Pacific Marine Environmental Laboratory
Laboratory Accomplishments

List 3-5 major accomplishments for your laboratory. If accomplishment occurred more than 2 years ago, cite recent progress. Please specify importance of accomplishment, who have been the major users and what has been the benefit to the taxpayer.

1.Near real-time in-situ ENSO Observing. The completion of the Tropical Atmosphere Ocean (TAO) Array in 1994 marked a major milestone in the field of climate observation. The array was designed for monitoring, describing, and predicting El Niño and La Niña events and was implemented through a multi-national effort led by PMEL. It was fully in place to capture the El Niños of 1997-98 (the largest of the 20th century) and 2002-03, providing advance warning of impending global impacts.

The TAO Array serves NOAA's operational need to support ENSO forecasts while simultaneously providing research-quality datasets to the scientific community for the purpose of understanding the ocean's role in climate, particularly as it relates to improving ENSO predictions. Researchers and operational forecast centers worldwide are able to access TAO data on a routine basis through the Global Telecommunications System and the World Wide Web. Significant advances have been made in the prediction of ENSO events owing in large part to the free and open availability of these data. Overall, the 1997-1998 El Nino is estimated to have had a total U.S. economic impact of $25 billion, which emphasizes the benefits of improved predictions of these events.

The TAO Array consists of deep-ocean moorings at 70 locations across the Pacific, with 15 sites in the western Pacific now maintained by the Japan Marine Science and Technology Center (JAMSTEC). Real-time data return has typically been over 80% and, since completion, TAO data have supported 30 to 50 publications per year in the refereed scientific literature. Dr. Michael McPhaden, TAO Project Director, was awarded the NOAA Gold Medal in 1997 for his efforts in completing the Array.

1. **First Recruitment forecast of commercially-important fish species.** The Fisheries Oceanography Coordinated Investigations (FOCI) Program, a joint research effort of PMEL and the NMFS Alaska Fisheries Science Center (AFSC) initiated in 1984, produced the first annual recruitment forecast for walleyed Pollock in 1992. Pollock is by far the largest component of the lucrative Alaska groundfish industry, which comprises 47% of the entire U.S. fish catch by weight. The recruitment forecast was the first of its kind tool to use environmental observations in assisting fishery management councils to determine expected fish yields for various commercially-important fish stocks. Since the initial forecast in 1992, FOCI research has focused on improving these annual forecasts through research aimed at understanding the role of

climate on the ecosystem and the subsequent impact on fisheries. Improved recruitment forecasts lead to greater success by the fishery management councils, which improves the sustainability of the fishery, benefiting the fishing industry and, ultimately, the consumer. With the recent shift to a broader ecosystem emphasis, future research is expected to benefit numerous species, including marine mammals, and result in recruitment forecasts for an increasing number of economically important fish species.

Related research efforts, such as NOS/COP-funded Global Ocean Ecosystems Dynamics (GLOBEC) and Southeast Bering Sea Carrying Capacity (SEBSCC) programs and the 2001-2002 study focused on the declining population of Steller Sea Lions, provide additional support to the FOCI mission. FOCI researchers have published more than 300 articles in the peer-reviewed literature in support of fisheries management and ecosystem research. The joint NMFS/OAR team that comprises the FOCI Program was awarded a joint organizational Bronze Medal in 2002 in recognition of their contributions to fishery management.

2. **Discovery of "Megaplumes", products of an episodic process of the release of hot, chemically and biologically unique, water during seafloor volcanic eruptions.** While investigating the environmental impacts of seafloor hydrothermal venting, PMEL scientists discovered the presence of a plume of hot, chemically distinct water rising hundreds of meters into the ocean from a site located along a seafloor spreading center in the northeast Pacific. The plume, a mammoth geyser which rose to a height of more than a kilometer, was a phenomenon never observed before in the ocean. Scientists quickly realized that this immense plume was the product of an active submarine volcanic eruption. This discovery revealed that, in addition to having steady-state impacts on ocean heat and chemistry budgets, the hot springs (called vents) that are created by magmas rising beneath the seafloor throughout the global ocean, also have the capability of creating episodic, large-scale, environmental change within a matter of hours.

