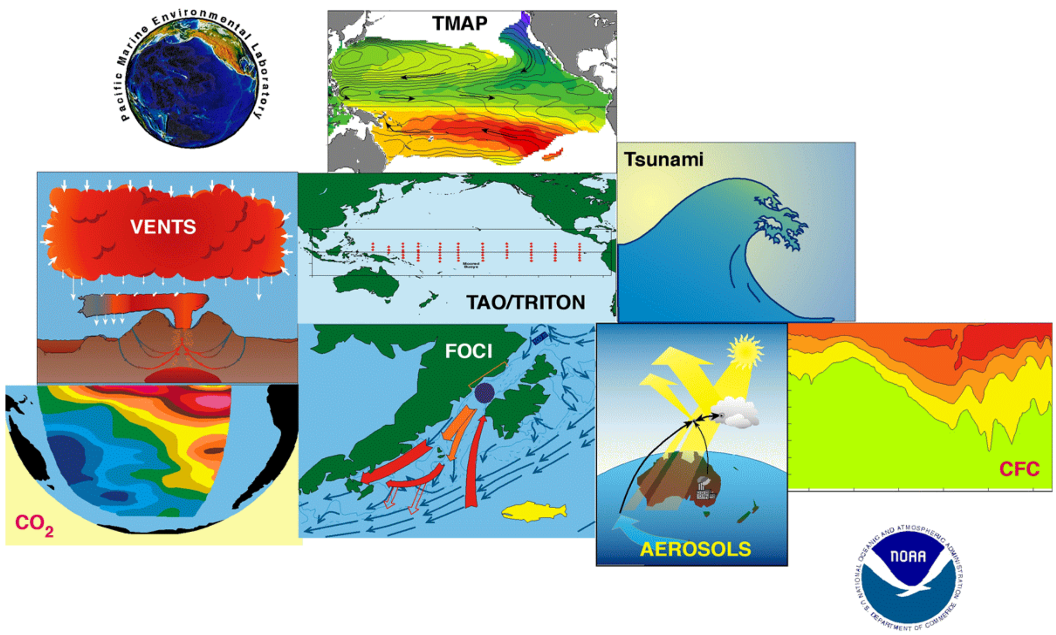
Pacific Marine Environmental Laboratory

5-YEAR PLAN

2001–2005



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National Oceanic and Atmospheric Administration

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Contents

Pacific Marine Environmental Laboratory

5-Year Plan (2001–2005)

I. Introduction

The Pacific Marine Environmental Laboratory (PMEL) [http://www.pmel.noaa.gov] is 1 of 12 Federal research laboratories within the Office of Oceanic and Atmospheric Research (OAR) [http://www.oar.noaa.gov] of the National Oceanic and Atmospheric Administration (NOAA) [http://www.noaa.gov]. The Pacific Marine Environmental Laboratory conducts interdisciplinary oceanographic and atmospheric research, develops quality products for use by NOAA and the broader scientific community, and provides scientific leadership and advice in support of NOAA's mission.

In 1980, 1985, 1990, and 1995, PMEL prepared 5-year plans to ensure the integration of wide-ranging research efforts into cohesive strategic plans for the Laboratory, guide the research direction and allocation of resources, and re-examine all programs in terms of their relevance to NOAA. In March 2000, PMEL scientists and support staff were asked to contribute to the next 5-year plan through presentations at the PMEL retreat [http://www.pmel.noaa.gov/home/5yrplan/RetreatAgenda.html] held April 4–5, 2000, in Seattle. These contributions form the basis of the plans contained in this document. Additionally, comments from outside reviewers to the PMEL Program Review [http://www.pmel.noaa.gov/programs/98prog-agenda.html] conducted in Seattle June 23–24, 1998, were carefully considered during this retreat. From May–August 2000, contributions were reviewed and individual interviews were conducted with many laboratory scientists and support staff to further refine the planning process. In August 2000, a draft plan was posted on the laboratory intranet for comment from the entire PMEL community. The current document is the final result of this process.

Background

Federal laboratories have an important role in the Nation's scientific infrastructure. Unlike the academic research environment, government laboratories are better able to maintain long-term experiments to examine earth processes over years to decades and therefore have an obligation to emphasize this approach. Unlike operational components of the government, however, Federal laboratories must maintain their basic research emphasis to ensure innovation. As a NOAA/OAR laboratory, PMEL must also focus its long-term research efforts on scientific challenges of critical importance to NOAA's mission and the strategic goals and objectives of OAR. Finally, the results of PMEL research must be made rapidly available to the agency, the scientific community, and the American public.

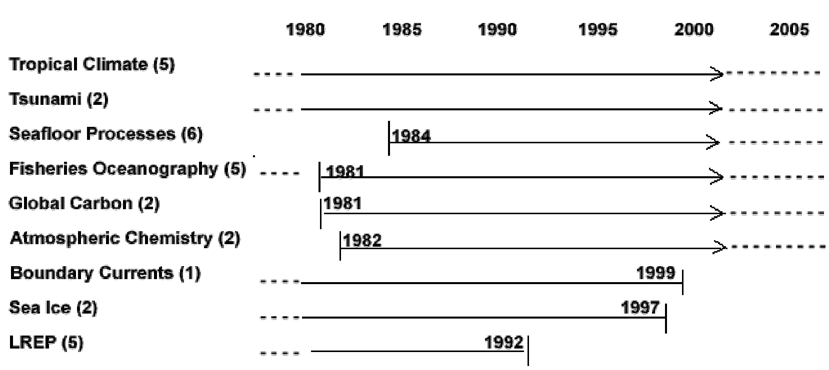
Over the years, PMEL has earned a reputation for being able to routinely conduct complex and difficult oceanic and atmospheric experiments throughout the Pacific Ocean. The Laboratory has become expert at end-to-end ocean observing systems, including designing, engineering, modeling, implementing, disseminating information, and delivering products. This expertise is well matched with OAR's vision:

> To create, through inspired research, the scientific basis for more productive and harmonious relationships between humans and their environment (OAR Strategic Plan, 2000).

The Laboratory's strength lies in the experience and knowledge of its professional and technical staff and their ability to obtain, process, analyze, and disseminate high-quality oceanographic and atmospheric measurements. This capability requires a modern, well-maintained inventory of instrumentation, computing hardware, and network connectivity. Although PMEL continues to stress its observational and analysis capabilities, the use of numerical models as planning and interpretive tools and the WorldWide Web (WWW) for disseminating information have received significant emphasis. The ability to integrate, synthesize, and disseminate reliable results from field and modeling experiments to the community in near-real time is considered the cornerstone of the Laboratory's future.

This vision of PMEL and its role in the scientific community was independently derived by outside reviewers at the PMEL Laboratory Review [http://www.pmel.noaa.gov/programs/98prog-agenda.html] held June 23–24, 1998, in Seattle. All reviewers felt that the long-term measurement programs conducted by PMEL, such as the Tropical Atmosphere-Ocean Array (TAO), the New Millennium Observatory (NeMO), Fisheries Oceanography Coordinated Investigations (FOCI), and Tsunami, and the emphasis on delivering quality, real-time data products to the community via the WorldWide Web, which was pioneered by the TAO program, were critical to conducting oceanographic research in the future. The full text of the reviewers' (James Rasmussen, Costas Synolakis, David Epp, Peter Niiler, Ron Baird, and Thomas Royer) comments can be found in the **Appendix**.

Summary of PMEL's Research in 1980 - 2005



A historical perspective of PMEL's major research themes is presented above, illustrating the gradual shifts in program emphasis since 1980. In the following sections Laboratory plans and major research themes for the next 5 years are presented for six existing research programs and two new research initiatives to address new issues facing NOAA. A discussion of Laboratory organization is followed by a section that discusses critical infrastructure issues for personnel, capital equipment, information access, facilities, and vessel support. The final section summarizes the philosophy of PMEL and the status of its programs.

II. Current Research Plans

The following sections present 5-year perspectives for ongoing PMEL research programs as submitted by senior laboratory scientists. The perspectives follow a suggested format but reflect the material submitted to the April 2000 Director's Retreat with only minor editing. Each submitter was asked to provide some background on the project, address goals, strategies, the relevance to NOAA, and finally to estimate new resources that might be required to fully accomplish the goals of the project.

Tropical Ocean Climate Research

Tropical Atmosphere and Ocean (TAO) Project [http://www.pmel.noaa.gov/tao]

Background

A. Several major field activities will continue:

- Maintenance of the bulk of the TAO/TRITON array
- Consolidation of the Pilot Research Moored Array in the Tropical Atlantic (PIRATA) in the tropical Atlantic
- Enhanced monitoring for the Pan-American Climate Studies/Equatorial Pacific
- Information Collection (PACS/EPIC) along 95°W

B. New activities that can be anticipated:

- Enhancement and possible expansion (into the North Pacific) of TAO for the Pacific Basin Extended Climate Study (PBECS)
- Expansion of TAO/TRITON into the Indian Ocean

Importance to NOAA

All the above work is relevant to NOAA's strategic plan element on improving seasonal-to-interannual climate forecasts. Major benefits are new data for description, understanding, and forecasting climate phenomena like El Niño, the North American and Indian monsoons, and tropical Atlantic variability. These phenomena either directly or indirectly affect weather patterns over the U.S. The data will also be useful in routine weather forecasting.

Resources Required

The expansions/enhancements mentioned above are all under discussion in various national and international fora. There is a likelihood that some or all may come to pass. If so, there will be implications for staffing, office and lab space, funding, computing, and institutional cooperation as outlined below.

A. TAO presently has 22 Full Time Equivalent (FTE) personnel, plus about 3 FTEs contracted from the Engineering Development Division (EDD). Staff will need to increase, as will office and lab space to accommodate them.

B. TAO will continue to require EDD support. The NextGeneration ATLAS (Autonomous Temperature Line Acquisition System) mooring has been under development for 4 years, and a fully functional version with enhanced capabilities is nearly implemented. It is expected that there will be ongoing engineering refinements, particularly as new data telemetry options become feasible and practical.

C. The amount of data collected by the TAO project is going up dramatically (2 orders of magnitude) with the enhanced resolution of new NextGeneration ATLAS. Our computing requirements will require a close examination, as we must learn how to process and disseminate these data more efficiently than at present.

D. There is the real and immediate issue of inadequate support for the TAO array, which must be addressed. An effective 10% cut (combination of inflation, increased overhead rates, and actual budget cuts) in FY 2000 set back the schedule to implement all new NextGeneration moorings in the Pacific. With no adjustments to TAO base for inflation ($125–150K per year), we will be unable to maintain the array in its present configuration.

E. In the past, the TAO project has been successful at developing partnerships with other institutions interested in ocean observations at both the national and international levels (e.g. Hayes Center, Memorandum of Understanding with the Japan Marine Science and Technology Center (JAMSTEC), France/Brazil on PIRATA, NASA/Goddard, etc.). This trend will continue and should be encouraged, as it brings both shared responsibilities for project development and shared rewards for successful implementation.

F. One aspect of existing partnerships is that ship time to maintain buoy arrays outside the core of the TAO array is usually provided by other institutions. It is likely that NOAA would not play a major role in providing ship time to support an Indian Ocean array, or an expanded Atlantic array (though NOAA ships may occasionally work in these areas).

Eastern Pacific Investigation of Climate Processes (EPIC)

Background

The eastern tropical Pacific near the Pan-American land masses is characterized by southerly winds and a stratus deck which extends from the cool waters off South America to the convective region of the cold tongue (CT)/intertropical convergence zone (ITCZ) complex. Beneath the stratus and particularly near the equator, sea surface temperatures (SSTs) are cool, while at and north of the ITCZ, in the "breeding grounds" of eastern Pacific tropical storms, SSTs are extremely warm. Understanding the ocean-atmosphere coupling responsible for the structure and evolution of the large-scale heating gradients and wind and rainfall patterns in the CT/ITZC complex is a prime objective of the Eastern Pacific Investigation of Climate processes (EPIC) program, a 5-year process study initiated by PACS.

Plan

- Enhance the easternmost (95°W) Tropical Atmosphere Ocean (TAO) line with additional buoys and sensors to monitor the air-sea heat, moisture and momentum fluxes, upper ocean temperature, salinity, and horizontal current structure in the cold tongue/ITCZ complex from the stratus deck region at 8°S, 95°W through the CT/ITCZ complex to the warm pool region at 12°N, 95°W.
- Obtain near-real time daily averages of all enhanced TAO data and make available to data center and the modeling community from PMEL-maintained ftp and web sites. Post-processed and high resolution 10-minute and hourly averaged data will be made available in delayed mode.
- Analyze the diurnal-interannual evolution of the CT/ITCZ system.
- Analyze the relationship between anomalous SST variability in this region and remote variability in the ocean-atmosphere-land climate system.
- Use the enhanced TAO array to provide a large-scale framework for the intensive process study (EPIC2001) planned for this region in 2001.

Importance to NOAA

The principal goal of the PACS program is to extend the scope and improve the skill of operational Pan-American seasonal-to-interannual climate prediction and, in particular, to improve warm season rainfall prediction over the Americas. Improved predictability will depend crucially on improving our understanding of the oceanic boundary forcing and, in particular, the relationship between the surface heating gradient and the sea surface temperature (SST).

Resources Required

- Significant EDD work needed to make the TAO moorings suitable for mixed layer studies

- $2.3M for 5 years
- New programmer. New Mooring Technician. New Student for next year

Pacific Equatorial Upwelling Experiment

Background and Importance to NOAA

The climate of the tropical Pacific is uniquely sensitive to factors that affect equatorial sea surface temperature (SST) because of the positive feedbacks that couple the zonal SST gradient and zonal winds. These feedbacks mean that even small external influences on equatorial SST can play a large role in the modulation of the El Niño-Southern Oscillation (ENSO) cycle. Recent theoretical and modeling studies suggest that such external influences could come from slow changes in the subtropical circulations of the Pacific that would result in changes in equatorial thermocline structure and be expressed at the surface through equatorial upwelling. Of course, upwelling and its variability is also the unsampled 800-lb gorilla of the equatorial heat balance.

Therefore, developing techniques to adequately monitor equatorial upwelling and its influence on SST over many years is crucial to gaining a full description of the evolution of the basin-wide climate, especially the low-frequency modulation of the ENSO cycle. Such monitoring will have to include an estimation of the rate of upwelling transport and its patterns of spatial and temporal variability, as well as the properties of the upwelling water, the depth from which it emerges, and how it is modified in the strong shears above the equatorial undercurrent. Because upwelling is both a local response to equatorial winds and a component of the inter-gyre exchanges in both hemispheres, it will be important to establish the connection to both of these elements.

