

Collaborative Research: A Mooring for Cabled Ocean Observatories

Project Summary

The world's oceans are most seriously under-explored in the time dimension: Sustained observations are now required for substantial advancement in the ocean sciences. The NSF Ocean Observatories Initiative expects to provide the basic backbone infrastructure of junction boxes on the seafloor for power and communications to sustain real-time observations at key sites over decades. To obtain spatial extent, a sensor network infrastructure is necessary to distribute the power and communications capability to other platforms and the science sensors. For a large fraction of the oceanographic community, the capability must be extended into the water column. This five-year project will design, build, and deploy a prototype ocean mooring system for cabled ocean observatories, including the software needed for real-time data management, data quality control, information product generation, and public outreach. The participating institutions are the Universities of Hawaii, Maine, and Washington.

The initial mooring deployment will be in mid-2005 at the recently NSF-funded ALOHA Observatory (AO) 100 km north of Oahu, where the Hawaii Ocean Time-series program has now provided nearly 14 years of sustained time-series data. Subsequent deployments of similar moorings are envisioned at the Hawaii-2 Observatory in the mid-Pacific, at DEOS buoy/seafloor junction box sites around the world, and on the planned NEPTUNE observatory on the Juan de Fuca Plate.

The mooring backbone infrastructure will supply observatory power, communications, and timing throughout the water column. Two primary junction boxes will be used, one at the bottom of the mooring and one on the subsurface float (200 m). Two mobile secondary J-boxes are attached to these: the winched profiler (0–200 m) and a McLane moored profiler (crawls along the mooring wire, 200–4800 m, with docking station inductive power/communications transfer). Energy storage (ultra-capacitors) will supply high peak power demands on the backbone power supply. The basic mooring will be designed with the goal of a 10-year life; active components on the mooring will be serviceable in place using a remotely operated vehicle.

Multiple sensors on the mooring will measure profiles of physical and biogeochemically-relevant variables. The combination of these collocated sensors will give a continuous, long-term, high-resolution picture of the processes responsible for the distribution of particulate and dissolved materials throughout the water column. Mixed-layer responses to local and remote atmospheric forcing, full water column mixing, eddies, high-salinity intrusions, and cold bottom water overflow events will be studied with the high resolution data. A particular objective of the AO is to observe and understand the biogeochemical response to these physical forcings; the proposed mooring will be the backbone for pursuing this objective.

The mooring infrastructure we develop will be used to acquire the high-resolution, long time-series data that are critical for understanding the essential elements of climate and biogeochemical cycles, and their broad impacts on society. Providing reliable streams of real-time data will document the present ocean climate, encourage creation and refinement of ocean climate models, and support experimental predictions. Information products developed from the mooring data streams and from models will support education and outreach. A post-doctoral investigator, along with graduate and undergraduate students, will learn essential skills to work with moored ocean observing systems, and will contribute to the workforce needed to build a sustained ocean observing system for operational purposes.

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Project Description

Results from Prior NSF Support

PI: **Bruce M. Howe**

Grant Number: OCE-0116750; \$1,943,183; 1 October 2001 – 31 March 2004

Grant Title: **Development of a Power System for Cabled Ocean Observatories**

This grant is supporting the design and prototype of a 100-kW parallel DC power system for cabled ocean observatories. The design will support regional ocean observatories such as NEPTUNE on the Juan de Fuca Plate offshore of the Pacific Northwest (see <http://www.neptune.washington.edu>). NEPTUNE with 3000 kilometers or more of fiber optic cable for power and communications may have thirty or more nodes, each capable of supporting complex sensor systems. The power system is being designed in collaboration with JPL and the NEPTUNE Engineering Team. A recent Concept Design Review was held with a panel of internationally recognized experts with favorable results. See papers (Schneider et al., 2002; Howe et al., 2002; Kirkham et al., 2001a, b) and the Web site <http://neptunepower.apl.washington.edu> (username neptune, password neptune). Three graduate students are involved in the project.