   Vents research continues to explore local and global impacts of seafloor volcanism on the ocean's physical, chemical, and biological environments. As a part of this research, in order to detect the episodic nature of submarine volcanism and venting activity, Vents has established a real-time acoustic monitoring system that utilizes the U.S. Navy's sound surveillance (SOSUS) hydrophone arrays. This capability makes it possible for PMEL scientists to detect small earthquakes that presage eruptions and accompany the rise of magma in the oceanic crust. PMEL communicates this information via the Internet to a world-wide community of ocean scientists who rely on Vents to enable them to study what has heretofore been impossible to observe---the submarine eruptions of the Earth's largest and most active volcanic system.

   In 1998, Vents scientists established the New Millennium Observatory (NeMO) in the caldera of a mile-deep active submarine volcano off the Oregon coast. This observatory was established to enable both NOAA and non-NOAA scientists to begin

quantifying the ocean environmental consequences of the planet's most important processes for the transfer of heat and chemistry from the interior of the Earth to its surface. Over 80% of this transfer takes places in the deep ocean in ways that, until Vents established its acoustic monitoring and NeMO, were totally unknown and unobserved. NeMO is the only long-term seafloor volcanic observatory in the world and it is further distinguished by technology that enables scientists on land to communicate with, and command, the *in situ* instrumentation in real-time.

One of the most important results of this monitoring and *in situ* research was the discovery that the megaplumes from the vents were laden with microorganisms that had, until the eruption dislodged them, been living beneath the seafloor in what we now know is a vast, global subseafloor biosphere. These microorganisms, which belong to a new kingdom of organisms, live in extreme environments of pressure, chemistry, and heat. These microbes have unique physiological growth and survival mechanisms and they are now increasingly recognized as having great potential for pharmaceutical and biotechnology applications.

Vents research has produced over 220 publications in the refereed literature, including 6 special issues of major, peer-reviewed journals. DOC Gold Medals have been awarded to Dr. Christopher Fox for his efforts in establishing the SOSUS-based acoustic monitoring system and to Dr. Robert Embley, a Vents geophysicist, for his leadership in establishing the NeMO seafloor observatory.

3. **Development of the first portable tsunameter which provides data necessary to forecast tsunamis in real time**. Also known as "DART" moorings, the tsunameter was developed by PMEL to increase warning time and reduce uncertainty in tsunami warnings. Prior to the development of DART, tsunami warnings were based on historical data and data from coastal water level gauges. PMEL-developed tsunameter technology quantifies tsunami energy rather than energy inferred indirectly from earthquake data. Since tsunami formation is composed of earthquake and simultaneous landslide energy, tsunameters provide the only data that can lead to a tsunami forecast. Ongoing research and development will ultimately provide NOAA's tsunami warning centers with a tsunami wave forecast capability. In 2001, PMEL initiated the transfer of responsibility for the Pacific-wide tsunameter array to the National Data Buoy Center. The transition is expected to be complete at the end of FY2003. The DART/tsunameter technology is highlighted in a 2004 Special Issue of the publication "Natural Hazards."

In parallel with the tsunameter development efforts, PMEL, working in cooperation with the five Pacific states, FEMA, and the USGS through the National Tsunami Hazard Mitigation Program, has been instrumental in the leadership of the development of tsunami inundation maps for at-risk coastal communities. These maps provide emergency managers and community planners with information they need to guide community development and preparedness activities. The goal of the entire Tsunami program at PMEL is to provide more accurate NOAA tsunami warnings of tsunami coastal impacts

and provide at-risk communities with tools they need to better plan for the next tsunami.

PMEL's leadership in developing and implementing the National Tsunami Hazard Mitigation Plan (NTHMP) was recognized through a Presidential Rank Award for Dr. Eddie Bernard, Chair of the NTHMP Steering Group.