Resources Required

It is not obvious how an array to appropriately sample upwelling would look, especially given the need for long-term observation which makes maintaining a dense network of profiling velocity moorings excessively expensive. The challenge is to devise a shorter-term (say 1–2 year) process experiment to learn how to interpret the relatively sparse broadscale observations (existing TAO and satellites) in a long-term monitoring strategy. Ideally the process study would demonstrate modest and sustainable enhancements to the broadscale network that would provide long-term monitoring capability.

The U.S. Climate Variability and Prediction Program (CLIVAR) has an Announcement of Opportunity this year for work to design an observational program, as a first step. We will be applying for funding under this announcement, probably in collaboration with a Joint Institute for the Study of Atmosphere and Ocean (JISAO) post-doc. The initial work will be a combination of analysis of historical data and the use of an ocean general circulation model to estimate scales and errors associated with potential sampling schemes. We will use the model to estimate the utility of measuring various other parameters (e.g., salinity), and hope to collaborate with assimilators to understand what measurements would improve the estimation of vertical transport in the context of the data assimilating forecast models.

We expect that the design study will lead to funding for a field program. Since these measurements will be most useful in the context of observations defining the circulation of the subtropical cells (so that the subtropical-equatorial connections can be evaluated), the appropriate time for the upwelling field program would be when a substantial part of the ARGO array is in place, say in 3–5 years.

Specific Resource Estimation

It is estimated that several months/year of one PI's time will be required for the design study (2 years (?)), with no new staff or facility needs during that time. A field program would involve ordering (10) current meter moorings plus another 20–30 point current meters on existing ATLAS moorings, to be maintained for 1–2 years. Permanent installations to be maintained after the field program would probably be only the point current meters.

Thermal Modeling and Analysis Project (TMAP) [http://tmap.pmel.noaa.gov]

Background

Over the past 5 years TMAP has focused its efforts on building tools (Ferret, Live Access Server (LAS), scientific analysis software), working with historical observational data sets (Comprehensive Ocean-Atmosphere Data Set (COADS), TAO, satellite altimetry, U.S. regional seasonal weather data, etc.), and tuning the NOAA Tropical Ocean Model (in use at the National Centers for Environmental Prediction (NCEP)) to reproduce the observed behavior of the tropical Pacific as well as possible. We identified the statistically significant U.S. weather anomalies that have occurred in conjunction with the past 11 El Niño periods as well as the robust global ocean surface anomaly patterns of El Niño and La Niña. The latest version of the model reproduces key aspects of both the seasonal cycle and other modes of variability better than any other model known to us. A number of papers have been submitted or are in preparation. The model is also being used to explore the modes of variability of the tropical Atlantic and Indian Oceans, with National Aeronautics and Space Administration (NASA) support. Ferret and the LAS have created a community of model and data users interested in model/data analysis and synthesis. We wish to continue to build this community and to work with it to advance NOAA's Seasonal-to-Interannual Forecast and Decadal-to-Centennial Change Goals.

We believe that the most important issues to work on for the next 5 years will use these tools to work further on the "climate-weather" connection. Our community must identify the strongest of the climate-weather connections, identify the patterns in the ocean and atmosphere that have the strongest U.S. weather associations, and do the data analysis and model studies that will let us define the observing system(s) needed to improve our knowledge and predictive skill for these modes of variability. Much remains to be understood about the processes that control the predictability of ENSO, and we will continue to work to see that the TAO array gets resources to expand its measurement suite. At present the absence of near-surface currents severely restricts model-data comparison and confident use of the model to explore the mechanisms of SST variability. ENSO has strong U.S. weather connections, of course. We have recently evaluated the La Niña weather associations and have begun to explore the extent to which Sea Surface Temperature Anomaly (SSTA) variability in the middle-latitude North Pacific can independently (and in association with ENSO) be connected with U.S. weather. One of the important new activities is to break free of the monthly and seasonal timescale anomalies that are most heavily reported and to look at the connections at higher frequencies. Drs. N. Bond and E. Harrison have found one example of the extent to which large-scale North Pacific SSTA is associated with strong regime shifts in the cold-season atmosphere; undoubtedly there are other relationships to be found. The more subtle aspects of the Pacific Decadal Oscillation (PDO) and ENSO-U.S. weather connections remain to be parsed.

The nature of air-sea interaction in middle latitudes remains unclear; PMEL has demonstrated the ability to make the needed measurements with its National Ocean Partnership (NOPP)-sponsored moorings at Ocean Weather Station (OWS) P and NNW of Hawaii. Dr. Harrison hopes to continue to support PMEL activities in building a North Pacific air-sea observing system to understand SSTA and biogeochemical changes. We also believe that there are great advances possible in the use of marine data (collected by PMEL systems) to advance short-term U.S. weather forecasting, and hope to be able to work to advance this activity within the framework of the U.S. Weather Research Program.

The role that ocean data assimilation will play in the future analysis of ocean data and models remains unclear, but will be given as much priority as resources permit. If appropriate data sets and analysis techniques can be developed, it is possible that much of oceanography will be done with "analyzed" data sets in future years. The use of data assimilation techniques to test ocean and coupled models is in its infancy, but the inconsistency of the much-used Cane/Zebiak (C/Z) model with TAO data is a milestone in ENSO research. More sophisticated dynamical systems are being evaluated now, using the same techniques that produced the C/Z result.

Importance to NOAA

These various activities support different NOAA Strategic Plan Goals: Advance Short-Term Warnings and Forecasts, Seasonal to Interannual Climate Forecasts, and Assess and Predict Decadal to Centennial Change. TMAP's data management, serving and tool development activity is "on a roll" now. Ferret, the Live Access Server, and the Distributed Ocean Data System are proving able to address a wide range of scientific and technical objectives for NOAA and for the research community. Appreciation of these capabilities is growing rapidly.

Resources Needed

TMAP will be able to continue the type of relatively wide-ranging work it has done only if the steady decline in support from NOAA to the Hayes Center stops, and if new funds are found to return it to its previous level of capability. TMAP's modeling program has been dormant for lack of support, despite its significant successes and the fundamental role it played in the design of the TAO array. TMAP has not been able to carry out the North Pacific studies that would help to shape the needed observing system there, and does not have prospects for doing so in the near future. Graduate students are crucial to the future success of TMAP, so the JISAO/Hayes Center connection remains key. Growing PMEL in-house computing capability is essential. The Hankin plus Harrison group will need to add two new staff to deal with the projects outlined.

Software Tool Building (TMAP)

Background

The software tool building activities within the TMAP group stand at approximately $0.4M/year. Our primary objectives are support of PMEL users, building desktop tools for analysis and visualization, and building Web tools for sharing distributed scientific data. Our "products" are, respectively, Ferret and the Live Access Server (LAS), with a major hand in the Distributed Ocean Data System (DODS). These systems are used widely within the ocean research community. The Geophysical Fluid Dynamics Laboratory (GFDL) has invited us to participate in a 5-year funded partnership to share our expertise with their Lab. The PMEL software survey, conducted last year, revealed that Ferret is also the most widely used scientific application at PMEL.

Plan for the Next 5 Years

The forces of "globalization," which splash the front pages of our newspapers daily, will have a profound effect on how we use data in oceanographic and climate research over the next 5 years and beyond. Two key aspects to this will be (1) hugely expanded access to scientific data sets, and (2) addressing the ever greater need for collaborations with distant scientists. The TMAP tools are poised to make significant contributions in these areas.

1. Expanded access to scientific data

Our goal over the next 5 years and beyond is to contribute significantly to the erosion of long-standing barriers that limit users' access to scientific data. Our approach, through modern networking techniques, is to eliminate the need to physically obtain and reformat data.

LAS (using Ferret and DODS) has demonstrated significant success at this strategy. Our latest server is already being installed for PMEL, GFDL, International Pacific Research Center (IPRC), U.S. Global Ocean Data Assimilation Experiment (GODAE), U.S. Joint Global Ocean Flux Study (JGOFS), Woods Hole Oceanographic Institution (WHOI), University of Rhode Island, and the NOAA/Climate Diagnostics Center (CDC), National Marine Fisheries Service (NMFS) and National Geophysical Data Center (NGDC). We will continue to develop the system's capabilities and to expand the breadth and volume of data served. Without a doubt, the techniques we employ will broaden to inter-operate with other emerging technologies. We will continue to work with data search efforts such as NASA's Global Change Master Directory (GCMD) and NOAA's Virtual Data System (NVDS), as well as developing new search strategies based on richer metadata through direct access to distributed data sets.

2. Tools to support wide area collaboration

In addition to basic data access as just discussed, collaborative systems must provide project-specific advanced tools for shared analysis, visualization, and "fusion" (e.g., comparison) of data, and must allow members to restrict access to in-progress data sets. We are currently engaged in such development work with the PMEL Tsunami Research Program (High Performance Computing and Communications (HPCC) funds) and the Office of Global Programs (OGP) Carbon Modeling Consortium.

Over the next 5 years we will be working to expand these systems. We will work to fund on-going development of Ferret out of these and related efforts.

Resources and Operational Challenges

To ensure that the benefits of our work return to PMEL, we need to continue fostering collaborations with PMEL research groups as well as outside projects. We will seek to empower the groups with which we are working to maintain and enlarge upon the systems that we provide, bringing them on as co-developers. We envision our development group remaining small and focused, not expanding by more than one or two individuals in the coming years.

A key challenge that we face will be to educate our funders and find stabler funding sources. Computer software development exists in a very rapidly evolving environment. A quick look at the software marketplace reveals that successful products (MS Word, Matlab, IDL, ...) continually develop to survive. Our projects must do the same. Successful systems which are cut off from further development funds will not long remain successful.

On-line Tour

For a quick overview of the systems that have been described here, see URL: http://tmap.pmel.noaa.gov/%7Ehankin/DODS/CAN/milestones_jan00/ for a recent summary of our work with DODS.

Global Carbon Cycle Research

Ocean CO_2 Measurement Program [http://www.pmel.noaa.gov/co2/co2-home.html]

Scientific Goal: To quantify, understand, and project the evolution of global ocean carbon sources and sinks in order to better predict future climate.

Background

Carbon dioxide is one of the most important gases in the atmosphere affecting the radiative balance of the earth. Atmospheric CO_2 concentrations in the past 400,000 years have oscillated from around 200 to 280 ppm. Current atmospheric concentrations are now around 367 ppm as a result of industrial and agricultural activities. In the past few decades, only half of the CO_2 released by human activity has remained in the atmosphere; on average, about 30% of the CO_2 is taken up by the ocean and about 20% by the terrestrial biosphere. The NOAA/(National Science Foundation (NSF)/Department of Energy (DOE)/ NASA-sponsored U.S. Carbon Cycle Science Plan (CCSP) focuses on two fundamental scientific questions: “What has happened to the carbon dioxide that has already been emitted by human activities (past anthropogenic CO_2)?” and “What will be the future atmospheric CO_2 concentrations resulting from both past and future emissions?” It is the latter question that holds the largest scientific and societal interest. Because carbon reservoirs in the ocean, atmosphere, and terrestrial biosphere are irrevocably linked, the U.S. CCSP calls for an integrated approach to studying the carbon cycle. The ocean plays a critical role in the global carbon cycle, since it has a vast reservoir of CO_2 containing approximately 50 times more CO_2 than the atmosphere, and therefore exerts a controlling influence on atmospheric levels.

Importance to NOAA

NOAA has the primary responsibility for the global atmospheric CO_2 monitoring network and the global ocean measurements. These program elements are particularly relevant to the ultimate objective of NOAA’s carbon cycle research program, to improve future projections of atmospheric CO_2. The oceanic component of an observing system for the global carbon cycle must serve two functions. First, it should measure the magnitude, spatial distribution, and the interannual-to-decadal variability of carbon uptake patterns in the global ocean. Second, it should provide a framework for which studies are implemented to improve our mechanistic understanding of processes controlling regional uptake. The long-term goals for PMEL’s CO_2 research in the Pacific Ocean are to: (1) quantify the uptake of anthropogenic CO_2 by the ocean, including its interannual variability and spatial distribution; and (2) to understand and model the processes that control the ocean’s uptake of CO_2. We intend to study these uptake fluxes utilizing a two-fold approach: (1) developing and maintaining a surface network of pCO_2 observations through a volunteer observing ship program, drifters, and moorings; and (2) conducting inventories of carbon and other key physical parameters deeper in the water column.

Resources Required

The research will be a major component of NOAA's contribution to the U.S. Carbon Cycle Science Plan. This program is planned for a major increase in funding starting in 2002. We expect to increase our funding by a factor of 3, the size of our group, and its interactions with the Engineering Development Division (EDD) and Computing and Network Services Division (CNSD) to meet the requirements of an expanding ocean carbon observational program. The initial phases of this expanded program will primarily emphasize hardware development. We intend to work closely with EDD to develop new underway CO_2 instruments for the NOAA and volunteer observing ships (VOS), construct CO_2 sensors to be deployed on moorings and drifters, and develop new CO_2 profiling instruments. Initially, we expect to expand the size of the CO_2 group by as much as four persons to support the construction and deployment activities.

We will need additional lab space, office space, computing, and administrative support for these new people.

Repeat Hydrographic Survey for CO_2, Heat, and Freshwater Inventories and Fluxes

Background

The World Ocean Circulation Experiment (WOCE)/Joint Global Ocean Flux Study (JGOFS) one-time survey of the World Ocean has provided us with an unprecedented baseline for global climate studies. A wide range of biogeochemical and transient tracers were sampled during this survey.

Importance to NOAA

Analysis of this large data set is really just beginning, and will allow improved estimates of ocean variability, ocean fluxes of heat and freshwater, ocean storage of carbon, and ocean fluxes of carbon and other biogeochemically important constituents such as nutrients and dissolved oxygen. For carbon alone, the as yet geographically limited estimates of anthropogenic uptake are spurring attempts at climate model improvements. The carbon flux estimates may provide an even more rigorous observational test of ocean biogeochemical modeling.

