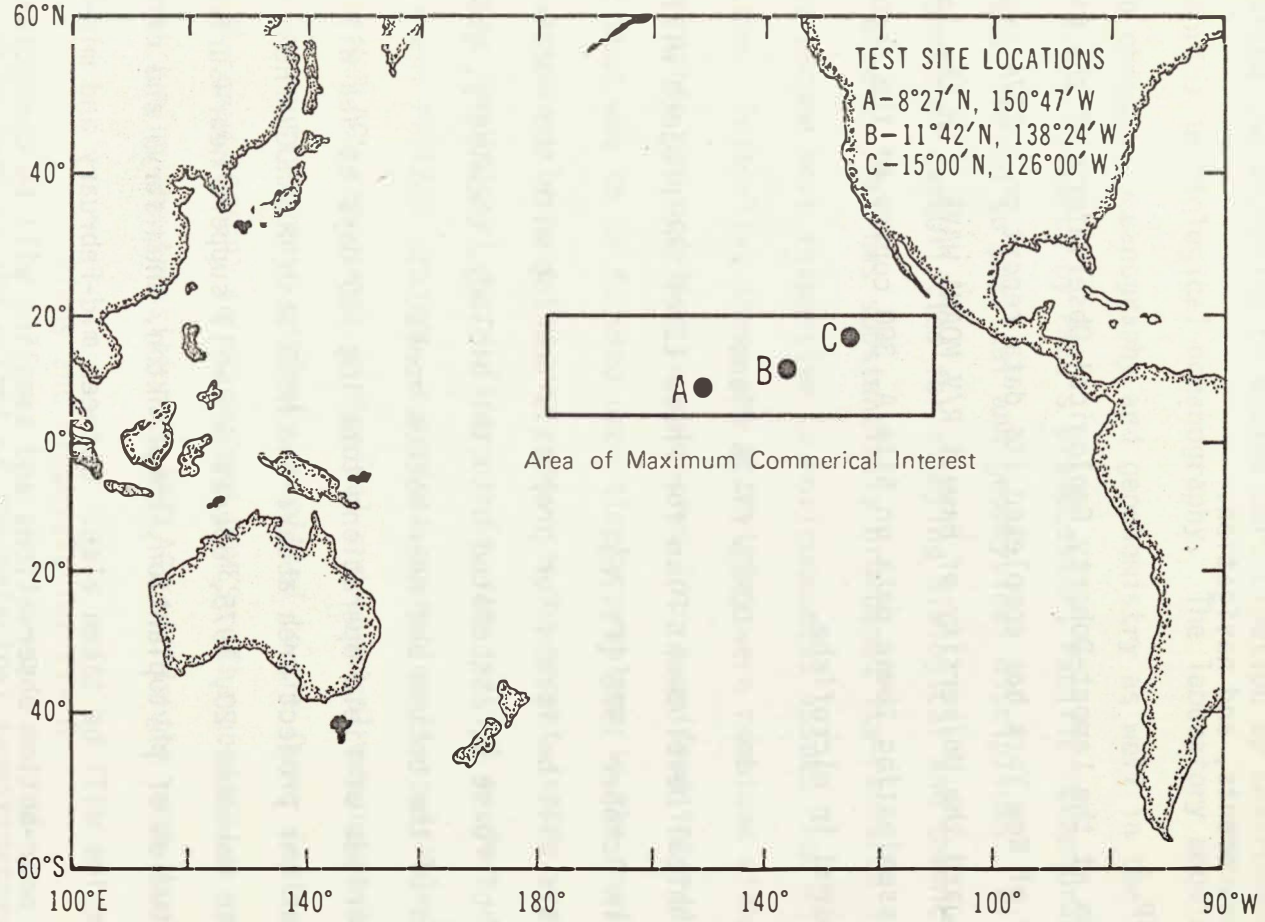


Figure 1. DOMES Study Sites

Laboratory. Also on board were working observers from Deepsea Ventures, Inc., and Kennecott Exploration, Inc. The resulting samples and observations pertained to benthic fauna assessment, water column characteristics, sediment characteristics, deep ocean currents, enrichment studies, bathymetric measurements, and navigation.

Data Workup

A team at the Lamont-Doherty Geological Observatory of the City University of New York has completed its data report on a 1974 cruise to Site A onboard the University of Hawaii R/V MOANA WAVE. In the interest of quickly disseminating these data on Site A, 300 copies of the report are being prepared in microfiche.

DOMES FY-76 Plans

A Technical Development Plan for Phase II of the project will be completed in October 1975 (FY-76).

Requests will be issued for proposals dealing with the remaining activities of Phase I, associated with the biology, chemistry, geology, and physics of the bottom and near-bottom zones.

Two periods of field operations totaling 160 days at sea will be conducted at the project area aboard the NOAA Ship OCEANOGRAPHER. From August 20 to November 20, 1975, operations will support near-surface seasonal studies of phytoplankton, zooplankton, chemistry, and circulation. Benthic samples will be taken also. Between mid-February and mid-May 1976, bottom and near-bottom observations and sampling will be conducted.

In August 1976, the DOMES project will publish a preliminary Phase I report including predictions of the effects of mining operations on the biology of the DOMES area.

B. MARINE LIFE AND GEOCHEMICAL SYSTEMS (MARLAGS)

The formation of Pacific Marine Environmental Laboratory (PMEL) in 1973 marked the beginning of active participation by Environmental Research Laboratories in biological oceanography. The laboratory acquired expertise in chemical oceanography and geochemistry as well in the following year. Prior research by PMEL's predecessor, Pacific Oceanographic Laboratory, was limited to physical and geophysical disciplines. With the development of capabilities for studying biological and chemical phenomena in the oceans, PMEL has substantially broadened its research interests and has become more responsive to environmental issues requiring Federal attention. Initially, these new activities were combined with physical oceanographic and modeling capabilities into a unified interdisciplinary effort that was to be focused upon timely problems in the marine environment. However, because program responses to recent issues were required in a more traditional disciplinary mode, the initial project evolved into the present MARLAGS project, a project operationally suitable for present needs. MARLAGS represents biological and chemical oceanographic efforts and is currently almost entirely committed to the Outer Continental Shelf Energy Program (OCSEP) in Alaska and DOMES. The activities reported here occurred during the transition to MARLAGS within the past year.