PI: **Roger Lukas**

Grant Number: OCE-9811921; \$896,172; 1 October 1998 – 30 September 2001

Grant Title: **A Time Series Investigation of Climate-Related Processes in the Subtropical North Pacific Ocean**

This grant supported physical observations for the Hawaii Ocean Time-series project at Station ALOHA. Objectives include documenting seasonal and interannual variability of water masses; relating water mass variations to gyre fluctuations; and developing a climatology of short-term variability. The physical component of HOT provides critical CTD/rosette sampling to the biogeochemical component of the program (cf. Karl et al., 2001), to many ancillary investigations, and for development of new instrumentation (<http://hahana.soest.hawaii.edu/hot> provides a comprehensive bibliography). Data are made available rapidly, generally within a month for CTD-based measurements (http://imina.soest.hawaii.edu/HOT_WOCE). Coherent T-S variations in the upper pycnocline at ALOHA occur on decadal time scales apparently related to rainfall variations over the mid-latitude North Pacific through subduction at the Subtropical Front (Lukas, 2001). During El Niño events, this front moves southward and active ventilation occurs at ALOHA (Lukas, 2002a). The mixed layer at ALOHA shows distinct impacts of variable freshwater fluxes, with ML salinity varying by as much as 1 psu, while mixed layer temperature varies by only about 2°C (Lukas, 2002b). Eddies transport waters of distinctly different character to ALOHA, contributing a portion of the turbulent diffusion that balances advection to produce the mean water mass distribution. An extreme water mass anomaly event observed during January 2001 is attributed to a sub-mesoscale eddy apparently spawned by the 1997-98 El Niño, carrying salty, O₂-depleted mid-thermocline waters from Baja California to Hawaii (Lukas and Santiago-Mandujano, 2001). More typically, eddies bring somewhat fresher thermocline waters to ALOHA (Figure 2) from a genesis region about half way between Hawaii and Mexico (Lukas et al., 2002). These eddies significantly impact biogeochemistry at ALOHA (Letelier et al., 2000). Cold, salty overflows from the Maui Deep to the Kauai Deep occur episodically, creating pronounced anomalies in the lowest 300 m, especially in temperature (Lukas et al., 2001). A time- and depth-varying eddy diffusivity model fit to observations of the thermal relaxation of the Kauai Deep yielded peak eddy diffusivities of 40–50 cm² sec⁻¹ near the sill depth for a month or more. Finnigan et al. (2002) independently confirm estimates of this enhanced near-bottom mixing at Station ALOHA.

1. Motivation and Objectives

Long-life sensor networks with real-time communications and necessary power will be a crucial part of sustained research ocean observatories and operational ocean observing systems. Our general long-term goal is to develop the required sensor network infrastructure that can attach to seafloor junction boxes, as envisioned by the NSF Ocean Observatories Initiative (OOI; <http://www.geo-prose.com/projects/ooi.html>). This infrastructure will expand the coverage away from “backbone” junction boxes providing power and communications, to cover the three-dimensional ocean and seafloor beneath. Here we address one aspect of the sensor network infrastructure, ocean moorings. The work will be done in the context of the science of the Hawaii Ocean Time-series program (HOT); robust physical, chemical, and biological (optics) oceanographic sensors will be used to address multidisciplinary problems.

The specific objectives of this proposal are:

- Develop and integrate the mooring infrastructure, including connection to the seafloor junction box, an electro-optical-mechanical mooring cable, junction boxes distributed along the mooring, an upper ocean winched profiler, a docking station with inductive power/communications transfer for a moored profiler, and energy storage for peak loads.
- Integrate existing sensors into the mooring system, including the winched profiler and moored profiler.
- Deploy, test, operate, and service the mooring at the ALOHA Observatory (AO; <http://kela.soest.hawaii.edu/ALOHA>) 100 km north of Oahu, Hawaii (Figure 1).
- Develop required software systems for real-time data management, data quality control, and information distribution.
- Investigate, in collaboration with HOT Program participants, and in conjunction with HOT cruises, scientific topics, including eddies, vertical mixing, advection and their impacts on the carbon cycle.
- Provide for the transition of the mooring to operational status as part of the AO.

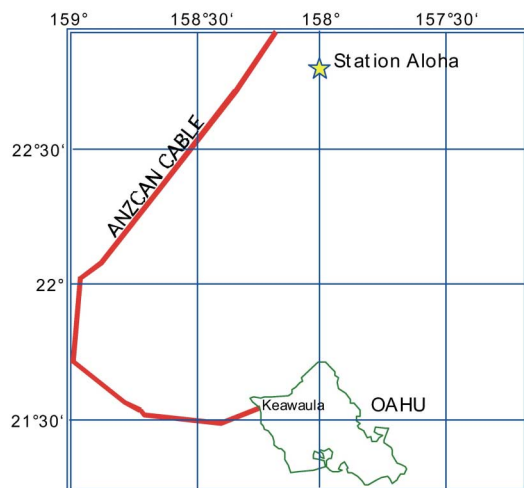


Figure 1 ALOHA Observatory (AO) located at 22°45' N, 158°00' W, 4750 m. The ANZCAN cable will be re-routed to the ALOHA site and a junction box attached.