Plan

There is a growing recognition within the scientific community that repeat occupations of a subset of the one-time survey will be necessary at 5- to 10-year intervals to evaluate the evolving role of the ocean in anthropogenic carbon uptake and in global carbon cycling. Changes in the chemistry, biology, and temperature of the near-surface oceans over decadal timescales may substantially change the ocean uptake of carbon. In addition, such a program will be useful for (1) studying ocean ventilation through the uptake of transient tracers such as Chlorofluoro-carbons (CFC), (2) allowing full-water column, mass conservation constrained heat and freshwater flux estimates that will not be possible with Expendable Bathythermographs (XBT) or Argo floats, (3) looking for changes in the water properties or flux rates of the deep circulation which is the flywheel of the global climate system, and (4) providing baseline deep salinity data for continued calibration of the Argo float conductivity sensors. It has already been nearly 10 years since some of the WOCE sections in the Pacific Ocean were occupied. Given the long lead time for these hydrographic surveys and the importance of the work for decadal timescale climate studies and Intergovernmental Panel on Climate Change (IPCC) needs, it is time to start planning the work now. Hopefully, PMEL principal investigators will be taking part in repeat surveys within the next 5 years. This is an activity with which we are familiar, having done it most recently in a 1998 transatlantic section.

Resources

Resources required are significant, but most of the personnel are still present locally. One more analyst (for dissolved oxygen) might need to be hired if this work spins up.

CFC Tracer and Large-Scale Ocean Circulation Program
[http://www.pmel.noaa.gov/cfc/home.html]

Background

The PMEL Chlorofluorocarbon (CFC) Tracer Program utilizes measurements of the distributions of dissolved CFCs to study ocean circulation and mixing processes. During the past 5 years, the group helped organize and participate in a number of major oceanographic expeditions as part of the World Ocean Circulation Experiment (WOCE) and NOAA's Ocean-Atmosphere Carbon Exchange Study (OACES) programs. These studies were done in close collaboration with colleagues at PMEL, the Atlantic Oceanographic and Meteorological Laboratory (AOML), and academic institutions.

Plan

During the next 5 years we intend to continue to document the entry of CFCs from the atmosphere into the world ocean by means of time series measurements and repeat long-line hydrographic sections at decadal intervals, and to use these observations to help test and evaluate ocean-atmosphere models. Time series measurements, such as the annual repeat surveys in the Greenland Sea, have documented the near-cessation of the production of cold, dense water (Greenland Sea Deep Water) by deep convective processes, and suggest connections with decadal-scale changes in surface conditions in the North Atlantic. Comparisons of CFC data from repeat sections highlight regions where intermediate and deep waters can rapidly take up anthropogenic gases such as carbon dioxide on decadal timescales. We plan to continue joint efforts for the analysis of these global data sets and work closely with numerical modelers to help evaluate and improve the ability of models to realistically simulate oceanic ventilation processes as well as carbon uptake and transport.

Importance to NOAA

The development and testing of models is critical for understanding the present state of the ocean-atmosphere system, quantifying the ocean's role in the uptake of climatically important trace gases such as Carbon Dioxide, and improving predictions of climate change for the coming century. Such comparison studies are relevant to NOAA's Strategic Plan, and critical if we are to have confidence in the ability of such models to predict possible changes in the Earth's climate due to release of greenhouse gases or other anthropogenic activities.

Resources

In order to detect climate-related changes in the interior of the ocean, an active and ongoing field observational program is necessary. PMEL and AOML are in the unique position of being within a mission-directed organization such as NOAA, and having the skilled personnel and infrastructure (ships, analytical equipment, etc.) that are needed to succeed with this task.

Nutrient Program

Background

Knowledge of nutrient distributions and variability can provide a better understanding of the biological draw down of atmospheric carbon in the World Ocean, and of primary production in biologically rich shelf ecosystems such as the North Pacific and the Bering Sea.

In addition to continued shipboard nutrient analysis on Ocean Climate Research Division (OCRD) and Ocean Environment Research Division (OERD) expeditions, the nutrient program is beginning several branches of research that will overlap between the divisions, and will lead to broad use of new technology in the next 5 years.

Major Research Goals and Strategies

Establish a Regional Nutrient Monitoring Network

Deploy autonomous, continuous, underway nutrient analyzers in conjunction with pCO_2 sensors on ships of opportunity in the Equatorial and North Pacific as part of the National Carbon Program. Newly-developed instrumentation for this effort will be field tested during the Gas Exchange Experiment (GASEX)-2001 cruise.

Assume responsibility for in-situ nutrient analyzers deployed on pCO_2 moorings in the Equatorial and North Pacific as part of the National Carbon Program.

Re-evaluate Redfield Ratios

Nutrient utilization is related to carbon production and oxygen utilization (AOU) through the Redfield ratio—the relative composition of these elements in phytoplankton (AOU:C:N:P). Uncertainty in the Redfield ratio has been considered the weak point in the carbon cycle program, and refining the ratio has been described by the journal *Science* as the "holy grail of ocean biogeochemistry." The PMEL nutrient program has begun a 3-year collaborative effort with Princeton University and Oregon State University to re-evaluate Redfield ratios using recent high-quality WOCE data. These results will be used by the PMEL carbon program in their efforts to better characterize the oceanic carbon flux.

Determine mechanisms of on-shelf nutrient transport in the North Pacific and Bering Sea

Deploy an array of in-situ nitrate analyzers in the North Pacific and Bering Sea. These will be acquired through a variety of programs including Global Ocean Ecosystems Dynamics or Global Ocean-Ecosystem Coupling (GLOBEC), Coastal Ocean Processes (CoOP), International Arctic Research Center (IARC), North Pacific Marine Research (NPMR) and Gulf Ecosystem Monitoring (GEM). The first PMEL deployment will occur in fall of 2000 in the Bering Sea.

Conduct a retrospective analysis of hydrographic data to predict nutrient transport from moored salinity and current data.

Importance to NOAA Goals

- Predict and Assess Decadal to Centennial Change by characterizing forcing agents and processes, and by examining the role of the ocean as a carbon reservoir.

These NOAA objectives will be addressed through a long-term regional nutrient monitoring program, a re-evaluation of Redfield ratios, and other ongoing research.

- Build Sustainable Fisheries by advancing fishery predictions through research.

This NOAA objective will be addressed by providing a better understanding of the mechanisms and variability of nutrient transport onto the North Pacific and Bering Sea shelves.

Resources Required

Maintaining moored and underway systems will require a doubling of laboratory and office space for two additional staff. All new instrumentation is commercially available and would entail little EDD effort.

Atmospheric Chemistry Research **[http://saga.pmel.noaa.gov]**

Background

The Atmospheric Chemistry Program at PMEL is a measurement-based program designed to improve the accuracy of estimates of climate forcing by tropospheric aerosol particles. Specific goals of the program are as follows:

1. Determine the physical, chemical, and meteorological processes that control the shape and magnitude of the aerosol number size distribution, aerosol chemical composition as a function of particle size, and aerosol light scattering and absorption;

2. Determine the spatial and temporal variability of these parameters; and

3. Compile a database of aerosol parameters essential to the estimation of aerosol radiative forcing that encompasses a wide range of geographical regions.

This information is needed to detect regional and global climate change, to attribute that change to anthropogenic aerosols, and to improve the prediction of future climate changes for various radiative forcing scenarios.

The first goal is achieved through process-oriented experiments conducted at sea. The process studies range in scope from one ship platform to international projects involving multiple ships, land-based sites, and aircraft (Aerosol Chemical Experiment (ACE) 1 and 2, Indian Ocean Experiment (INDOEX), ACE-Asia, EPIC 2001). The second goal is achieved through ocean cruises covering wide latitudinal and longitudinal transects in different seasons (Radiatively Important Trace Species (RITS) 93 and 94, ACE 1, Aerosols 99) and through long-term measurements at a network of sites across North America. Our land-based measurements are carried out in conjunction with NOAA’s Climate Monitoring and Diagnostics Laboratory (CMDL), the University of Illinois, and the University of Washington. The final goal, which relies on information from the first two, is to compile a database of aerosol parameters central to the estimation of aerosol radiative forcing. Because of the geographical range of cruises and land-based measurements, the database includes a wide range of aerosol types from remote marine to polluted continental. These data are available for use in climate model calculations and validations.

Plans for 2001–2005

Continue our observational program. Two major field projects are planned in FY 2001. ACE-Asia will allow us to characterize aerosol properties in the outflow from Asia. Our participation in EPIC 2001 will focus on measurements of marine and continental cloud condensation nuclei and their effect on the region’s stratocumulus clouds. Shipboard projects will be proposed for FY 2003 and 2005 to expand our regional aerosol characterization database.

These observations will be coordinated with satellite overpasses (SeaWiFS, Terra, Picasso) to validate and improve satellite aerosol retrieval algorithms. Additional funding has been requested to extend the spatial coverage of ground-based observations through the use of a transportable aerosol sampling system. The system would be deployed at annual intervals in data-poor regions. Candidate aerosol types for characterization include biomass-burning, pollution in developing countries, and mineral dust.

- Add measurements of carbonaceous and mineral aerosol species to both the shipboard and ground-based observational programs. These species contribute the largest uncertainties to current estimates of radiative forcing by aerosols. We will develop analysis techniques and sampling protocols using the new PMEL X-Ray fluorometer (XRF), the existing scanning electron microscope (SEM), and the new organic carbon/elemental carbon analyzer.

- Continue the development of our measurement-based model that is designed to characterize the aerosol molecular species, refractive index, density, water uptake, and optical properties. The model, which is used to interpret the contributions of each aerosol chemical component to scattering and aerosol optical depth, will be applied to the ACE-Asia aerosol system.

Potential new directions

Intercontinental Transport and Chemical Transformation (ITCT)—The intercontinental transport of photochemical pollution currently is attracting considerable interest with a particular focus on ozone and fine particles. There are increasing indications that these pollutants and their precursors, even compounds with reasonably short lifetimes, can be detected at great distances from their sources. The interest in the problem is further heightened by questions regarding how long-range transport may change as the global climate changes. From a U.S. perspective we are well poised to study the intercontinental transport of pollution to the U.S. from Asia. A workshop to discuss future research programs was scheduled for March 16–17, 2000 in Tokyo, Japan.

The International Global Atmospheric Chemistry Program (IGAC) is currently undergoing a period of integration and synthesis. A product of this effort will be an international workshop scheduled for April 27 to May 2, 2000 in Aspen, Colorado, to “define outstanding research questions and a long-term strategy to address them.” PMEL has been an active leader and participant in the IGAC aerosol activities. Several international aerosol field projects will likely be defined within the framework of this integration and synthesis activity.

There appears to be renewed interest in understanding the marine sulfur cycle, the flux of dimethysulfide (DMS) to the atmosphere, and the impact of marine sulfur on the atmospheric aerosol and climate. Funding may be available through the National Science Foundation Biocomplexity program. An initial area of interest is the Bering Sea as a result of the recent coccolithophore blooms.

Importance to NOAA

The NOAA PMEL aerosol program is an integral part of the national Global Change aerosol research effort and the International Global Atmospheric Chemistry Program. Within NOAA the PMEL aerosol program directly addresses key uncertainties in decadal-to-centennial climate prediction.

Resources required

Similar space (building 3 lab and office), ship time (2 months every other year), engineering, administrative, and computer resources, as in the past few years. Additional funding has been proposed through a 2002 NOAA aerosol research initiative. This expansion would likely require additional technician time and van-park space.

Seafloor Processes Research

Vents Program and the New Millenium Observatory (NeMO)

[http://www.pmel.noaa.gov/vents/home.html]

- Understand the effects of submarine volcanism on the ocean's physical, chemical, and biological environment.
- Discover and quantify dynamic processes that link the microbial biosphere with the chemistry and geology of submarine volcanic systems.
- Employ hydrothermal tracers to understand the patterns, roles, and fate of hydrothermal emissions on local-to-regional geographic scales.
- Communicate research rationale, plans, and discoveries to the public through outreach programs and the Internet.

Background

We live on a volcanically active planet largely covered by liquid water. More than 70% of the Earth's volcanic activity occurs along seafloor spreading centers where volcanic activity focuses thermal and geochemical energy that are critical to the initiation and sustenance of unique biotopes on, and beneath, the seafloor. The principal objective of the Vents NeMO project is to establish an in situ, long-term, near-real-time link to a wide variety of interdisciplinary experiments, all of which will contribute to an eventual understanding of the subseafloor microbial biosphere.

In addition to studying the physical, chemical, and biological consequences of quasi-steady-state hydrothermal venting, the Vents Program has also pioneered acoustic detection of underwater volcanic activity. Vents scientists also pioneered, and are playing leading roles in, sea-going rapid-response activities aimed at understanding the physical, biological, and chemical consequences of episodic volcanic events. The Vents Program continues to develop state-of-the-art hydrothermal sampling capabilities and the program is organized around a long-term plan/approach that puts it in a unique position to achieve major scientific and technical goals. Among the most important scientific objectives for the next 5 years are (1) to begin to determine the biosphere’s species diversity, (2) to obtain samples of the unique microorganisms that live within the biosphere, and (3) to conduct research that will help to understand the biosphere's physical and chemical characteristics.

Vents/NeMO is now poised to apply the information and skills learned over the past 15 years in a wide-ranging investigation of a completely unknown portion of the ocean environment: the vast hydrothermal habitat within the uppermost several hundred meters of seawater-saturated basaltic crust.

NeMO is envisioned to be a decade-long effort which will establish a seafloor observatory at Axial Volcano (AV). Five principal goals are envisioned to be implemented sequentially: (1) Develop seafloor-to-laboratory interactive communication links to enable control of observational and sampling instrumentation from the Internet; (2) penetrate the ocean crust with boreholes to monitor and directly sample the deep biosphere; (3) deploy robotic instrumentation (e.g., autonomous underwater vehicles (AUVs)) capable of performing pre-programmed sampling operations on command; (4) create a local area network (LAN) of instruments around the AV caldera for coordinated monitoring of physical, chemical, and biological systems; and, eventually (5) connect this LAN to the relatively high bandwidth and power resources of the NEPTUNE cable network.

Importance to NOAA

Submarine volcanic activity provides critical opportunities for observing the nature and the inhabitants of the subsurface microbial biosphere. Microbes within the biosphere, in turn, apparently exert a powerful influence on ocean chemical budgets. Deep ocean exploration in the time domain is essential because episodic volcanic and tectonic events have important but, as yet, un-quantified effects on physical, biological and chemical ocean environmental processes.

Hydrothermal environments are so dynamic in space and time that a dedicated seafloor observatory is essential for obtaining the information and samples needed to advance our understanding of the deep biosphere. Benefits of an observatory are varied and numerous, but perhaps the most important of these is that the envisioned observatory will yield interactive, interdisciplinary observations and sampling unfettered by ship schedules or weather considerations. This will, in turn, make it possible to provide a continuous stream of information available for cooperating scientists, educational curricula, and public information via the WorldWide Web (WWW).