Plans and Proposals for FY-76

A major part of the effort of the principal investigators has been directed toward recruiting staff and toward planning. We contributed to the development of three major study plans: Draft Study Plan for the Environmental Assessment of the Gulf of Alaska, Southeastern Bering and

Beaufort Seas (January 1975); DOMES Technical Development Plan (April 1975); and a revised Project Development Plan for the Puget Sound MESA study. In addition, we participated in drafting a report of the Environmental Quality Monitoring Task Team Workshop sponsored by NOAA.

Various proposals for research integral to OCSEP and DOMES were prepared and accepted. These investigations comprise the major research effort planned for MARLAGS during FY-76. They include OCSEP proposals for investigating: (1) phytoplankton and primary productivity, (2) zooplankton, (3) suspended particulate matter, and (4) light hydrocarbon fractions. During the first year the emphasis will be on determining spatial and seasonal distributions and variability of the several parameters measured in Alaskan coastal waters. Subsequently, studies will focus on identifying ecosystem processes that affect the distribution of petroleum hydrocarbons and associated contaminants among planktonic and other populations, and on evaluating the effects of such contamination on whole populations. We will determine the distribution and composition of suspended matter in waters of the DOMES region.

Operational Capability

By participating in OCSEP and DOMES, MARLAGS will gain operational ability to measure a broad spectrum of biological and geochemical variables. Indeed, this development began during FY-75. A preliminary study was conducted in Puget Sound to determine the feasibility of using light-scattering measurements as indicators of suspended particle distributions in nearshore regions. We found a high correlation between suspended particle concentrations and light scattering when the physical and chemical

characteristics of the particles were similar from sample to sample. Variables measured in the suspended-matter studies include light scattering, weight of particles filtered from seawater, elemental composition determined by x-ray fluorescence, mineralogy determined by x-ray diffraction, and particulate organic carbon and nitrogen by gas chromatography.

The light hydrocarbons (C_1 - C_4 molecules) are good indicators of the presence of petroleum in ocean waters and are easier to measure than the higher-weight aliphatic and aromatic compounds. An analytical system for measuring light hydrocarbons at sea is nearly operational. In addition to determining the distributions of these compounds, we will examine the relationship of ethylene and propylene to primary production. Correlations between these variables have been observed elsewhere.

Primary productivity and the abundance and composition of phytoplankton and zooplankton over the Gulf of Alaska continental shelf region will be determined. The capabilities for obtaining this information are nearly operational. During a DOMES cruise in the spring of 1975, procedures for continuous flourometric measurement of chlorophyll a aboard NOAA vessels were developed and will be adopted for the OCSEP studies. Only near-surface values can be obtained at present, but the acquisition of a submersible pump-sensor system during FY-76 will enable us to measure continuous vertical profiles of chlorophyll simultaneously with several related variables.

Although the general features of vertical distributions and migrations of zooplankton are known, there had been no previous studies regarding the effects of vertical mixing of the water on plankton stratification.

During September and October 1974, we attempted to examine the effects of strong tidal mixing on vertical distributions and diurnal migrations of zooplankton in the San Juan Island region. The study was designed and executed concurrently with the National Ocean Survey's (NOS) tidal current survey. Two stations were occupied in each period: one was selected for low velocity tidal currents and the other for high velocities, so that plankton distributions could be compared in relatively mixed and unmixed conditions. The zooplankton samples have been sorted into major taxa. A draft manuscript reporting the initial findings has been prepared, although the samples and data require and are receiving further analysis.

C. MODELING AND SIMULATION STUDIES (MASS)

Numerical Modeling Activities During FY-75

During FY-75 a relatively modest effort within the laboratory was directed toward numerical modeling and simulation studies. These were carried out within the estuarine group (see Section E) and were quite natural extensions of larger, ongoing field programs. The researchers and support personnel who were conducting the modeling studies were also responsible for the field programs; hence the modeling work was a part-time activity.

The numerical studies, or experiments, were made in support of two environmental assessments: the BLM-sponsored study in the Gulf of Alaska and the MESA-sponsored study in Puget Sound. A shelf circulation model was developed for the Alaska study. This model is diagnostic in that it processes routine hydrographic or oceanographic station data and interpolates from boundary conditions so that the flow is dynamically consistent. The resulting flow patterns are in geostrophic and Ekman balance and include baroclinic as well as barotropic flows (fig. 2). The theoretical development of the model is covered in a PMEL technical report and the accompanying computer software development is completed through the initial test and evaluation stage. The preliminary results from a test geophysical run are presented in the first annual report on the BLM contract, and some extended study cases are being prepared for the Symposium on Science and Natural Resources in the Gulf of Alaska (October 16-17) sponsored by the Arctic Institute of North America.

The second modeling study was based on the observational program being conducted in Puget Sound. Since this work was initiated during the