1.1 Programmatic context

The recent NSF-sponsored report, *Ocean Sciences at the New Millennium* (Ocean Sciences Decadal Committee, 2001), emphasizes the need for long duration Eulerian observations. The challenge for acquiring sustained *in situ* observations is supplying the required power while also retrieving the data in real time. The solution is either a dedicated submarine cable or a semi-permanent moored buoy with on-board power generation and satellite telemetry connected to a seafloor junction box (e.g., DEOS; Orcutt and Schultz, 1999). These facilities are referred to as ocean observatories. The NRC report, *Illuminating the Hidden Planet* (NRC, 2000), makes a compelling scientific case for such seafloor observatories and enumerates the benefits and risks. We will not quote from the report, but it is appropriate to paraphrase the recommendations, namely (p. 108-111): the need for basic observatory infrastructure and sensor development (#5), the need for a framework for evaluating proposals for sustained observations (#6), the encouragement of individual scientists to convert their

instruments to community assets (#7), high priority for public outreach and education (#8), the necessity of information dissemination (#9), and coordination on an international scale (#10).

Ocean observatories will greatly expand the capability to observe physical, chemical, and biological processes. Fitting the definition of an enabling technology, they provide an opportunity to acquire understanding in ways previously unthinkable. Observatories enable the exploration of spatial variability of ocean thermal structure and currents on multi-year (climatic) time scales. There are few multi-year datasets with which to study episodic, high-frequency as well as long-period, sub-surface ocean variability. Observatories enable the collection of data about shorter timescale phenomena (eddies, Rossby-topographic waves, internal tides, etc.) to not only produce statistical reliability of estimates of mean properties (e.g., energy levels and fluxes, interaction with the “mean” currents) but also to examine the long-time-scale modulation of these phenomena that are suspected to have important roles in redistributing energy throughout the oceans, supplying energy to mixing processes, and forcing biogeochemical variations. The last century of oceanography is a story of sampling: starting very poorly and improving (Munk, 2002).

For all the reasons cited above, as well as others, NSF has undertaken the Ocean Observatories Initiative (OOI). “The proposed system has three elements, 1) a lithospheric plate-scale observatory, consisting of interconnected sites on the seafloor that span several geological and oceanographic features and processes, 2) several re-locatable deep-sea observatories based around a system of buoys, and 3) an expanded network of coastal observatories” (Clark, 2001).

Fixed, cabled observatories such as AO, H2O (Petitt et al., 2002), LEO-15 (Schofield et al., 2002), and the planned NEPTUNE system (NEPTUNE Phase 1 Partners, 2000), which permit the long-term deployment of instrumentation with power, real-time command-and-control, accurate time distribution, and data acquisition over a specific region are acknowledged to be an essential complement to more traditional observing schemes. (See Edson et al., 2002, for a special issue of *IEEE Oceanic Engineering* on this topic.) The AO is a variant of OOI element 2, i.e., a deep-sea junction box; it is with this system that we envision our proposed sensors and mooring network infrastructure being deployed, tested, and operated. We must prepare the latter so they are ready when the AO and other observatory infrastructure are installed in late 2004 and after.

We intend the proposed work to take place within the OOI structure, which includes the DEOS and SCOTS efforts hosted by CORE (Dynamics of Earth and Ocean Systems, Scientific Cabled Observatories for Time Series, Consortium for Oceanographic Research and Education; for all see <http://www.coreocean.org>). Specifically, the science will be coordinated through the HOT program, and the infrastructure developed through the NEPTUNE program. The goal of the latter is to “wire” the Juan de Fuca Plate for science – anticipating OOI element 1 above. Several parts of NEPTUNE are funded: 1) power, communications, and system engineering funded by NSF and NOPP, 2) the Monterey Assessable Research System (MARS; a testbed system, <http://www.mbari.org/mars>) funded by NSF, 3) the Victoria Experimental Undersea System (VENUS, <http://142.104.11.31/venus.html>) in the straits of Georgia and Juan de Fuca funded by the Canadian Foundation for Innovation (CFI), and 4) the northern part of NEPTUNE, also funded by CFI (<http://neptunecanada.com>). These funded projects provide a framework for the proposed development.