Resources

Establishment of a long-term observatory requires substantial new resources, approximately $3M/year. Increases in ship time and remotely operated vehicle (ROV) support will also be required. PMEL Vents and EDD personnel will develop new instrumentation, including physical and chemical sensors and long-term samplers to monitor the thermal, chemical, and microbial output of hydrothermal systems. Development of two-way seafloor-to-lab acoustic telemetry via satellite is underway, and future linking to a cabled network (NEPTUNE) is envisioned. Physical and chemical modeling require access to high-performance computing facilities, e.g., the massively parallel Forecast Systems Laboratory (FSL) system, high-volume data storage, and PMEL personnel involved with visualization.

To play an effective role in the ensuing microbiological research revolution, we must add a microbiologist principal investigator to our group, as well as additional instrumentation. Three new support staff will be required during the next 5 years. This will probably result in a need for office space and, if a microbiologist is brought aboard, one additional lab will be essential.

Tsunami Research [http://www.pmel.noaa.gov/tsunami/]

Since the 1992 northern California earthquake and tsunami, NOAA has led the development and implementation of the U.S. National Tsunami Hazard Mitigation Program (NTHMP), a partnership with the United States Geological Survey (USGS), Federal Emergency Management Agency (FEMA), NSF, and the states of Alaska, California, Hawaii, Oregon, and Washington aimed at reducing the loss of life and property on U.S. coastlines. To this end, the NOAA/PMEL Tsunami Program conducts research and development (R&D) that focuses on advanced modeling and measurement technology to increase the speed and accuracy of tsunami forecasts and warnings, and on improved tsunami inundation maps and other hazard assessment tools. Accordingly, the Tsunami Program is structured as three tightly integrated R&D activities: Tsunami Inundation Mapping Effort (TIME), Deep-ocean Assessment and Reporting of Tsunamis (DART), and Short-term Inundation Forecasting of Tsunamis (SIFT).

Importance to NOAA Goals

NOAA bears national responsibility for tsunami warnings and hazard mitigation, as explicitly stated in the Advance Short-Term Warning and Forecast Services component of the NOAA Strategic Plan: A Vision for 2005. The only NOAA activity conducting tsunami R&D in support of this mission and the U.S. NTHMP is the PMEL Tsunami Program.

Tsunami Inundation Mapping Effort (TIME) [http://www.pmel.noaa.gov/tsunami/time/]

The Tsunami Inundation Mapping Efforts Center develops inundation maps for at-risk communities.

Major Goals and Strategies

Goal: Institutionalize TIME as a stable focal point for continuing U.S. tsunami modeling research, development, and application.

Strategy:

- Establish a virtual Facility for the Analysis and Comparison of Tsunami Simulations (FACTS) to link U.S. and foreign academic and government scientists, engineers, and emergency managers to on-line tsunami models, massive distributed databases (archived model runs, bathymetry/topography, field observations, etc.), and state-of-the-art analysis and visualization tools
- Exploit FACTS R&D to improve inundation mapping technology
- Expand coverage to all at-risk communities in the U.S. and U.S. protectorates
- Develop maintenance program to systematically revisit and upgrade existing maps

Resources Required

Add one full-time permanent modeler and increase budget by $200K to cover expansion of TIME activities and development of FACTS. Possible sources: re-programming of NTHMP funds; NSF/Network for Earthquake Engineering Simulation (NEES) and/or other outside funding.

Deep-ocean Assessment and Reporting of Tsunamis (DART) Project
[http://www.pmel.noaa.gov/tsunami/field_obs.html]

The Deep-ocean Assessment and Reporting of Tsunamis Project develops and maintains an early tsunami detection and real-time reporting network.

Major Goals and Strategies

Goals:

- Expand DART network to cover all major North Pacific tsunamigenic source regions
- Develop international and national partners/contributors/collaborators
- Improve DART systems to increase reliability

Strategy:

- Increase platform support through collaborations and joint research efforts
- Add additional oceanic and atmospheric sensors to DART platforms
- Decrease costs with improvements in fabrication, maintenance, and deployment methodologies

Resources Required

DART: Add one support person and increase budget by $350–500K to cover technological improvement, expansion, and maintenance of DART network. Possible sources: re-programming of NTHMP funds; research partners.

Short-term Inundation Forecasting of Tsunamis (SIFT) Project

The Short-term Inundation Forecasting of Tsunamis Project is developing real-time forecast guidance for the Department of Defense (DoD) Pacific Disaster Center and the NOAA operational Tsunami Warning Centers.

Major Goals and Strategies

Goal: Operational forecast capability for event- and site-specific tsunami inundation of all communities in the U.S. and U.S. protectorates that are at risk.

Strategy:

- Combine real-time data (seismic, DART, and coastal tide gage data) with pre-computed simulation databases to forecast inundation by first few waves
- Combine real-time data with statistical algorithm to forecast maximum heights of later waves
- Continue improvements through basic research: source specification, data inversion, etc.
- Collaborate on field experiments: Hawaii infragravity/surrogate tsunamis; Hilo intensive monitoring network; monitor Skagway landslide events

Resources Required

SIFT: Increase budget by $100K to cover field experiments. Possible sources: NASA/DoD, NSF/NEES and/or other outside funding.

Fisheries Oceanography Research (FOCI)

[http://www.pmel.noaa.gov/foci/home.html]

North Pacific Decadal Variability

Background

FOCI's long-term goal is to understand the physical and biological mechanisms that affect recruitment of fish and shellfish in Alaskan waters. Initially FOCI research focused on pollock in Shelikof Strait. Over the years our research has expanded to include the Bering Sea. As we studied how the biophysical environment impacts pollock, it became apparent that one cannot understand the variability in pollock recruitment without studying the ecosystem. We have broadened our research to include collaboration with scientists studying other fish, marine mammals, and birds. There is growing evidence that decadal variability of the ocean and atmosphere has been amplified through linkages to the biological communities resulting in rapid changes in species abundance and composition, and spatial distributions. FOCI is well positioned to take up the challenge of understanding this variability and the linkages, and establishing the observational database necessary to provide indicators and investigate this problem. The ability of managers to respond to rapid changes in ecosystems is now considered the most critical factor to the successful management of marine resources.

Goals

- Develop a strategy to determine when a regime shift has occurred within 2–3 years by monitoring and understanding mechanisms of climate in the North Pacific
- Identify the biolinks that connect climate shifts to viability in marine populations (fish, mammals and birds)

Strategies

- Deploy 15 biophysical moorings in the North Pacific that will provide time series in near-real time to detect physical and biological climate shifts. Instrumentation will include sensors that measure CO_2 and nutrients; concentration of phyto- and zooplankton, and fish, along with temperature, salinity, currents, and meteorological variables
- Use the biophysical moorings, satellite imagery, atmospheric data, and satellite tracked drifters to contrast two main hypothesis:

  1. The basin-scale spin up of the subarctic gyre, which is associated with the Pacific Decadal Oscillation (PDO), is the primary mechanism that determines decadal variability of the North Pacific; and

  2. Variability in local atmospheric forcing, which is correlated to the PDO, determines the oceanographic variability of the biologically important coastal region.

- Support development of fisheries and ecosystem models, which include regime shifts

Importance to NOAA Goals

Understanding and being able to predict environmental impacts on fisheries is necessary to advance fisheries management, which is part of the Build Sustainable Fisheries element of NOAA's Strategic Plan. Many of our most important commercial stocks in the Pacific Ocean and elsewhere require scientific information and improved management plans to meet the challenges posed by regime shifts and fishing pressure. FOCI's goals over the next 5 years and beyond will systematically focus on measurements of environmental indicators of ecosystem variability. Information will continue to be transferred through web pages, direct contacts with fisheries scientists, and contributions to the scientific literature and conferences.

Resources Required

Establishment of an array of long-term, real-time moorings requires an increase in funding of $2.5M/year and an additional 30 days/year of ship time. Funding opportunities include Fisheries and the Environment (FATE), Study of Environmental Change in the Arctic (SEARCH), Coastal Ocean Program (COP)/GLOBEC, and GEM. To maintain our effective leadership role in North Pacific research FOCI requires two new physical oceanographers and one post-doc. In addition three support scientists/technicians will be needed to process data, assist in analysis, maintain the database, and participate in research cruises. Increased supercomputer requirements are needed to run coupled North Pacific atmosphere/ocean models. One full-time web specialist is needed to maintain web pages that will provide data from the moorings and satellite-tracked drifters in near-real time.

III. New Research Initiatives

North Pacific Climate Research

Background

There is increasing evidence that coherence between physical and biological variables in the North Pacific appears to predominate at the decadal scale and not at the annual scale. Hierarchy theory states that there must be a spatial and temporal scale overlap for energy to be effectively transferred between system components. The temporal variations of the two modes of North Pacific weather patterns, the difference in shoaling of the mixed layer and zooplankton response between the late 1950s and 1980s, and the smaller mean size of salmonids in the 1990s all have strong decadal characteristics over a spatial scale of the North Pacific Gyre.

Variability of the ocean/atmosphere system in the central North Pacific is believed to be important both for continental U.S. climate and for northwestern fisheries. The Pacific Decadal Oscillation (PDO) has recently been characterized from ocean surface data, and has also been strongly linked to salmon catch in the Canadian and Alaskan fisheries. The type and frequency of medium duration (a few days to a couple of weeks) atmospheric anomalies over the North Pacific also recently have been linked with periods of substantial positive or negative PDO SST anomalies. There is evidence that SST responds relatively quickly (i.e., on monthly timescales) to anomalous atmospheric forcing in the North Pacific. But there is scant understanding of the mechanism(s) which integrate or rectify the ocean's response to yield the decadal timescales of the PDO.

The northern North Pacific and Bering Sea are also influenced by another climate mode, the Arctic Oscillation (AO). The AO represents a modulation in the speed of the polar vortex which results from a transfer of mass between the Arctic and mid-latitudes. The importance of the AO is that there has been a persistent positive phase since the 1970s, which appears to be associated with increased levels of CO_2. Springtime warmings are taking high latitude ecosystems into new regimes, with impacts on commercial and endangered species.

PMEL has a unique opportunity and capability to begin to implement a biological, chemical, and physical observing system that will better document the structure and dynamics of climate modes such as the PDO and their relationships to fisheries. Current or soon-to-be technology includes measurements of carbon system variables, chlorophyll, and ambient light. In addition to other observations, an Acoustic Doppler Current Profiler (ADCP) provides important biological backscatter measurements that provide information on distribution, timing, and abundance of zooplankton communities. Mixed layer depth, however, is probably the most important parameter. The central and northern portion of the North Pacific gyre would be the most important locations for observations. For historical reasons, Ocean Station PAPA should be included.

By re-occupying the Ocean Weather Station (OWS) PAPA site (45°N, 150°W) with an upper ocean mooring, we can initiate the deployment of an optimal array of moorings that will document air-sea interaction and upper ocean variability in the central North Pacific. These observations are timely because it appears that the present climatic regime is different from the regime that prevailed while OWS PAPA was in place. The installation and maintenance of a mooring at OWS PAPA, and eventually at other sites in the North Pacific, would also provide opportunities to measure biological parameters of direct relevance to fisheries.

The linkages between the physical and biological components of the North Pacific on interannual timescales have been investigated in planning for FATE, a joint OAR/NMFS program. An observational strategy has been designed to address outstanding issues regarding the marine ecosystem of the North Pacific. For example, it is unclear why marine populations co-vary so strongly across the entire North Pacific. Resolving this and other issues requires the types of measurements that can be provided by state-of-the-art biophysical moorings. A logical first step would be to collect simultaneous measurements in the two poles of the PDO, and then expand the array as our understanding of the system matures.

Because of improvements in technology it is now, or soon will be, possible to make in situ measurements of precipitation as well as evaporation over the open ocean. These types of in situ observations are virtually nonexistent, yet are recognized as being of great scientific interest (e.g., Global Energy and Water Experiment [GEWEX], Tropical Rainfall Measuring Mission [TRMM], etc.). The array of moorings would also provide badly needed validation data sets for mid-latitude satellite estimates of SST, sea level height, surface winds, precipitation, and net surface radiation. These observations thus would support the needed on-going calibration of National Polar-orbiting Operational Environmental Satellite System (NPOESS) sea surface sensors as well as satellite sensors that will be flown in research mode by NASA in coming years.

With a focused Pacific observing program, PMEL has the opportunity to contribute toward understanding decadal variability. We would be positioned to provide vital insight into the evaluation and interpretation of high-resolution numerical model results of the Pacific. The CLIVAR PBECS program has identified long-term observations in support of understanding and predicting decadal Pacific Ocean variability as priorities. We would be able to make a major contribution to these Climate Variability and Prediction Program (CLIVAR) goals. We also would be able to collaborate with the portion of the biological community that has developed the North Pacific Marine Science Organization (PICES) Climate Change and Carrying Capacity Initiative, the NMFS Carrying Capacity Project, and the Global Ocean Ecosystems Dynamics (GLOBEC) programs. We also could contribute importantly to the developing U.S. Carbon Cycle Science program, with its goal of documenting and understanding the sources and sinks that control Northern Hemisphere atmospheric carbon dioxide concentrations.

The Goals

1. Develop and implement a sustained observing system for physical, chemical, and biological processes in the North Pacific.

2. Support climate and fisheries predictions and services through database development, observations, and modeling.

Near-Term Scientific Objectives

1. Evaluate existing large-scale gridded data sets and climate model outputs to explore causal mechanisms for the PDO .

2. Compare air-sea heat fluxes, SST, and upper-ocean thermal structure with historical data sets from OWS PAPA. Focus on the differences between opposite phases of the PDO in structures such as mixed-layer depth.

3. Compare observed rainfall with operational NWP simulations of rainfall at OWS PAPA. Provide quantitative measures of the accuracy of model parameterizations of latent heating over a near data-void oceanic region.

4. Participate in the Study of Environmental Change in the Arctic (SEARCH) Program.

The Future

In conjunction with evolving FOCI and OCRD research activities, the OWS PAPA and other North Pacific sites would be maintained indefinitely; additional mooring sites would be added to meet and complement CLIVAR, Global Climate Observing System (GCOS), and fisheries needs. We anticipate that there would be special interest in sites monitoring the poles of the PDO, the Alaskan Stream, and the Kamchatka/Oyashio Current.

Develop and implement an integrated U.S.-Canadian Gulf of Alaska observing system, with supporting modeling and data assimilation work. Expand the integrated observing system westward as resources permit and in the form suggested by observing system design studies.