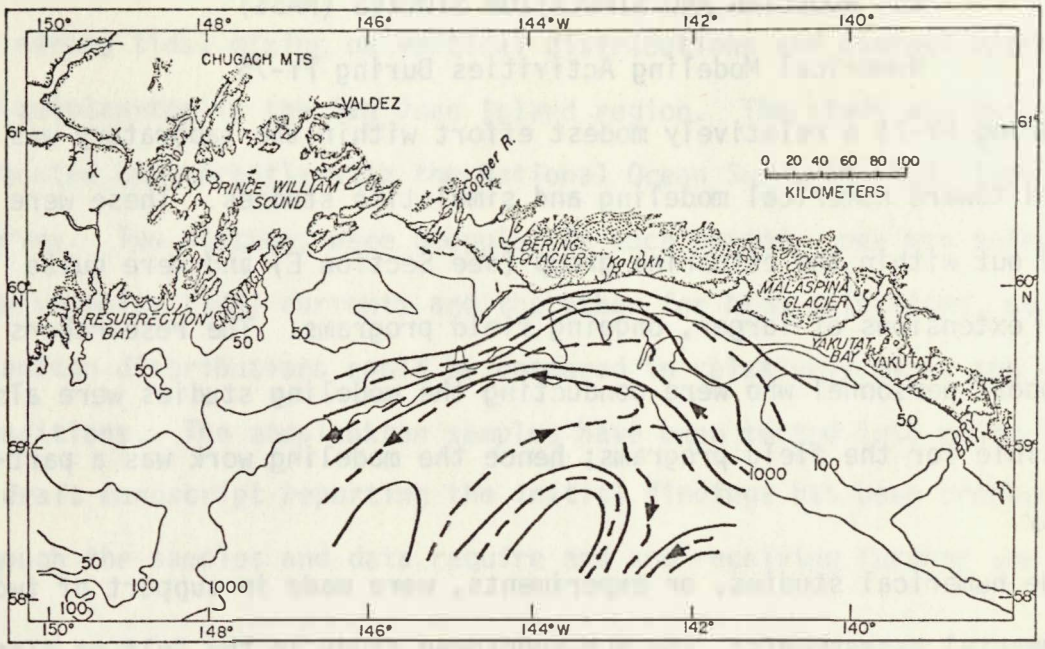


Figure 2.a. Surface elevation and contours and indication of surface currents assuming homogeneous water (results from diagnostic model).

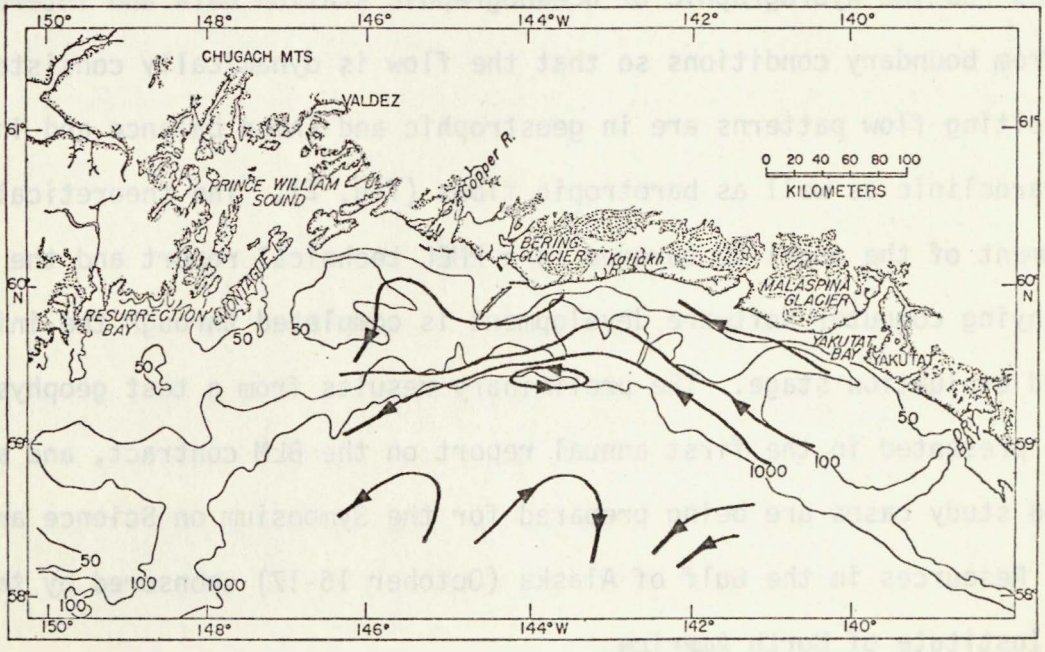


Figure 2.b. Surface elevation contours and indication of surface current direction including the effects of stratification (results from diagnostic model).

second half of the year, the results are only preliminary. One aspect of the study deals with the complex dynamics of the central basin where thermohaline, tidal, and wind-driven currents interact. For this case, the equations have been formulated and alternate numerical techniques are being investigated. A second aspect of the study has used finite-element techniques to study strong tidal currents interacting with thermohaline flow.

MASS FY-76 Plans

During the course of FY-75, it was recognized that further modeling studies were needed to strengthen the laboratory program in environmental studies. It was clear that this expansion should be developed in concert with mutually supportive observational field studies. A number of proposals were submitted to the BLM-OCS program and PS-MESA that were carefully coordinated with the planned fieldwork and built upon the preliminary work being conducted this year for the same sponsors. As a result, the laboratory's modeling program will grow significantly in the coming year. Funding levels will support four new positions, in addition to the two already in existence, and the establishment of a separate MASS group. The group will include two senior researchers and three support scientists. These positions are filled. An additional position for a research scientist is open, and it will be filled as soon as possible. In addition to the full-time personnel, two students are working with the group.

Numerical modeling studies in the MASS group are planned in association with five individual studies. Four of these are being financed by reimbursable funds. The five studies can be subdivided into nine efforts at modeling, the first two of which are direct extensions of work initiated during FY-75.

1. A Diagnostic Shelf-Circulation Model will use field data to generate (interpolate) current patterns assuming simplified dynamics and continuity constraints. The study is aimed primarily at the Gulf of Alaska and secondarily at the Bering Sea.

2. An Estuarine Circulation Model, a dynamic two-dimensional (X-Z) model of estuarine flow, is being constructed in support of an observational program in the central basin of Puget Sound.

3. A Distribution of Variables Model will be essentially a mass balance model to simulate the advection and diffusion of a pollutant. Initial efforts will look at two-dimensional surface distributions.

4. A Stochastic Advection Model uses current-meter data and a stochastic formulation to simulate time-dependent advective and diffusion effects.

5. A General Circulation Model is designed to study the response of the Bering Sea to large seasonal variations in wind-stress forcing.

6. An Ice Model Review Study will review sea-ice models in order to estimate the potential for predicting pollutant trajectories in the Beaufort Sea.

7. A Surface Current Prediction Model will compile and synthesize the information available in National Ocean Survey tidal current tables for Puget Sound in order to forecast surface currents.

8. The Finite Element Modeling Study investigates finite modeling techniques and their possible application to environmental modeling.

9. The Triangular Interpolation and Extrapolation Study investigates topological considerations in using triangulation routines for modeling.

The initial development obviously has concentrated on hydrodynamic modeling and simulation with some preliminary work on distribution modeling. These areas are supported by observational programs within the laboratory, and we anticipate productive interaction with the other projects.

D. OCEAN-ATMOSPHERE RESPONSE STUDIES (OARS)

The OARS group conducts laboratory and field experiments primarily to investigate and describe physical processes occurring in the ocean resulting from variable atmospheric forcing. Some aspects of our work are relatively independent and others occur within large-scale studies involving many people. The OARS group includes research scientists, technologists, and graduate students.

OARS FY-75 Activities

During FY-75, analyses of data obtained from the upper ocean and marine atmosphere at two different coastal upwelling areas (Oregon and northwest Africa) were continued and a number of reports and research papers were produced. Our investigations formed one component of the Coastal Upwelling Ecosystems Analysis (CUEA) program of the International Decade of Ocean Exploration. They included a number of results: we determined the wind-stress curl near a coastline; we observed the response of the upper ocean to variable winds; and we estimated the mixing parameterization of the upper ocean and the role of tidal and wind-generated internal waves in the dynamics of coastal upwelling. Our findings should help to improve the management of coastal fisheries and the forecasting of local coastal weather.

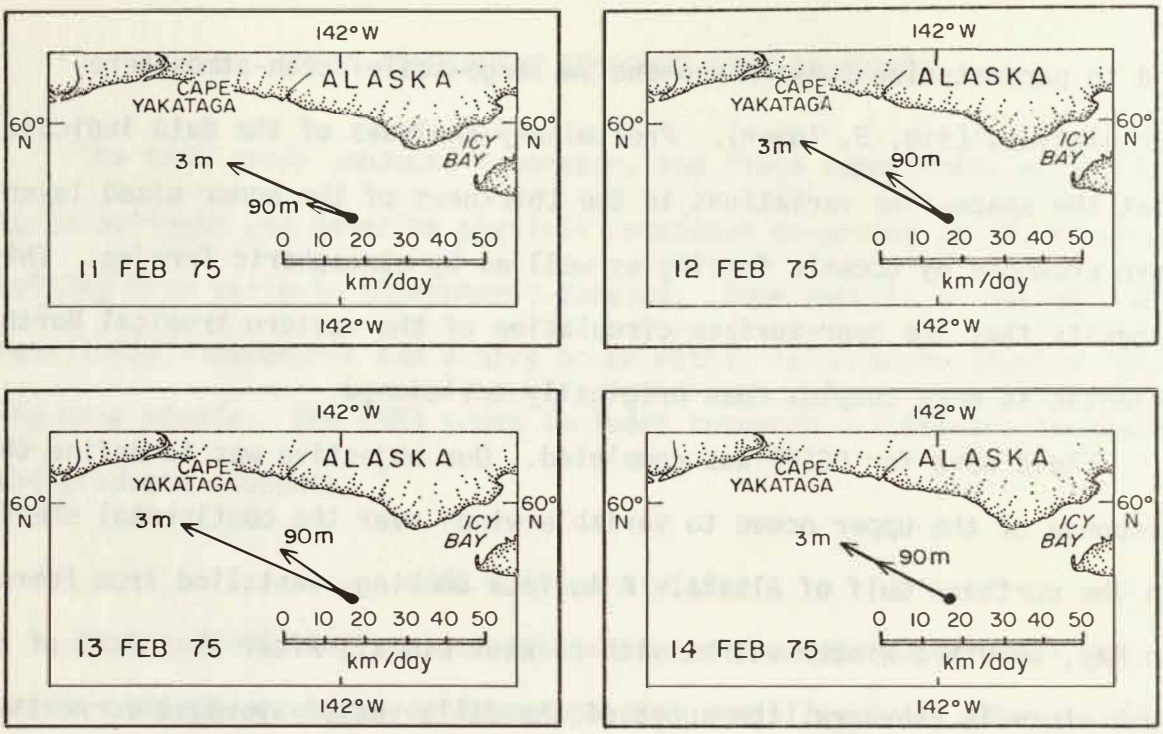
Field work for the GARP Atlantic Tropical Experiment (GATE) C-Scale Oceanographic Experiment in the eastern tropical North Atlantic was completed in collaboration with many national and international oceanographic research groups. Our objectives were to define the small-scale processes occurring in the upper ocean in response to variable atmospheric forcing,

and to parameterize these phenomena in large-scale ocean-atmosphere circulations (fig. 3, lower). Preliminary analyses of the data indicate that the space-time variations in the thickness of the upper mixed layer were produced by oceanic forcing as well as by atmospheric forcing. This suggests that the near-surface circulation of the eastern tropical North Atlantic is more complex than originally envisioned.

Field work for OCSEP was completed. Our objective was to define the response of the upper ocean to variable winds over the continental shelf in the northern Gulf of Alaska. A surface mooring, installed from February to May, survived winter storms with 80-knot winds. After the onset of one such storm in February, the speed of the daily vector-averaged currents measured 3 m below the surface increased by 400 percent to approximately 40 km per day in a generally onshore direction (fig. 3, upper).

Several technological developments were completed during FY-75. A prototype pressure recorder for bottom pressure measurements was constructed and successfully tested. An instrument platform for surface floats was designed and will be tested at sea during the fall of 1975. An integrating data logger has been built. Tilt sensors were added to a vector-averaging current meter. We have improved instrument checkout procedures; for example, a rotating table for current meters was constructed. Computer programs to process vector and scalar time-series of measurements were updated.

Other FY-75 activities of the OARS group included preparing nine proposals (CUEA, DOMES, GATE and OCSEP); attending numerous meetings to prepare plans for environmental studies; and providing computer software, electronic instrumentation, and mooring materials for many groups.