Acoustic Monitoring Research
[http://newport.pmel.noaa.gov/geophysics/acoustics_geophys.html]

Background

Passive underwater acoustics provides an ideal means to monitor ocean phenomena on a global basis. The presence of an underwater "sound channel" [http://newport.pmel.noaa.gov/whales/acoustics.html#SOFAR] allows propagation of low-frequency acoustic energy over ocean-basin scales. This medium has been exploited by the United States Navy since World War II for military applications, but recently PMEL-led research efforts have proven the value of these same methods to ocean environmental science. Significant discoveries have included the ability to monitor underwater seismic activity at levels far below the threshold of the land seismic networks [http://newport.pmel.noaa.gov/geophysics/land-sosus.html], the detection of undersea volcanic [http://newport.pmel.noaa.gov/geophysics/land-sosus.html]activity associated with seafloor spreading, the discovery of the sub-seafloor, microbial biosphere, and the distribution and migratory paths of large baleen whales [http://newport.pmel.noaa.gov/whales/], in particular the blue whale.

Importance to NOAA

There are numerous applications of underwater acoustics relevant to NOAA's mission and environmental science in general. Many applications outside environmental science critical to the Nation are also obtained through underwater acoustic monitoring. Only passive methods (simple listening without injecting sound into the ocean) are being proposed here. Acoustic tomography for long-term climate change measurements are being addressed by the academic community. Areas of effort could include:

Biological Acoustics
Ambient Noise Monitoring
Ocean Seismic Monitoring
Volcanic/Hydrothermal Monitoring and the Subseafloor Biosphere
Sea Surface Monitoring
Human Activity Monitoring

Resources Required

Initially, PMEL's acoustic effort depended exclusively on the use of U.S. Navy Sound Surveillance System (SOSUS) [http://newport.pmel.noaa.gov/whales/], but low-cost portable monitoring devices [http://newport.pmel.noaa.gov/geophysics/haru_system.html] have been developed in Newport and deployed in several ocean areas. Partnerships are in place between NOAA/OAR and NOAA/NMFS, as well as with various Navy commands, academic institutions, and international partners. At least three budget initiatives are currently on the table to support acoustics within NOAA, and PMEL is the lead component for providing acoustic technology and expertise on each. These include a large scale ($10M/year) effort to monitor the entire northern hemisphere for ambient noise using portable hydrophones and existing sensors, and integrating all of these data streams. A smaller scale effort ($1.5M/year) with NMFS regional centers focuses on applying acoustic methods to marine mammal population assessment. Finally, acoustic monitoring is a key component of the NeMO project. Which, if any, of these initiatives is funded will determine the scale of effort and impact on the Laboratory. Engineering development has been shared between the project and EDD in the past and this would continue. Manufacturing a large stable of instruments and moorings would require an outside contract, and would require additional staging facilities similar to those used by TOGA/TAO. New staff, and the associated office and laboratory space, would also depend on the scale of the funded effort but would probably require a large presence at Sand Point or significant new construction in Newport. Finally, data integration and dissemination would require additional computing and communications facilities.

IV. Organization and Support

The organizational structure at PMEL [http://www.pmel.noaa.gov/home/pmel-org.html] is focused on one objective: providing laboratory scientists with the most productive environment possible to perform high-quality research. In order to address administrative necessities, research efforts are partitioned within two Research Divisions headed by active research scientists in relevant fields. An Administrative Division provides the interface to the Western Area Support Center and a wide range of internal functions to reduce repetition of activities within the other divisions. Technical support is provided by the Engineering

Development Division and Computer Network Services Division. Other centralized functions and the overall leadership of the Laboratory is provided by the Office of the Director.

Ocean Climate Research Division

The Ocean Climate Research Division (OCRD) is focused on in situ observations of the physical, chemical, and biological properties of both the ocean and the marine atmosphere important for understanding climate variability. Many of the measurements can best be interpreted in terms of models, so modeling studies are another major OCRD activity. Climate studies are divided into two overlapping groups based on the timescales of interest. One is seasonal to interannual ("short term climate variability") and the other is decadal to centennial.

Ocean Environment Research Division

The Ocean Environment Research Division (OERD) includes three major research efforts within PMEL: The Vents Program [http://www.pmel.noaa.gov/vents/home.html], which conducts interdisciplinary research focused on determining the impacts of the earth's largest volcanic system on the ocean; the Fisheries Oceanography Coordinated Investigations (FOCI) [http://www.pmel.noaa.gov/foci/home.html], which is a collection of NOAA research programs attempting to understand the influence of environment on the abundance of various commercially valuable fish and shellfish stocks in Alaskan waters and their role in the ecosystem; and the Tsunami Research Program [http://www.pmel.noaa.gov/tsunami/home.html], which seeks to mitigate tsunami hazards to Hawaii, California, Oregon, Washington, and Alaska. Division personnel reside at PMEL facilities in both Seattle and Newport, Oregon.

Administrative Division

The Administrative Division (AD) provides a wide range of services to PMEL scientists including procurement, contract/grant support, financial management, travel arrangements, property management, publication support, and interfacing with the Western Area Support Center (WASC) [http://www.wasc.noaa.gov/]. During the next 5 years, AD will develop and deploy the Financial Data Management System (FDMS) [http://www.pmel.noaa.gov/fdms/] to all operating units of OAR, which will allow integrated financial management over all of OAR. Also within the next 5 years, AD will be instrumental in helping PMEL transition to Financial Management Center (FMC) status and the Commerce Administrative Management System (CAMS) accounting system [http://www.rdc.noaa.gov/%7Ecams/index.html].

Engineering Development Division

The Engineering Development Divison (EDD) [http://www.pmel.noaa.gov/engineering/edd-home.html] supports the PMEL research effort with innovations in the fields of electronics, mechanics, materials, and software engineering. The staff is responsive to the needs of a broad range of investigators, and the nature and scope of projects vary accordingly. Project engineering is employed to expand and refine our measurement capability in the marine environment.

Computing and Network Services Division

The Computing and Network Services Division (CNSD) [http://www.pmel.noaa.gov/cnsd/] provides computing and network resources and support for PMEL scientists and staff. PMEL's computer facilities have evolved from a simple remote job entry terminal system to a complex networking distributed system with multi-platform server and desktop systems. PMEL's computing and networking resources have improved steadily and dramatically in the past 25 years and CNSD has been instrumental in implementing changes and supporting both new and existing technologies.

Office of the Director

The Office of the Director (OD) oversees the operation of the Laboratory, including ship scheduling and support, information technology support, facilities support, and is the primary interface to OAR and the rest of NOAA.

V. Infrastructure

PMEL's scientific productivity depends upon a stable infrastructure which includes first-rate scientific and technical personnel, state-of-the-art capital equipment, easy access to data and information, suitable office and laboratory space, and the availability of ship, aircraft, and ROV resources with which to conduct field investigations. Although careful stewardship of these resources is critical to the continuation of existing programs, new technological advances in computers, communications, and instrumentation require a more aggressive investment if we are to respond to the challenges presented by NOAA's cross-cutting programs.

Personnel

Following a period of rapid growth in the 1970s (during which PMEL's staff grew from approximately 20 in 1973 to a high of 125 in 1979), the 1980s were characterized by relative stability and low personnel turnover. This resulted in a highly experienced scientific and technical staff that successfully completed many difficult and formative field experiments, establishing PMEL as an early leader in climate and coastal programs. During the 1990s, the number of federal employees actually declined due to tightening budgets and the shift from base-funded programs to an increasing reliance on proposal-funded research (making it easier to pay non-federal salaries than federal salaries). In 2000, the number of federal employees (GS, wage grade, and NOAA Corps Officers) was 100, while the number of University of Washington and Oregon State University employees on campus (joint institute personnel) had climbed to 60. In addition, PMEL had 20 contract personnel aboard (primarily located within the support divisions) and 2 post-doctoral fellows, for a total staff of 182 persons.

In 2000, 82% of PMEL's senior staff had been with the Laboratory for more than ten years, a slight increase over the 1996 value of 78%. Of those senior employees, 5 are retirement eligible at this time (15% of the Lab's senior staff) and by 2005, another 11 employees will become retirement-eligible, representing 48% of the Lab's senior staff. With the recent trend in Congress of not funding inflationary pay adjustments, the present trend of allowing vacancies to go unfilled for long periods is likely to continue, which will, over time, erode the scientific leadership within the Laboratory. It is important that promising young scientists and technicians be recruited at every opportunity to keep the Laboratory fresh and energized.

While the number of federal employees has declined, the number of joint institute employees working on campus has increased from 46 in 1996 to 60 in 2000.

The recent problems with the NOAA Corps have led to a decrease in the number of officers in the Corps and, subsequently, a decrease in the number of Corps officers at PMEL. While there were 12 officers at PMEL as recently as 1998, today there are only seven officers. Due to the decrease in ships serving PMEL programs and the number of junior officers aboard those ships, it is becoming increasingly difficult to attract junior officers to PMEL because of unfamiliarity with our programs. Several billets are key positions that have been held by officers for many years that are being forced to go unfilled for long periods.

Capital Equipment

PMEL's capital equipment inventory involves oceanographic instrumentation, computing and networking hardware, and support equipment. This inventory has an FY 00 value of approximately $12.5M (coincidentally, very near to the same dollar value of the inventory in 1996). Significant items in the inventory include 200 acoustic releases, 170 current meters (including acoustic Doppler current meters), 7 conductivity-temperature-depth probe/profilers (CTDs), 46 Sea-Bird Conductivity and Temperature Recorders (SEACATs), 12 water level recorders (BPRs), 35 chromatographs, chemical analyzers, and spectrometers, 10 microscopes, 3 fork lifts, and miscellaneous support equipment, including a wind tunnel, a 38-foot work boat, environmental chambers, electronic test instrumentation, and machine shop tools. The in-house computing inventory consists of 16 central server systems, 2 router systems, 20 ethernet switches, and nearly 600 desktop, workstation, X-terminals, and laptop systems. While most of the Lab's capital equipment is owned by programs, certain common use items (i.e., acoustic releases, CTDs) are maintained by a central PMEL Instrument Pool. It is essential that this equipment be maintained and enhanced to meet growing and technically difficult program requirements. Programs must be cognizant of the need to replace or modernize equipment and include those costs in proposals and initiatives, as appropriate.

In addition to this PMEL-owned equipment, the Laboratory maintains access to the U.S. Navy's SOSUS network through leased lines between PMEL, Newport, and NAS Whidbey Island, Washington. PMEL also has access to supercomputing resources at the Alaska Supercomputing Center in Fairbanks and is in the final stages of gaining access to the massively parallel processing system at the OAR Forecast Systems Laboratory in Boulder, Colorado.

Management and support of instrumentation and computer/network hardware are generally provided by the Engineering Development Division and the Computing and Network Services Division. User groups provide the primary forum for open discussions concerning scheduling, maintenance, and upgrades. Periodic involvement of and feedback from user groups are considered essential to providing responsive laboratory services. For new and emerging technologies that are expected to drive the long-term health of the Laboratory (e.g., Doppler current profilers, nutrient analyzers, and desktop systems), special laboratory-wide working groups will provide the focus for early development and implementation.

Data and Information

The data and information managed within PMEL have been steadily increasing in volume and complexity during the past 5 years and it is expected that this trend will continue over the next 5 years. PMEL can meet the challenge of providing timely, efficient, and centralized access to an increasingly large information flow by using its substantial software and technology base and making maximum use of emerging technologies such as the WorldWide Web, powerful, low-cost, computer hardware and software, and modern technologies for managing and accessing web page content and scientific data.

PMEL information technology [http://www.pmel.noaa.gov/%7Enns/PMEL2000/PMEL-IT_files/v3_document.htm] developments have culminated in significant contributions to NOAA in the following areas: 1) software for data management, analysis, and distribution, 2) thematic web pages for science, data distribution, topical information, and administrative information, 3) visualization, 4) administrative systems, and 5) networking. These activities have resulted in recognition of PMEL as a center of excellence in support of NOAA and the wider scientific community. Continuation of this expertise rests on continued active software development activities based on modern technologies, critical infrastructure support for desktop computing, networking, Internet access, and exploration and evaluation of emerging technologies.

PMEL faces a significant challenge over the next 5 years to keep up with fast-changing Internet, computing, and information technologies while maintaining a stable computing environment. Increased access to and dependency on Internet-shared data and information as well as applications that share multimedia information will continue to require bandwidth increases on both backbone and desktop. Implicit in these requirements is the need for a robust physical infrastructure and continued high bandwidth access to the Internet as well as system and network security controls and policies. High performance web servers and web-based applications are critical for a highly visible scientific laboratory. E-mail continues to grow in volume and complexity and a dedicated mail server will soon be serving mail to desktop users. Both commercial and custom software are used for scientific computing and need to be supported, with different requirements for both types. Storage capacities continue to grow requiring increased requirements for network backup services. High-performance computing resources must keep pace with industry advances, especially for modeling applications. High-speed bandwidth to homes is bringing new remote access requirements and security concerns. System management is critical, especially as desktop operating systems add functionality. Scalable solutions for supporting desktop systems must be found so careful and responsive system management can be provided. Effective training and help desk services are needed, especially to introduce new capabilities to users. Meanwhile, as this new technology is introduced, high-performance local servers, printers, and services must be kept stable and up to date and older technology must be retired.

Office, Laboratory, and Shop Space

Space needs have risen slowly over the past several years and are expected to continue as programs expand only slowly or remain constant. As the number of personnel within the Lab increases, so does the need for office space. PMEL is currently approaching the limit of being able to absorb any more personnel within the confines of the present PMEL space configured for offices in Building 3. Average square footage for office space (not including labs and shops or the people who aren't assigned office space) within the Laboratory is 141 sq. ft. per person.

Given the recent decision to make the Laboratory liable for rent charges on a square foot basis, it is likely that the Lab will be constrained to absorb any minor near-term growth of personnel within the existing space allocated to the Laboratory. In the event of the creation of a new major laboratory program, consideration will be given to expansion into Building 32, although any new program commitment would have to provide sufficient infrastructure dollars to bring those spaces into compliance with current codes and habitability minimums. Other possible space options may present themselves as the locations of PMC and NOS are subject to change in the coming year or two.

With regard to shop and electronic lab spaces, as the number of moorings per year deployed and recovered by the Lab increases, so does the need for the preparation, staging, and storage of equipment. The number of moorings recovered and deployed annually has increased dramatically since the mid-80s, yet our methods of turning moorings around remains for the most part unchanged. Perhaps a thorough review of the way in which moorings are turned around is in order to determine whether there are more efficient methods to accomplish the preparation, storage, and shipping for redeployment.