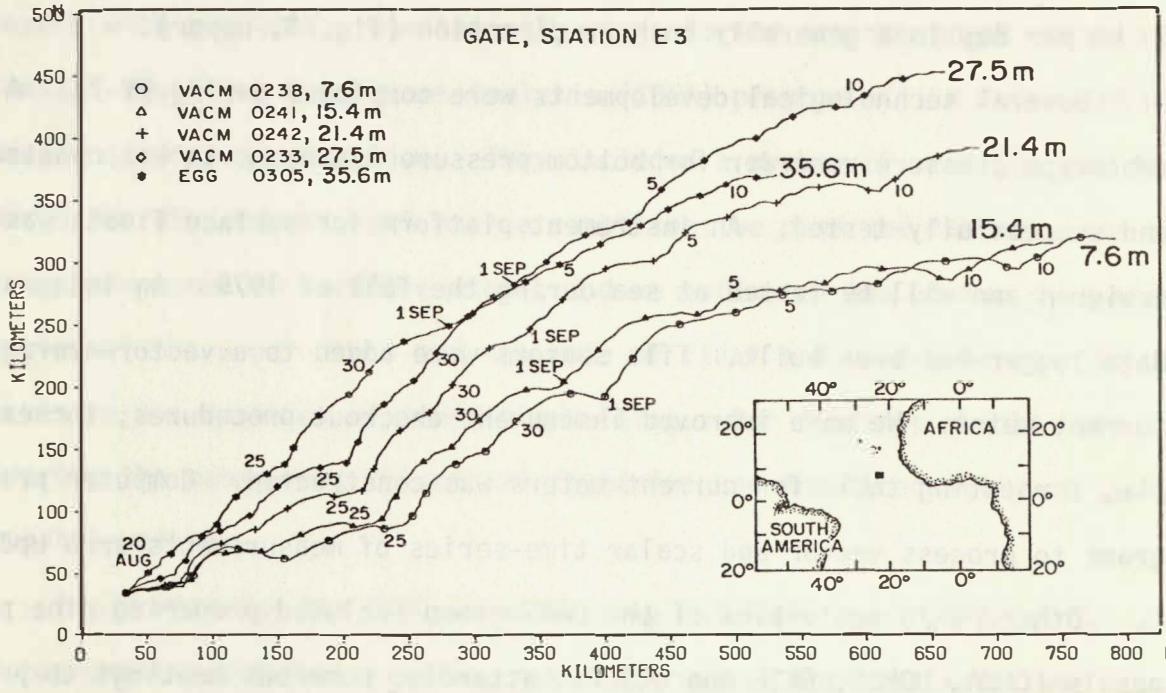


Figure 3. Two examples of the response of the upper ocean to wind forcing. (Upper) Daily mean current vectors on 4 successive days during a winter storm, which were 400% to 700% larger than speeds measured before onset of storm. (Lower) During GATE, current vector rotated counterclockwise with depth; current direction at 7.6 was cum sole to mean wind direction.

OARS FY-76 Plans

Two new research programs, initiated during FY-75, will continue through FY-76. We will attempt to determine the space-time variations of sea-surface slope and its response to atmospheric and oceanic forcing over a mesoscale region of the continental shelf. Measurements of bottom pressure will be made with a prototype instrument. Findings will be used to predict ocean currents and transport of materials and to improve forecasting of storm surges. We will attempt also to determine the near-bottom currents and the structure of the circulation of the bottom boundary layer on the continental shelf. Our analyses should facilitate decisions regarding waste disposal, dredging, and the stability of conditions on the sea floor.

E. STUDIES OF COASTAL AND ESTUARINE NATURAL ENVIRONMENTS (SCENE)

Although the SCENE group was formed officially in FY-76, coastal and estuarine research has been carried out at PMEL for a number of years. During the early 1970's, a number of national reports indicated the need for greater understanding of the Nation's estuaries and coastal waters in order to assist resource managers in regional planning. Recognizing this need during FY-71, PMEL (then the Pacific Oceanographic Laboratory) began an experimental program primarily to study estuarine dynamics, particularly of the Puget Sound system (fig. 4). Initial experiments were planned to measure and describe the horizontal, vertical, and temporal distribution of currents through the use of unattended, moored arrays of instruments. During 1973 and 1974, the program was expanded to include interdisciplinary studies addressing specific environmental questions, and personnel were added to cover further oceanographic disciplines and numerical modeling. Other estuarine environments also were included: the San Juan Island passages and the Strait of Juan de Fuca, the Washington Coast, and various Alaskan coastal areas. In addition, there is a small program to investigate some aspects of large-scale oceanic processes. Although specific questions and areas are being addressed, emphasis is on understanding basic processes and on developing a sound physical basis for quantitative models that will predict the composition and distribution of biological elements of estuaries and coastal areas in general. Information on advective and diffusive processes is a fundamental input in all these studies.

Initially these programs were carried out within a single group involved in multi-disciplinary studies. Growing diversity within that group

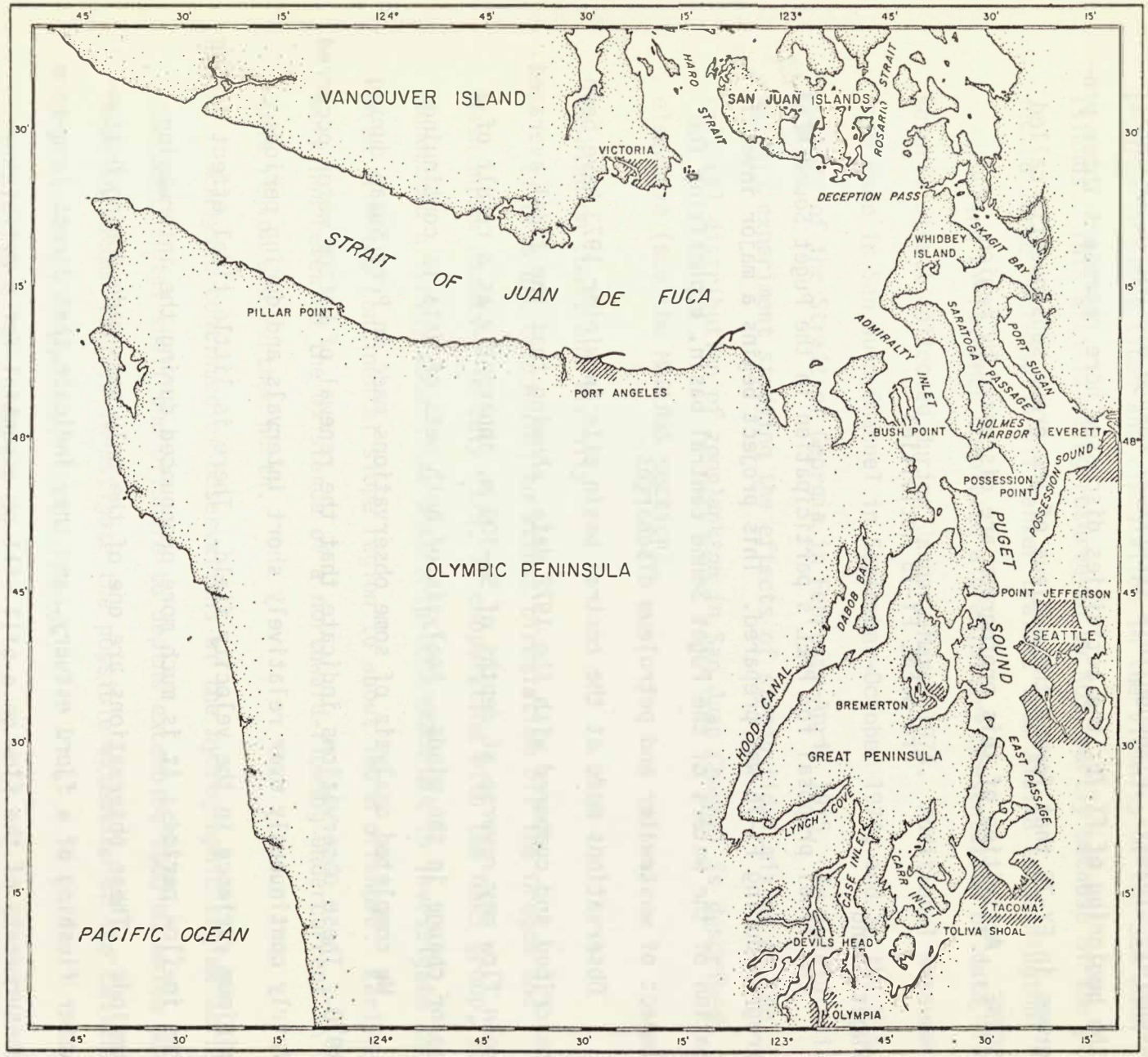


Figure 4. Puget Sound and Approaches

and management considerations necessitated dividing the original group into three separate groups (MARLAGS, MASS, SCENE) which continue to cooperate closely. Although this structural change did not occur until the beginning of FY-76, the activities discussed here represent those programs in FY-75 that formed the nucleus of the group subsequently called SCENE. Activities of this protogroup are discussed by region.

Pre-SCENE FY-75 Activities

Puget Sound

The final proposal for PMEL's participation in the Puget Sound MESA program during FY-76 was prepared. This project begins a major investigation of the waters of the Puget Sound central basin, emphasizing the impact of wastewater and petroleum discharges.

Observations made at the central basin site in winter 1973 have been described and compared with the 1972 data, showing that the tidal averaged mean flow may reverse at depths of 50-100 m, apparently as a result of a major change in the winds. Analysis of both sets of data is continuing.

We completed analysis of some observations made in Port Susan during 1970. These observations indicate that the renewal of bottom water occurred fairly continuously over relatively short intervals and during periods of minimum variance in the velocity field. There is little tidal effect during the in-flow periods; it is much more pronounced during the intervening periods. These observations are one of the only sets made during bottom-water flushing of a fjord estuary, and they indicate that direct long-term measurements of the flow on a sill will be essential for a definitive study of the bottom water renewal process in fjords or similar basins.

San Juan Island Passages

PMEL participated again with NOS in the second year of a several-year program to study tides and circulation in the vicinity of the San Juan Islands. This area is being resurveyed by NOS, partly because of the projected large increase in oil tanker traffic from Alaska to Washington.

During FY-75, PMEL completed a preliminary presentation of data from Rosario Strait collected during January-March 1974. Additional measurements were made in San Juan Channel in September-October 1974, and in the U.S. portion of the Strait of Georgia in February-April 1975. An interdisciplinary experiment studying the effects of strong tidal mixing on the vertical distribution of zooplankton in San Juan Channel is described elsewhere (see the MARLAGS section).

Washington Coast and Vicinity

Efforts are continuing to assess circulation off the Oregon and Washington coasts. In July 1975, in cooperation with the OARS group, we conducted a survey aboard the NOAA Ship OCEANOGRAPHER to investigate the area from the continental slope region to about 100 m offshore. Earlier work had revealed the existence of a northward-flowing undercurrent in this region and further north.

Analysis continued of observations of the hydrographic regime across the continental shelf and offshore to depths exceeding 2000 m, which were made in autumn 1971 to investigate the possible extension of the California Undercurrent off the coast of Washington.

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Alaska

During FY-75, BLM's OCSEP for the northeast Gulf of Alaska was initiated. The physical oceanography program is focused on direct measurement of circulation, on forming a data base to serve both as input to a diagnostic model and as a check on its output, and on providing velocity-field information to examine the fate and effects of possible oil spills or seepage related to proposed oil drilling activities. Five cruises have taken place in the northeast Gulf of Alaska, occupying STD stations and deploying current meter moorings. One current meter mooring has been maintained continuously for over a year. In less than a month, software was developed for preliminary processing of current meter records. The PMEL physical oceanography program in Alaska has been carried out jointly by researchers in this group, in the OARS group, and in the MASS group.