Ship, Aircraft, and Submersible Requirements

During FY 2000, PMEL utilized 531 days of NOAA ship time to support its programs. Time was split between the NOAA Ships *Ronald H. Brown* (209 days at sea), *Ka'imimoana* (246 days), and *Miller Freeman* (76 days). Projects supported in 2000 include TAO, FOCI, Vents, Tsunami DART, and NOPP. As is clear from earlier sections of this document, the focus on collecting long-term observations and conducting periodic intensive field surveys at PMEL will continue for the next 5 years, necessitating the continuing requirement for large amounts of ship time. For FY 2001, PMEL scientists requested 625 sea days of Class I and Class II ship time, the equivalent of 2.54 ship years (at 250 sea days per year). The same holds true for the FY 2002 request. PMEL programs could make full use of the *Ronald H. Brown* and the *Ka'imimoana* and still have need of approximately one-half year of ship time to meet program requirements. This need will continue for the foreseeable future, necessitating PMEL's use of UNOLS or other charter platforms. The University of Washington R/V *Thomas G. Thompson* is an acceptable substitute for *Brown*, but lacks several systems installed aboard *Brown* by PMEL and Office of Marine and Aviation Operations (OMAO) to support PMEL programs (nutrient meter, CO_2 sampling system, Terrascan receiver, extendable transducer, etc.). The Oregon State University R/V *Wecoma* has been found to be adequate for some tasks, particularly Vents water column investigations, but less desirable for high latitude work, mooring work, or ROV work where a large amount of open deck space is required. Other vessels used in recent years include the Canadian Icebreaking Buoy Tender *Laurier*, the Russian R/V *Professor Kaginovskiy*, as well as several other smaller vessels arranged in-house for short-term near-shore projects. Of these, *Laurier* remains under serious consideration for future high latitude support, particularly of FOCI programs.

The competition for ship time, both aboard NOAA ships and charter platforms, is becoming very keen among the labs and between programs within the lab. Funds from the OAR Acquisition of Data line item have been insufficient for us to accomplish our research goals, whether it be base-funded research or proposal-based research, which is even more dependent on delivery of promised results. Addition of the planned "FRV40" fisheries research vessel to the fleet in 2004 is expected to ease some of the problem with securing ship time in high latitudes, but it remains to be seen whether NOAA can continue to operate *Miller Freeman* after the addition of the first FRV40 vessel to the fleet.

In addition to ship time, about 100 hours of WP-3D aircraft time is utilized every other year to support atmospheric and boundary layer investigations in the tropics or in coastal areas. The Vents and the Groundfish Habitat programs require the annual use of ROVs, primarily the Canadian ROV ROPOS (Remotely Operated Platform for Ocean Science), to investigate seafloor hydrothermal vents at the NeMO observatory and near-shore groundfish habitat areas, respectively. Annual ROV use for these two programs is expected to remain near 30 diving days per year.

VI. Summary

PMEL's primary mission is to conduct interdisciplinary scientific investigations in support of themes outlined in the NOAA Strategic Plan. Toward this end, PMEL has developed a reputation for being able to routinely conduct complex and difficult observational experiments throughout the Pacific Ocean and adjacent seas. The Laboratory's strength lies in the experience and knowledge of its professional staff and their ability to obtain, process, and analyze high-quality oceanographic measurements. This capability requires a modern, well-maintained infrastucture of scientific instruments, computing and networking resources, and oceanographic research ships. In the future, PMEL will push to maintain and enhance its proven observational and analysis capabilities with increased emphasis on numerical modeling techniques as a tool to aid in observing system design, experiment planning, and data interpretation. PMEL will continue to focus on research that improves the services and products that NOAA's service Line Offices offer to the general public.

Successful implementation of long-term experiments requires a long-term organizational commitment. All of the research programs described above have evolved through several stages of planning and development that are absolutely essential for success. First is scientific planning, which cannot be conducted within a vacuum but must be accomplished in close association with the broader international scientific community. PMEL scientists serve on or chair many of the planning committees involved in science planning and have done so throughout the last few decades. Experimental design, the development of prototypes, the field implementation and maintenance of systems, and the robust acquisition and transmission of data from the field to the shore must be performed in deliberate sequence to assure quality at each stage. The collected data only achieve their full value after careful scientific analysis, as reflected in the publication of quality, peer-reviewed scientific manuscripts, and the data are made available for use by other agency line offices, other scientific research programs, and the general public. Finally, all of these projects must evolve with the changing requirements placed on NOAA to address critical national environmental issues, as reflected in the NOAA strategic plan and OAR mission statement.

A major challenge for every NOAA research laboratory is to anticipate the needs of the agency far enough in advance to have critical experiments in place when they are required. Such long-term experiments require many years to several decades to accomplish, and therefore the scientific planning and experimental design must be completed far in advance of the final issuing of a requirement. PMEL has been able to successfully meet this challenge and remain relevant to both the NOAA Strategic Plan and the Strategic Plan for NOAA Research. The following matrix illustrates the current status of many of the projects described in this planning document, including (in the final two columns) how each addresses specific elements of the NOAA-wide and NOAA Research Strategic Plans. As the needs of NOAA and the Nation change, the focus of PMEL research will also change to reflect these new priorities and the mission of NOAA Research:

> to conduct research, develop products, and provide scientific information and leadership toward fostering NOAA's evolving environmental and economic mission.

PMEL Long-Term Experimental Status as of September 2000

Project	Science Planning	Experimental Design	Prototype Development	Implementation	Operations	Science Products	Outreach	NOAA Relevance	NOAA Research Element
Tropical Climate	X	X	X	X	X	X	X	SIC	Economy
Tsunami	X	X	X	Underway		X	X	SHC	Safety
Seafloor Processes	X	X	Underway	Underway	Underway	X	X	DCC	Economy
Fisheries Oceanography	X	X	X	Underway		X	X	BSF	Economy
Global Carbon Cycle	X	X	Underway			X		DCC	Health
North Pacific Climate	Underway							SIC	Economy
Acoustic Monitoring	Underway		X					RPS	Health

NOAA Strategic Elements

SIC = Seasonal to Interannual Climate
DCC = Decadal to Centennial Change
BSF = Build Sustainable Fisheries
RPS = Recover Protected Species
SHC = Sustain Healthy Coasts

VII. Acronyms

ACE-I, ACE-II	Aerosol Characterization Experiment I and II
ADCP	Acoustic Doppler Current Profiler
AFSC	Alaska Fisheries Science Center
AO	Arctic Oscillation
AOML	Atlantic Oceanographic and Meteorological Laboratory
ATLAS	Autonomous Temperature Line Acquisition System (moorings)
AUV	Autonomous Underwater Vehicle
BPR	Bottom Pressure Recorders
CCSP	Carbon Cycle Science Plan
CGCP	Climate and Global Change Program
CLIVAR	Climate Variability and Prediction Program
CNSD	Computing and Network Services Division
COADS	Comprehensive Ocean-Atmosphere Data Set
CoOP	Coastal Ocean Processes
COP	Coastal Ocean Program
CT	Cold Tongue
DART	Deep-ocean Assessment and Reporting of Tsunamis
DODS	Distributed Ocean Data System
DOE	Department of Energy
ENSO	El Niño-Southern Oscillation
EPIC	Eastern Pacific Investigation of Climate Processes
ESDIM	Environmental Services Data and Information Management
FACTS	Facility for the Analysis and Comparison of Tsunami Simulations
FATE	Fisheries and the Environment
FEMA	Federal Emergency Management Agency
FOCI	Fisheries Oceanography Coordinated Investigations
GASEX	Gas Exchange Experiment
GCMD	Global Change Master Directory (NASA)

GCOS	Global Climate Observing System
GEM	Gulf Ecosystem Monitoring
GEWEX	Global Energy and Water Experiment
GLOBEC	Global Ocean Ecosystems Dynamics
GODAE	Global Ocean Data Assimilation Experiment
HPCC	High Performance Computing and Communications
IARC	International Arctic Research Center
IGAC	International Global Atmospheric Chemistry Program
IMET	Improved METeorological Instrumentation
INDOEX	Indian Ocean Experiment
IPCC	Intergovernmental Panel on Climate Change
IPRC	International Pacific Research Center
ITCZ	Intertropical Convergence Zone
JAMSTEC	Japan Marine Science and Technology Center
JGOFS	Joint Global Ocean Flux Study
JISAO	Joint Institute for the Study of Atmosphere and Ocean
LAN	Local Area Network
LAS	Live Access Server
NASA	National Aeronautics and Space Administration
NCEP	National Centers for Environmental Prediction
NEES	Network for Earthquake Engineering Simulation
NeMO	New Millennium Observatory
NEPTUNE	submarine network of fiber-optic cables on the Juan de Fuca Ridge
NOAA	National Oceanic and Atmospheric Administration
NOPP	National Ocean Partnership Program
NPMR	North Pacific Marine Research Program
NSF	National Science Foundation
NTHMP	National Tsunami Hazard Mitigation Program
NVDS	NOAA Virtual Data System
OACES	Ocean-Atmosphere Carbon Exchange Study

OAR	Office of Oceanic and Atmospheric Research
OGCM	Ocean General Circulation Model
OGP	Office of Global Programs
OWS	Ocean Weather Station
PACS	Pan-American Climate Studies
PBECS	Pacific Basin Extended Climate Study
PDO	Pacific Decadal Oscillation
PICES	North Pacific Marine Science Organization
PIRATA	Pilot Research Moored Array in the Tropical Atlantic
PMEL	Pacific Marine Environmental Laboratory
RIDGE	Ridge InterDisciplinary Global Experiment (program)
RITS	Radiatively Important Trace Species
ROV	Remotely Operated Vehicle
SEARCH	Study of Environmental Arctic Change
SEBSCC	Southeast Bering Sea Carrying Capacity
SIFT	Short-term Inundation Forecasting of Tsunamis
SLP	Sea Level Pressure
SOSUS	Sound Surveillance System
SST	Sea Surface Temperature
SSTA	Sea Surface Temperature Anomaly
TAO	Tropical Atmosphere-Ocean Array
TIME	Tsunami Inundation Mapping Efforts
TMAP	Thermal Mapping and Analysis Program
TOGA	Tropical Ocean and Global Atmosphere (program) [WCRP]
TOPEX Poseidon	Altimetry Research in Ocean Circulation (ocean surface topography satellite mission [NASA-CNES]
TRMM	Tropical Rainfall Measuring Mission
UA	University of Alaska
USGS	United States Geological Survey

VOS	Volunteer Observing Ship
WHOI	Woods Hole Oceanographic Institution
VENTS	NOAA’s hydrothermal venting research program
WOCE	World Ocean Circulation Experiment
XBT	Expendable Bathythermograph

VIII. Appendix

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
OFFICE OF OCEANIC AND ATMOSPHERIC RESEARCH
Environmental Research Laboratories
1315 East West Highway
Silver Spring, Maryland 20910

December 18, 1998

MEMORANDUM FOR: Eddie N. Bernard
Director, PMEL

FROM: James L. Rasmussen
Director

SUBJECT: Pacific Marine Environmental Laboratory Review

I want to commend you and your staff for organizing and conducting a very effective review of Pacific Marine Environmental Laboratory on June 23-24, 1998. The expert reviewers were well qualified to review the Laboratory and the presentation, posters and background materials were well done and throughly informative. All reviewers commented on the PMEL use of the internet as the key infrastructure medium for the review especially the availability of the review material before and after the actual review. Using the web capability as the mechanisms for video displays during the review was innovative and allowed for a smooth flow of information. Such presentations will improve as everyone gets used to the system - PMEL's efforts in this regard are truly cutting edge and will be emulated.

By now you have received the written comments from the reviewers and perhaps have begun to act on their advice. In this letter I would like to provide an emphasis on these comments that seem particularly important to me and offer my own comments based not only on the review, but also on my general awareness of PMEL.

First, I want to concur with the unanimous statements of the Reviewers that PMEL is conducting important programs with a high degree of scientific quality. The over-all publication record and international reputation; the strength of the engineering and technician infrastructure; the excellent facilities (with some concern for a growing requirement for office space for scientists); the clear signal that PMEL is truly focusing on carrying out excellent research on a limited set of scientific programs - rather than spreading the effort over a wider spectrum of possible research themes; the contribution to NOAA’s mission and to ocean science and services in general and the quality of your laboratory management were all cited by the reviewers as evidence that PMEL is truly a vital component of ERL, NOAA and the overall ocean/atmosphere science community.

The ocean observations activities of PMEL were highlighted by all of the reviews as a core function of PMEL. The role of the PMEL engineers and technicians in this success was clearly acknowledged. The importance of having the science programs (analysis and modeling) tied closely with the more engineering and operational activities was underscored. The tie here with the University of Washington (JISAO and Hayes Center) seemed to be unclear and bothersome to at least one reviewer. Another felt that joint work sessions or planning workshops of these entities and PMEL would help clarify the situation and develop working relationships that the outside world (and ERL Headquarters) would understand and support. The emergence of Scripps as a player in the NOAA/ERL program should be entrained in the growing ocean observations program and including them in the dialog at some shape would also be useful and constructive.

The importance of PMEL’s emergence as a source of real-time ocean data for services and research was also highlighted by reviewers. We need to work to ensure that this highly visible role is fostered and improved. Working in the context of a distributed data quality control and dissemination and archival system and in cooperation with the emerging activities at AOML and with the Joint/Cooperative Institutes should prove to be an exceedingly cost effective way to deliver the data to the broad user community to NOAA’s credit and visibility. Extending this effort to the hydrographic, chemical, and marine aerosol data sets was seen as important potential additions to this data distribution function.

Finally the reviews noted the contributions that PMEL scientists are making to national and international science program planning and implementation. In this regard PMEL management is encouraged to get its top-notch scientific staff involved in global science issues - at least as far as the scientific input and planning goes - and not limit itself to Pacific issues alone.

Without exception the external reviewers were pleased and supportive of PMEL - its scientific programs and management. It is gratifying to read the letter reports and to be reminded of the central role PMEL plays in ERL, NOAA and in ocean science on both the national and international levels. I congratulate you and the PMEL staff conducting such a comprehensive, thorough and enjoyable reviews.

Attachments

USC
UNIVERSITY
OF SOUTHERN
CALIFORNIA

Dr. James Rassmussen
Office of Oceanic and Atmospheric Research
ERL/NOAA
1315 East West Highway,
Silver Springs, Maryland 20910

September 19, 1998

Dear Dr. Rassmussen,

I am writing to submit the PMEL review proforma, and to apologize for the inordinate delay. Shortly after the review I traveled to Japan for two weeks and immediately upon my return to the US, the Papua New Guinea tsunami hit, and the subsequent filed investigation put me back considerably, in terms of my earlier commitments. I do hope however, that this review arrives in sufficient time to be considered by the NOAA administration.

The PMEL program review was conducted on June 23 and 24. The objective was to assess how well is primary mission of conducting interdisciplinary investigations supporting NOAA's overall strategic plan. The review was structured around the internet technology allowing participants and reviewers access to information about PMEL scientific programs before, during, and after the review. The review consisted of a few selected oral presentations followed by a poster session for each of PMEL's three major science divisions: Ocean Climate, Fisheries Oceanography, and Seafloor Spreading Research.

Overall, I was very impressed with the scope of PMEL's work, with how well it meets NOAA's goals and national scientific and economic priorities, and with the morale of the scientists and staff of the lab. PMEL runs efficiently and, without any exception, the budgets for most programs are a fraction of what the same program would cost if run by an institution of higher education. NOAA-PMEL is one of the crown jewels of NOAA and it should be nurtured and supported to continue its mission. NOAA-PMEL brings badly needed visibility to NOAA among the lay public which often regards the agency as a poor step-cousin to other more visible federal agencies. This reviewer was an earlier quiet observer of PMEL's tsunami work, but this review made me an enthusiastic convert and fan of its entire spectrum of activities.

In my view, the unique strength of PMEL is the delivery of end-to-end ocean systems including designing, engineering modeling, implementing and disseminating information. This integration of field and modeling results allows for the best understanding of the evolution of environmental systems and it more than adequately addresses NOAA's vision of becoming the authoritative voice on environmental assessment and prediction of weather/ climate and ocean resources and of water resources. I can think of a few other federal laboratories that match as well the parent's organization mission. Another excellent strength of the laboratory is that interdisciplinary research is fostered and conducted without the confines and the jargon of the politics of subfields of subfields.

In terms of accomplishments, clearly the cornerstones are the development of the ATLAS buoys and their deployment in the Tropical Atmosphere Ocean(TAO) and the TSUNAMI programs, and the VENTS program. The TAO array's ability to measure

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surface and subsurface parameters to 500 meters and the real time transmission of the data easily qualify as one of the top 10 engineering achievements in environmental monitoring of this century. The TAO array provided valuable data during the recent El Nino which helped mitigate substantially its impact on the west coast of the US, and the measurements will "feed" for years climate, atmospheric and oceanic modellers as they assess intrinsic physical mechanics of the ENSO. I highly recommend the extension of TAO into the program known as PIRATA for the tropical Atlantic.

VENTS is a program that effectively couples innovative technology development with innovative science of lucrative commercial potential. The discovery of the episodic thick lens of volcanically heated water rapidly injected above the active hudrothermal venting and its correct association with submarine eruptions is surely the "right stuff' for the nineties. The terrestrial seafloor is known in many locales less well than the surface of Venus, and for good reason, most agencies do not have the leadership or imagination to dedicate resources in what they probably perceive as a hum-drum field of research. Of course, chance favors the prepared mind, and the VENTS's discovery of hyperthermophilic bacteria and their unusual and unexpected biological attributes for pharmaceutical polymerases creates incredible commercial opportunities for American science. A toff of the hat to those who imagined and implemented this program. Oh, yes, incidentally, the associated SOSUS hydrophone array program is one of the best application of dual-use technology in practice today.

The Deep Ocean Assessment and Reporting of Tsunamis (DART) is an incredibly successful and cost-effective program which has provided the first nuggets of the holly grail of geophysical submarine research, i.e., the deepwater signature of tsunamis close to their generation. To this date, geophysical models of seafloor deformation are quite crude and can not provide adequate definition of the three-dimensional distribution of vertical seafloor displacement, of any practical use for real time for tsunami warnings. Even the best hydrodynamic models (such as PMEL's MOST which is the leading code in the world), these codes routinely underpredict the tsunami coastal inundation, primarily because of this difficulty with the definition of the initial seafloor deformation; only when nearshore, and only when massive amounts of nearfield seismologic data are available can the initial condition be sufficiently well-defined to produce quantitatively correct hydrodynamic predictions, as NOAA's MOST did for the Okushiri, Japan event, where it produced better quantitative results than the state-of-the-art Japanese codes, not to mention spectacular visualizations. Because of this difficulty with the initial condition, deep-ocean measurements are the only "hope" of getting quantitatively correct real-time predictions. This was the unanimous conclusion of an NSF sponsored workshop last year as published in SCIENCE in 1997, in a perspectives article which made specific mention of PMEL's DART program. DART will reduce the potential of false-tsunami warnings in coastal areas of the US, where false warnings not only reduce substantially the credibility of the warning centers, but they also cost upwards of $30million per false-alert.

NOAA-PMEL has taken leadership to organize the preparation of inundation maps for the Pacific States through the TIME program. As PMEL scientists realized the potential for quantitatively correct real-time warnings were possible through the application of efficient algorithms in the ATLAS buoy real-time data, the natural next step was the preparation of inundation maps for the Pacific States. Long before tsunamis became a favorite subject of science documentary producers, NOAA-PMEL quietly orchestrated the appropriation of funds and the raising of the awareness in the science and emergency services community for coastal hazards mitigation. This program's director managed exceedingly well to build sustainable collaborative projects with investigators in all the affected Pacific States, thereby disseminating PMEL's MOST technology effectively and with redundancy built in. This was not an easy task, as most individual investigators had their own pet-projects, yet NOAA-PMEL managed to bring the community together and agree on a consistent methodology to address the issue. In terms of bung for the buck, the tsunami program is the most leveraged, with only 20% NOAA basefunding. Not only the number of buoys needs to be increased by a factor of five at least, but also more resources need to be dedicated to the TIME project, particularly since NOAA is the only agency charged by Congress with tsunami hazards mitigation. As an added bonus, the TSUNAMI program appears to be the most visible program in the media, and the PMEL director, and the program scientists are quoted in newpapers around the Pacific almost daily when there is a tsunami disaster, not to mention that all tsunami documentaries filmed in the past fice years, they all feature PMEL's work; one of these documentaries has been airing weekly on cable in the last year, and it has brought tremendous visibility to NOAA at large.

I also want to mention the Fisheries and Oceanography Coordinated Investigations (FOCI) program with a goal to understand the recruitment of polock in the Gulf of Alaska in the Berring Sea. It does show promise of saving the Pacific walleye pollock from the fate of the cod and swordfish in the Grand Banks in the Atlantic. More importantly it promises the development of a methodology for a notoriously difficult problem.
Finally, Ferret is a very effective tool for analysis and visualization of data was developed at PMEL and it appears at least as good or better than commercial packages such as Spyglass or ImageLab. NOAH should invest resources in producing a user's manual and then consider making it more widely available than it already is.

In terms of difficulties, the aging of the population of senior scientists in the laboratory is a problem which -coupled with the tendency toward soft-funding positions replacing permanent positions-, this does affect the morale of some senior investigators. The PMEL leadership is aware of this, and interestingly the morale of the more junior people is high. One factor is the sirene location and the well-maintained physical plant of the laboratory which is an attraction all of its own, and the culture of innovation which permeates the lab. Spending two days among PMEL people was like reading an Ayn Rand book, quality is its own reward. Another feeling I had was that I was surfing with the lab the crest of the wave, amazing, as I am by nature a cynic. It is very refreshing that the lab still attracts top entry level people, despite the level of government salaries and the state of the economy which generates numerous other options for these entry-level staff. Nonetheless, this is an area that NOAA needs to address in its strategic planning, the lab needs to accelerate the rate at which it is adding people in advance of the retirement of its senior scientists, to provide continuity and mentorship to continue its innovative work well into the next century. Also, PMEL needs more base-funding to assist in public dissemination and "promotion" of its results in the FOCI and TAO programs, to match the visibility of the DART, TIME and VENTS programs.

Another difficulty is the leveraging of the laboratory and its increasing dependence on peer-reviewed funding. Even though peer-review helps the best science to get done, several of PMEL's programs are of strategic importance to the nation, and they should not be interrupted because of the political problems that sometimes individual investigators fall into with changes in personell in funding agencies. The continuity of time series in ocean data is paramount, or else the value of the existing results diminishes drastically. NOAA should carefully consider a venue to ensure that key PMEL programs have a cushion of funding to carry them through in lean years. This of course is the problem in many federal laboratories, but PMEL may fall a victim of its own success because of how highly it is leveraged with NOAA external funding. I recommend a minimum of 50% base funding in all programs, and that NOAA have a formula to reward the lab's successes in attracting NOAA-external funding, such as matching in base funding in the following FY all external funding of the prior year that exceeds a threshold,. say 10% of the total. This will allow for more stable funding, and it maybe a good scenario for the expansion of the laboratory.

As a final note, if PMEL is a crown jewel of NOAA, the director Dr. Eddie Bernard is the crown jewel of the laboratory. He leads by example, and I am certain that the high morale in the laboratory is to an extend due to his energy and vision. His work in tsunami hazard mitigation is exceedingly well known worldwide. More importantly, he is internationally recognized as the leader of the US scientific community in this field, and he is now the undisputed spokesperson of the international community as well. Through his own individual efforts, he has advanced the field significantly in the past fifteen years, both in terms of innovation and in terms of bringing in funding for the entire US scientific community in tsunami detection and tsunami hazards. Overall, his tenure at PMEL has enhanced NOAA's standing in world science.

I want to thank you and NOAA for allowing me this opportunity to participate in this review.

Sincerely yours,

signed

Costas Synolakis
Professor of Civil and Environmental Engineering

From:"depp@nsf.gov" 7-JUL-1998..05:36:23.5
To: James.Rasmussen@noaa.gov","Bernard@pmel.noaa.gov"

Comments for PMEL review

July 7, 1998

PMEL has a strong group of scientists and a balance of ’scientific expertise that is suitable to NOAA goals. It is clear that the science done at PMEL is o£ high quality and is a significant contribution to NOAA's mission, and to broader scientific efforts to understand the ocean environment. PMEL programs have achieved an excellent balance of cutting-edge research and applying that research to NOAA goals.

A second strength is PMEL's leadership in the use of technology. Particularly important are PMEL's abilities in instrumentation and observation technologies. The instrumentation and the resultant observational databases are a critical part of PMEL science programs, and are a significant contribution. Leadership in use of information technology was demonstrated in the on-line presentations during the review, and is also apparent in on-line databases and home pages.

A third strength is a management that takes a long-term view. The commitment of PMEL, and NOAA, management to long-term observations and monitoring, combined with excellent scientists and strength in observation and monitoring technology allows PMEL to contribute significantly, and perhaps uniquely, to understanding ocean processes. There is a compelling need for long-term time-series measurements, and PMEL's contribution in this area is a necessary part of the overall science and must be continued.

I am concerned that maintaining PMEL's commitment to long-term observations may be compromised by short-term funding commitments. The centrally-held program money (in OGP, COP, ESDIM and HPCC) has fostered ties between OAR and other line organizations, and the benefits are apparent in, for example, the FOCI program. The centrally-held project funding is, however, very much like academic funding and does not provide the continuity in funding necessary for long-term time-series measurements. There is (apparently) no mechanism for evaluating whether time-series observations begun with project funding need to be continued beyond the life of the project funding, and for continued support of these absevations. It is important for NOAA to recognize the importance of their contribution in this area, and that NOAA has perhaps a unique ability to provide the necessary long-term commitments.

There are a couple of personnel issues that are of concern. First is the status of people in the joint and cooperative institutes. The people in different institutes undoubtedly have different career and tenure linkages with NOAA and the associated universities. In some cases, however, the people do not have a firm position in either NOAA or the university. Unless the rewards offered in such positions are commensurate with the risks in job security, it will be difficult to get and keep good people. These institutes provide an important contribution to PMEL’s activities, and an important linkage with the academic community, and it is important that they continue to attract quality people.

The second issue that deserves some consideration is how to judge and reward people who contribute significantly to monitoring efforts. The effort required by the monitoring and the time necessary to accumulate sufficient data may not be reflected in the publication rate of the individual. Thus, publications may not be a suitable measure of the individual’s contributions.

I have two minor suggestions related to the science programs. Climate-change research has benefited from the linkage between observations (and real-time observations in particular) and modeling. While PMEL should not divert it's focus on observations, the strength to be gained from linkages to modeling should be recognized and fostered by other science programs.
Finally, NOAA should recognize that some of the most innovative science happens at the boundaries between disciplines and may not always fit nicely into the Strategic Plan. Interdisciplinary research is difficult, both scientifically and programmatically, and it is important to recognize and to foster such research.

David Epp
National Science Foundation
Marine Geology & Geophysics

July 21, 1998

Dr. James Rasmussen, Director
Office of Oceanic and Atmospheric Research
ERL/NOAA
1315 East West Highway
Silver Spring, MD 20910

Dear Jim,

It was a pleasure to participate in the review of PMEL that occurred on June 23 and 24, 1998 in Seattle. This is a written report of my observations, most specifically about the assigned task of reviewing the "Ocean Climate Research Division", headed by Dr. Dennis Moore. First, I will cover the general topics about which you requested opinions in your directive of June 23 rd and then I will add the more specific observations.

PMEL Research Program Review
by Peter Niiler, Professor of Oceanography
Scripps Institution of Oceanography
July 21, 1998

1. General Issues:

a) Relevance, uniqueness and feasibility to NOAA Strategic Plan
PMEL views itself as the principal, ocean-going NOAA research laboratory, with sole interest in the Pacific Ocean. This view can be advantageous when defending turf, but it can be limiting. PMEL's projects are principally in the Pacific, perhaps due to historical accidents and by division of sphere of influence at some higher level of NOAA management. Recently, the TAO project chose to expand its activities to the Atlantic with the deployment of PIRATA. PMEL should now change its mission to the global ocean, just as the ocean climate change is global. PMEL technology is applicable globally.

PMEL's research programs are relevant to the NOAA mission. This is carefully monitored by the mechanism of NOAA instituted peer review and the granting of project funds to scientists who can compete successfully on the national level. It is my contention that relevance is much more difficult to maintain when a program that is directed by a small number of Directors from the top than motivated from the grassroots. A small group has limited experience and tends to end up with a parochial view of what is important in science. Most individual research scientists tend to be interested most in their Ph.D. thesis topic, revisiting it perhaps too often. The peer reviewed science is a "good thing" for PMEL and it should be fostered by the hiring of scientists who can compete on that open market.

PMEL['s] mission is feasible because PMEL has great engineers and technicians.

b) Accomplishments, recognition and quality in community.