We have collected reports of standard meteorological observations, and we have determined the average climate in this area and the transient effects of the individual cyclones, fronts, etc. A study of the effects of air-modification processes was conducted in terms of the relationships of surface wind stress to geostrophic winds under varying conditions.

Large-Scale Oceanic Processes

PMEL continues to study the processes affecting the heat content of the upper ocean. Measurements of insolation and net long-wave radiation have been made aboard the NOAA Ship OCEANOGRAPHER in order to evaluate various formulas for estimating these parameters. Recent oceanic data, plus data from selected National Weather Service coastal stations, permitted us to evaluate the various formulas for estimating insolation under clear skies.

Work on precipitation over the oceans has been revived. Collaboration with Captain G. P. Britton, who is conducting studies for the World Meteorological Organization, has allowed us to assess the various coefficients for estimating rainfall from present weather reports.

SCENE FY-76 Plans

PMEL's field research in the Puget Sound MESA program will aim primarily at further characterizing and understanding the advective and mixing processes. This field program will include mooring a current meter for about a year at a site in mid-channel just north of West Point, a previously occupied site for which there is a large amount of data. This site is in the vicinity of Seattle's West Point plant, the largest single discharge point within Puget Sound; hence it will yield information directly applicable to managing a major discharge. Closely associated with this field program will be the development, by the modeling group (MASS), of a mathematical model of significant physical processes in the central basin.

During FY-76 we will continue to examine data pertaining to circulation in the San Juan Island passages and to participate in NOS operations in the eastern end of the Strait of Juan de Fuca. We plan to analyze data not routinely dealt with by NOS in order to obtain better descriptions and understanding of the circulation in this extremely complicated area.

We will investigate details of the circulation of the coastal waters of Washington and Oregon using the geostrophic relation and water-mass analysis. This should resolve many features inadequately described by previous surveys.

Our current efforts regarding large-scale oceanic processes are concerned principally with assessing the various cloud factors for insolation and net long-wave radiation. Plans are in progress to derive rainfall estimates for the North Pacific from the carefully edited NORPAX data tapes at Fleet Numerical Weather Central, Monterey, California.

F. TSUNAMI RESEARCH EFFORT (JTRE)

The Joint Tsunami Research Effort is a cooperative program of the University of Hawaii and the Environmental Research Laboratories of the National Oceanic and Atmospheric Administration. The Joint Tsunami Research Effort is the Hawaiian component of the Pacific Marine Environmental Laboratory, Seattle.

The two main objectives of JTRE are to improve the Tsunami Warning System (TWS) and to establish tsunami hazard design criteria for coastal structures. The most significant improvement in the TWS would be the ability to issue a quantitative warning. The most significant capability in establishing tsunami hazard zones would be the prediction (in a statistical sense) of tsunami heights and currents at coastlines for specified times.

The technique that we believe will lead to the quantitative tsunami warning is to measure the tsunami in its path of progress in real time and to calculate the terminal effects as a function of space and time. This would lead quite naturally to the second objective of establishing tsunami hazard design criteria. If one can compute the result of a given tsunami, the consequences of a design earthquake can be evaluated.

JTRE FY-75 Activities

In order to achieve our objectives, we have a modest program of instrumentation and a somewhat more comprehensive program of hydrodynamics and numerical fluid dynamics. We have been involved also in an attempt to measure small tsunamis from the cable-connected gage, 5 km off the north shore of Oahu.

The main effort in the past year was the construction and fielding of the joint U.S.S.R. and United States experiment in the Japan-Kuril Islands region. Under NOAA/ERL Grant funding, and with considerable of our own direct effort, 11 deep-ocean tide gages were constructed, of which nine were completed in time for the Japan-Kuril cruise. In addition, an ocean-bottom seismograph system was built, and these various systems are in operation in the cooperative U.S.S.R. and United States experiment. The objective of this experiment is to measure a small tsunami in its relatively undistorted form in the open ocean.

Another aspect of our instrumentation program was the preparation of the tsunami and tide gages for an array experiment. In this array experiment, we will observe pressure as a function of time at four locations on the sea floor. From this we will compute energy as a function of frequency and direction to identify sources of tsunami-frequency background energy that would then furnish us with a method of verifying the hydrodynamic computational techniques.

The studies of the multimode, long-wave transport in regular basins describe the current state of the art of analytic hydrodynamics. For a simple geometry we are able to provide an analytic solution to the interaction of long waves with an irregular basin estuary or coastal topographic feature.

Along the line of more traditional, numerical tsunami hydrodynamics, JTRE has put together the basics for a "second-generation" tsunami-propagation program. Any given source function anywhere in the ocean will produce an output for any location--limited principally by the quality of the depth data regarding the world ocean.

Within range of this same type of work, a relatively high resolution (5 km grid size), numerical computation for the Hawaiian Islands is being made. The final product will be both a hazard map for the State of Hawaii and data that could be used to predict the real time of runup, given some offshore tsunami wave data.

In response to a specific request, we made a study of Honokohau Harbor on the Island of Hawaii and its long-wave response to the modifications that will result from proposed dredging.

In the absence of any major tsunami, Dr. Jimmy C. Larsen has analyzed the large-scale water motions derived from his electric field measurement system and he has produced a new set of cotidal charts for the Hawaiian Islands region of the ocean. The electric field measurement system acts as an averaging current meter, operating over a large body of water and particularly throughout the entire water column. In the event of a tsunami we would have the water motion, averaged out to a fairly large radius and averaged over the entire depth of the water. Again, a measure of undisturbed tsunami in the region of the Hawaiian Islands.

JTRE FY-76 Plans

The numerical (Green's) function technique will be put into application. Individual numerical time-stepping studies of tsunamis will be continued. Individual harbors within the Hawaiian Islands will receive special attention. The relative tsunami hazard maps should be completed for the State of Hawaii, and we hope to go on to other coastal states. Oregon is probably the next candidate for relatively intensive treatment.

By way of data gathering, all of the historical runup data that has been collected for the Hawaiian Islands will be presented in graphical report form. Maps showing various runup heights are being prepared.

Work on large-scale water motions derived from magnetotelluric data will continue.