PMEL's reputation in physical oceanography and climate studies today relies heavily on the seagoing operations in the Pacific (and more recently in the Atlantic). These sea-going operations should be carefully fostered and supported, especially at a time when program managers in Washington find it easier to fund analysis of community data. But someone has to gather this community data, and PMEL is the leader here. In the community, PMEL's instrumental measurements have the highest reputation for quality, and the analysis is not far behind. An effective modeling component in relation to this data is not as evident. Modeling is just as difficult as observations and it requires just as much commitment and personnel. PMEL has decided that it will concentrate on the observations, which is wise for the moment.

A significant modeling program could be accomplished at PMEL, is always an opportunity and it would make eminent sense. But that would require a significant change of priorities at the top NOAA management's level. At the moment, NOAA's modeling of annual to interannual climate change is distributed in eight or nine national centers, all of which operate on a sub-critical level, working on identical problems. This sad state of affairs appears is further complicated by heavy congressional meddling, instigated by the scientists who wish to maintain their separate empires. I believe that the best mode of scientific interactions is where modelers and observers are concentrated in the same physical location. That scenario could well occur during the next millennium at PMEL. Since it is easier to install a roomful of workstations than to build a new harbor, PMEL should keep a pulse on the funding directions of modeling which are the most relevant to its observational programs.

It is the perception of the academic community that NOAA research laboratories have a specific responsibility to provide innovative technologies and methodologies to the operational arms of NOAA. At PMEL there is a much closer connection to the university laboratories than to the more operational side of NOAA. This is a NOAA wide phenomenon. Dr. Ants Leetmaa has explained to me several times that, for example, GFDL, busy in their academic research, does not support the model development that he needs for modernizing the ENSO prediction model. This course of action leaves NDBC and perhaps also the Fisheries (and NOS and etc.) floundering in age-old technologies, serviced largely by relatively inefficient and very greedy industrial firms. It was very clearly explained to me at PMEL that there are great chasms between various NOAA line organizations, which appear have nearly identical objectives at sea as, for example, long-term deployment of marine data buoys in the Pacific Ocean. NDBC has not benefited, or has perhaps rejected, the low-cost and innovative TAO approach, which I estimate to be at least six times more efficient. The solutions to this perceived problem rests perhaps at higher levels than ERL: It may be as simple as more clearly delineating the role of ERL in these matters or as difficult as actually working with NDBC.

c) Resource distribution.

The several year average distribution of the resources was presented at the review clearly and concisely. But the mechanisms and rationale or the distribution of core research funds and the permanent government scientific FTEs was not discussed in an open forum. Distribution of competitive grant funds requires no explanation. Privately, Dr. Bernard was very forthcoming about limitations and opportunities of resource allocations and was appreciative of my advice to support permanent science positions associated with the TAO and North Pacific climate change (see the discussion below).

d) Infrastructure

The infrastructure of PMEL is excellent in its library, computing, general grounds, etc. No scientist complained about administrative support. Several scientists wondered why the director's office takes such personal interest in the travel plans of the senior scientific staff, but that is obviously related to government strictures which they perhaps do not understand. The principal facilities need is to expand PMEL office space within Building 3. Some wonder why routine drawing of maps by NOS has to occupy precious research space. Most JISAO employees assigned to PMEL have to share offices, two to three together. It is not clear what the rationale which governs the allotment of space is. Perhaps that is too difficult to explain, as it certainly is at the universities.

e) Minimum mission

PMEL existence depends on more than a half dozen missions, each of which are larger than would be required for the continuance of a NOAA Laboratory (or any excellent oceanographic laboratory for that matter). PMEL remains flexible, molds itself to the funding opportunities and carries the torch for significant ocean research with a global reputation (see the physical oceanographic review below). Within NOAA (and US) ocean science planning framework, PMEL scientists sit on a number of important panels that define the future and goals of ocean science. While it might appear that PMEL is opportunistic by following the money, a more careful assessment of the dynamics of science planning comes up with a somewhat different interpretation. Through national and international science planning committees, PMEL scientists actually steer the funding of future programs into directions which are viable and which they perceive results in the best science of the future for them at PMEL and for US in general. Here again, the importance of grassroots science participation in this process comes into play. I tend to trust this proletariat method, as that is how great leaps forward were made in the past fifteen years in, for example, annual to interannual climate prediction and observations. The very minimum mission for PMEL is to maintain a first class group of scientists, have them to vigorously participate in the science planning process and for the administration to listen to what the scientists perceive to be the best science for NOAA and PMEL to accomplish.

II. Ocean Climate Research Division

PMEL is one of the most outstanding physical oceanographic research laboratories in the United

States. It has excellent sea-going facilities, outstanding scientists and stable, long-term funding from several NOAA project offices to carry out both fundamental and practical research programs. Physical oceanographers at PMEL are in the possession of the most comprehensive data set of the tropical Pacific climate change ever assembled. This is due to the strong commitment of ERL sending a major research vessel to the equatorial Pacific at least twice a year for the past twenty years. It is in the analysis and wide distribution of this data with which PMEL physical oceanographers have left an indelible mark on our science.

Since 1995, at the end of EPOCS and TOGA, PMEL has become truly the Mecca of tropical oceanography data distribution in the US. My research staff and I access this rich data file by electronic means on a frequent weekly basis. With the continuation of the remarkable TAO array, PMEL has also become the global operational data center for the real-time description of El Nino (the Pacific equatorial ocean phenomena) and for the verification of the prediction of ENSO (the global ocean/atmosphere response). This latter position is quite lofty because of the enormous commercial or financial implications of PMEL's real-time data. It is a credit to the wise management of ERL that the El Nino data is free to the global community, unlike the trend in our sister institutions in Europe. PMEL is the global leader and the stand alone facility in maintaining TAO and the PIRATA array in the Atlantic.

The second area of critical interest to the climate community is the hydrographic and ocean water chemical data sets maintained at PMEL. Here, in contrast to the tropical ocean data sets, the cooperation of the larger ocean community, both academic and government, is most important. In order for this portion of the research group to stay healthy, active and productive, PMEL needs to assure that this cooperation is fostered and that hydrographic, and especially the chemical data (specifically C02, CFCs and nutrients), is continued to be sampled on a Pacific wide basis.

Thirdly, the marine aerosol data gathered at PMEL is of critical importance in the assessment of marine processes in global warming. The satellite remote sensing community is spending considerable resources on this issue and insitu marine data from the Pacific is of very much an integral part of evaluating the satellite data. The marine science community in this area is small and they as a group tend to work in one ocean at a time. It is important that, besides having a head start on the Pacific data, the PMEL group have the opportunity of participating in marine aerosol studies in other oceans as well.

The overall recommendations in the Ocean Climate Research Division area are:

1) Careful attention should be paid to the fact that each area of sea-going observations continues to have the physical presence of and core salary support for first rate scientists in each discipline. For example, a program the size and reputation of TAO should have at least 5-6 principal scientists associated with the analysis of the data right at PMEL (there are a very much larger number using this data in other research and operational institutions). Presently, the strength of analysis is in the water column, and the air-sea interaction part could use help. Unless a healthy science program exists within TAO, there is a danger of PMEL/TAO becoming another NDBC.

2) Successful implementation of plans for expansion of the instrumental time series into the

North Pacific requires grassroots, principal investigator leadership comparable to that of TAO. Presently there are some ideas on how to proceed, but the leader who needs to be in contact with and enjoy the respect of the North Pacific climate observing community is not yet identified.

3) The remarkable success of the instrumental observations at PMEL depends on the health of the engineering group (who also have a healthy international reputation). These very able technicians and engineers are now severely taxed with ever increasing requests for aid in instrument development, testing and maintenance at sea. The impression among the senior scientists at PMEL is that there is now the danger of loading this group down with too many new projects, course which always results in unfortunate inattention to some of the existing projects. A careful and systematic look at the schedule and plans for the next several years of the engineering group would perhaps be a valuable guide by which to set priorities.

4) The "Hayes Center" has been funded by OGP at the University of Washington with the mission that is perceived at PMEL to be the support the analysis and modeling of TAO and other climate observations at PMEL. There is a significant disconnect between that view and what the University of Washington scientists view as the role of this center. In the atmosphere of, tight and very competitive funding, it is not enough for the University to simply hire the "best persons working on the best science" at this center. A clearly enunciated and understood detente is needed. It was rather surprising at the review not to have a presentation from JISAO, as they employ a very large number of climate technicians and scientists who essentially reside at PMEL. How the U of W relationship is]progressing and how to make it better are questions perhaps worth revisiting on a more continual basis than the 5-year cycle.

I would be glad to discuss any or all of these observations verbally in more detail. Thanks for your hospitality.

Sincerely yours,

signed

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UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Sea Grant College Program
1315 East West Highway
Silver Spring, Maryland 20910

June 30, 1998

MEMORANDUM FOR: James L. Rasmussen
Director, Environmental Research Laboratories

FROM: Ronald C. Baird
Director

SUBJECT: Pacific Marine Environmental Laboratory (PMEL)

My thanks and appreciation for including me on the PMEL science review. My time was well spent, the trip both enjoyable and informative. There are also several promising areas for Sea Grant collaboration that I will enumerate below.

My comments and observations on the PMEL Program follow:

a. The review format was excellent. The combination of historical overview with significant time devoted to poster sessions gave reviewers considerable depth of perspective and appreciation of both quality and relevance of the R&D portfolio.

b. The use of Internet technology in both the presentations and for "on line" access to data is innovative, informative and state of the art.

c. The R&D portfolio is clearly relevant to NOAA's mission and includes some of the best oceanographic science being done in the world today. d. The investment leverage provided by strategic partnership with other NOAA entities (NMFS, Sea Grant, NURP) and federal agencies (e.g. NSF) has greatly enriched the return on investment in the R&D portfolio in terms of new technology and increased knowledge.

e. Because of the long range commitment to programs of benefit to NOAA customers, PMEL has established a world leadership role in ocean instrumentation, and the technology to conduct state of the art monitoring and research on ENSO, deep sea vents and fisheries oceanography, all generating information on issues of high priority to NOAA and the Administration. In fact, I think the most cogent results from these programs are yet to come because of the knowledge and technology momentum these initiatives now have.

f. My only caveat is that there is the potential to diffuse effort as these programs expand in scope. The focus needs to be on the core mission and technology. Indeed, one of PMEL’s great strengths in my mind has been its focus on a few high profile areas where it has been able to develop world class "core" technologies that enable the program to produce significant results. That concept of the application of "core" technologies is essential to success.

g. The presentation emphasis on both past and future gave reviewers an excellent perspective on both PMEL’s capability and the appropriateness of the future vision and direction.

Finally, there are a number of areas for future collaboration with Sea Grant, primarily in essential fish habitat and in bio-product development from deep-sea vent organisms.

Again, my thanks. PMEL is a national resource, well managed, highly productive and peopled with bright, dedicated individuals. The excitement shows.

cc: E. Bernard
L. Echols
A. Thomas

CENTER FOR COASTAL PHYSICAL OCEANOGRAPHY

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July 17, 1998

Dr. Eddie Bernard
PMEL/NOAA
7600 Sand Point Way NE
Seattle, WA 98I15-0070

Dear Eddie,

I thank you and others in NOAA for providing the opportunity to review the program at PMEL. I found the presentations to be informative and interesting. Interactions with the PMEL personnel provided insight into their impressions of the work there and visions for the future. It was especially satisfying for me to be able to see the development of PMEL from my initial work with the organization in the first stages of the Alaska OCS program up through my present work in the Northeast Pacific GLOBEC project. We have all changed over the years and PMEL has developed many worthy programs in the past 25 years.

PMEL's crown jewel is the TAO program, particularly with last year's ENSO event. Many aspects of that program should be repeated in other future programs at PMEL. These include long term ocean measurements, real time data availability and public outreach efforts. PMEL should decide those niches in marine science that it wants to occupy in the future. How does or will PN1EL differ from an oceanography department in a major university or an academic research institute? I see an important role for PMEL in long term ocean measurements throughout the North Pacific. PMEL is afforded the opportunity to have a longer vision than an academic department and has the infrastructure to carry out the work. PMEL's ability to deploy surface moorings and current meter arrays is particularly impressive. Such capabilities are becoming rare in the oceanographic community so it is important for them to sustain this capability.

I sense that there is presently a conflict between lab directed research and the PI initiated research that is funded through the proposal process. While I am a strong advocate of peer review, mission oriented research should always be an important component of PMEL's research program. The level of proposal supported research should be carefully considered. Higher levels of such research might be inappropriate or incompatible with the PMEL's science mission.

The presentations during the review program demonstrated PMEL's abilities to use Internet technology and to develop public outreach. programs. Such programs can play an important role in the oceanographic community to gain wider acceptance of scientific programs. While the TAO/ENSO work is well known, other PMEL programs can be presented to the public in a similar manner, as these presentations demonstrate. PMEL can play an important role in the K-12 educational process with their WEB work and other interactions with the public.

In the next decade, important oceanographic research issues will include determination of the global freshwater budget and changes in fisheries. The freshwater (and heat) budget work will require long term salinity (and temperature) measurements throughout the ocean. The TAO work has demonstrated their ability to carryout these measurements in a limited region. While PMEL cannot cover the globe, they should continue to address high latitude fisheries oceanography problems where they have initiated programs over the past decade. This will continue to be tougher than the El Nino problem since the field programs must be conducted in a harsher environment with longer time scales (at least decadal), shorter space scales, and it must deal with biological interactions that are probably nonlinear with anthropogenic influences. The convergence of the ocean climate and high latitude fisheries problems will enable PMEL to provide leadership in both topics.

The ability of PMEL to provide leadership in North Pacific climate and fisheries studies in the future would be greatly enhanced through improved cooperation/coordination with other NOAA divisions, the National Ocean Survey (NOS), the National Data Buoy Center (NDBC), the National Weather Service (NWS) and the National Oceanographic Data Center (NODC). Globally, the resources available to make ocean measurements are very limited and the outlook for expansion is bleak. Therefore, while these divisions have digerent missions, long term ocean measurements would benefit from joint efforts of these units. PMEL should also continue to work with other national and international science programs such as CoOP, GLOBEC, PICES and CLIVAR. The cooperative institutes are very good mechanisms to have NOAA scientists interact with the academic scientists. There is a sense, however, among many in the academic community that these are unequal partnerships, with most of the funding and intellectual property going to PMEL. The solution to this is unclear, but enhanced communication such as program planning workshops might help. However, the apportionment usually occurs in the proposal, funding and publication aspects of the work.

PMEL is in a unique position to continue to provide leadership in the oceanographic community. They have been working on and have developed the expertise to address many of the significant problems in the next decade. Their personnel and facilities are well prepared to meet these future challenges.

Sincerely,

signed

Thomas C. Royer
Slover Professor of Oceanography