An analysis and recommendation on the Straits of Magellan experiment will be completed.

Work will continue on mass transport velocity in cnoidal waves propagating steadily over a smooth horizontal bed. The result of this study should be directly applicable to tsunami problems and the dissipation of tsunami and tsunami wave energy in coastal regions. A calculation of the second approximation of the mass transport velocity within the bottom boundary layer is also being made.

We will continue to work also on the differential approach to nonlinear gravity-wave problems. These are difficult problems that must be sorted out before we can understand the tsunami-shoreline interaction. A certain amount of effort is being devoted to the Bureau of Land Management project in Alaska.

In addition to the array experiment mentioned earlier we are considering a second cooperative cruise with the Russians in the seismically active area of the Kuril Islands.

One of the administrative objectives during this coming year will be an attempt to broaden the base of support for tsunami research and to initiate plans to obtain research funds from the various appropriate agencies.

G. BASE OPERATIONS SUPPORT SERVICES (BOSS)

BOSS was initiated at the beginning of FY-75 to provide technical support for the many research projects undertaken by PMEL.

BOSS FY-75 Activities

Beginning with a staff of five (increased in June 1975 to 10) without quarters, equipment, or tools and with a very limited budget, during the past year BOSS has:

1. Constructed its own shop and office space in an unused warehouse at the Naval Support Activity at Sand Point.

2. Established an electronic section capable of designing and fabricating new equipment as well as testing, calibrating, and repairing the many and varied electronic instruments used by the various projects.

3. Designed and fabricated mooring assemblies, underwater camera systems, sample washers, small biological trawl frames, and other mechanical hardware requirements of the research projects.

4. Established a shipping, receiving, and property-control section.

5. Developed remodeling plans for the PMEL section of the NOAA Building 32 Remodeling Project at the Naval Support Activity at Sand Point.

6. Refurbished NOAA Building 264 at Sand Point to provide temporary office and laboratory space for PMEL's increased scientific staff.

7. Provided limited graphic services.

8. Provided carpentry, light machine shop, and small-boat support services.

9. Provided electronic, physical science, and engineering technicians to support field activities in the Gulf of Alaska, Puget Sound, and the Southeast Pacific.

BOSS FY-76 Plans

During FY-76, BOSS will continue to enlarge and improve its support capability with the objective of eventually being able to provide appropriate technical services to the rest of the laboratory.

LABORATORY STAFF

Deep Ocean Mining Environmental Studies (DOMES, Seattle)

Padan, John W., Project Supervisor

Anderson, George (U.W. contract)
Erickson, Barrett H.
Poor, George M.
Wing, Robert H.

MARine Life And Geochemical Studies (MARLAGS, Seattle)

Larrance, Jerry D., Project Supervisor

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Modeling And Simulation Studies (MASS, Seattle)

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Ocean Atmosphere Response Studies (OARS, Seattle)

Halpern, David, Project Supervisor

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Studies of Coastal and Estuarine Natural Environments (SCENE, Seattle)

Charnell, Robert L., Project Supervisor

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Schumacher, James D.
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Joint Tsunami Research Effort (JTRE, Honolulu)

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Larsen, Jimmy C.
Lembeck, Louise B.
Loomis, Jimmy C.
Nakamura, Alex I.
Preisendorfer, Rudolph W.
Spielvogel, Lester Q.

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Kimrey, Leal, W., Project Supervisor

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Gable, James A.
Grigsby, Michael W.
Jackson, Thomas G.
Newman, Roy
Parker, William J.
Pizzello, Marilyn F.
Spell, B. D.
Stephens, James L.
Stevens, H. R.

Administrative Support (Level III, Seattle)

Cunningham, Ralph F., Administrative Officer

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Dombrowski, Marion L.
Hirst, Susan
Jensen, Mary F.
Johnson, Louise L.
Johnson, Virginia I.
Keil, Cynthia A.
Martinez, Sheila M.
Schapiro, Sandra L.

GRANTS AND CONTRACTS

A. From BLM (OCSEP):

1. "Calculation of Long-Wave Response Properties of Various Bays and Sounds in the Bering Sea, Beaufort Sea, and Gulf of Alaska"

   - R. W. Preisendorfer

2. "Meso-Scale Physical Oceanographic Measurements Program - Gulf of Alaska"

   - S. P. Hayes and J. D. Schumacher

3. "Gulf of Alaska Numerical Modeling"

   - J. A. Galt

4. "Meso-Scale Physical Oceanographic Measurements Program - SE Bering Sea"

   - J. D. Schumacher and L. K. Coachman (U.W.)

5. "Bering Sea Numerical Modeling"

   - J. A. Galt

6. "Beaufort Sea Numerical Modeling"

   - J. A. Galt

7. "Distribution, Composition and Transport of Suspended Particulate Matter in the Gulf of Alaska"

   - R. A. Feely

8. "The Distribution, Transport, and Elemental Composition of Suspended Particulate Matter in the Southern and Southeastern Bering Shelf"

   - R. A. Feely

9. "Distribution of Light Hydrocarbons C_1-C_4 in the Gulf of Alaska"

   - J. D. Cline

10. "Distribution of Light Hydrocarbons C_1-C_4 in the Bering Sea (Bristol Bay)"

- J. D. Cline

11. "Biological Oceanography of the Pelagic Zone - Gulf of Alaska Plankton"

- J. D. Larrance and D. M. Damkaer

12. "Physical Oceanographic Studies in the Northern Gulf of Alaska"

- J. A. Galt and D. Halpern

B. From MESA-Puget Sound:

1. "Puget Sound Dynamics"

- G. A. Cannon

2. "Puget Sound Modeling"

- J. A. Galt

C. From GATE Project Office:

1. "Investigations of Oceanic Mesoscale Structures Near the Ocean-Atmosphere Boundary"

- D. Halpern

D. From National Science Foundation:

1. "Dynamics of Upper Ocean in Coastal Upwelling Environment"

- D. Halpern

E. From DOMES Project:

1. "Upper Water Physical Oceanography (DOMES)"

- D. Halpern

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