1.2 The Hawaii Ocean Time-series (HOT) Program and ALOHA Observatory (AO)

The HOT Station ALOHA (A Long-term Oligotrophic Habitat Assessment) has been supported by NSF under the JGOFS and WOCE programs, with approximately monthly sampling since October 1988 (Karl and Lukas, 1996). During nearly 14 years of comprehensive observations, significant responses of the water column physics, chemistry, and biology to episodic and climate variations have been observed and studied (Karl et al., 2001). The El Niño/Southern Oscillation has a strong influence on mixing and stratification at ALOHA, and thus on nutrients and biology (Karl et al., 1995; Karl 1999). Decadal variations of mixing, circulation, and biogeochemistry appear to fundamentally reorganize the ecosystem. HOT observations have provided great insights into the functioning of the North Pacific subtropical gyre and its ecosystem, challenging some of the most closely held assumptions in ocean biogeochemistry. Some of the most significant biogeochemical features are: 1) the variations in the mechanisms of nutrient supply, especially the ecological consequences of pulsed nutrient delivery (e.g., via eddies; cf., Figure 2, and Letelier et al., 2000), and the nitrification of low-latitude regions in the absence of turbulence (e.g., enhanced N₂ fixation [Karl et al., 1997; Karl, 1999]), 2) the

relationships between ocean physics and biology, especially for community structure and trophic dynamics (cf. Cullen et al., 2002), and 3) the resultant physical and biological controls on the ocean's carbon pump. The decoupling of production, export, and remineralization processes in time and space, and the detection of decade-scale, climate-driven ecosystem perturbations and feedbacks combine to reveal time-varying biological and biogeochemical complexities (even on time scales as short as a day to a few weeks) that are just now becoming evident in these independent ocean time-series data sets (e.g., Dickey and Falkowski, 2002). These variations in ecosystem structure have important implications for carbon dioxide sequestration, as well as the productivity of higher trophic levels (e.g., fish and micronekton) in the North Pacific subtropical gyre.

These insights will be followed with research focused on guiding the development of the sustained, high-frequency, long-term ocean observing system components needed to quantify these variations and feedbacks accurately, and to support assessment and prediction efforts. Thus new objectives for HOT include: 1) continuing critical time series measurements, and enhancing them with high frequency and spatial sampling; 2) improving our understanding of critical physical and biogeochemical processes for improved predictive modeling capabilities; 3) identifying the most important variables (and their time and space scales) for sustained observations to quantify carbon cycling; 4) testing advanced sensors for measuring these variables and integrating them into observational systems; and 5) testing advanced ocean analysis and prediction capabilities. The strategy for approaching these objectives is to conduct *in situ* perturbation experiments to test hypotheses regarding controlling factors for primary production and carbon cycling and sequestration, to develop improved ecosystem model parameterizations based on these results, to integrate autonomous measurements with ship-based *in situ* observations, and to develop and test model-based data analyses and predictions in conjunction with intensive process studies as part of national and international research programs. **It is intended to evolve the ongoing intensive shipboard observational strategy of the Hawaii Ocean Time-series to one that relies on continuous autonomous time series with less frequent shipboard work. The autonomous measurements will be made from moorings to provide critical time series, and using AUVs, gliders, tomography, and other platforms and techniques to provide essential spatial context.**

The goal of the NSF-funded ALOHA Observatory project (AO) is to establish cabled observatory infrastructure at Station ALOHA for the next generation of the Hawaii Ocean Time-series. The AO seafloor junction box will be deployed in late 2004; it will provide power to scientific equipment and real-time two-way communication between sensors and scientists for at least the next ten years. Continuous measurements will then enable scientists and students to detect trends and variations that are not well observed by standard ship-based observations. AO is designed for maximum flexibility, with the ability to support a wide range of experiments, from simple listening devices to vertical arrays with ports for removable sensor systems. With the proposed mooring, observing systems from the deep ocean floor to the ocean surface will benefit from AO. At the end of the mooring development, the hardware and software systems will be transitioned to "operational" status as part of the AO backbone.

The AO will be an important contribution to the integrated ocean observing system, providing sustained *in situ* observations of key ocean variables beyond temperature and salinity, and resolving shorter time and space scales than can be achieved by satellites and the Argo float array. An important motivation for this element of the integrated ocean observing system is that it provides the co-located multivariate and multidisciplinary observations required by interdisciplinary scientific objectives (Send et al., 2001). AO will be embedded within the basin-scale observing system (including remote sensing from space), and its observations will provide an important benchmark for basin-scale, model-based ocean analyses. It will also help to provide the observational basis for research linking ocean-state assessments and predictions on the basin scale with those of island coastal regions. In addition, AO will provide a high quality testbed for development of novel sensor technologies to observe key ocean variables, such as proposed here.

2. Science Opportunities at ALOHA

The present ~monthly shipboard observations at Station ALOHA include 36-hour burst sampled CTDO₂ profiles to resolve the strong internal tides. Other than oxygen and fluorescence measurements, there are no biogeochemical variables that resolve high-frequency variations while on station. Transient episodic events (e.g., plankton and *Trichodesmium* blooms, eddies) are observed only serendipitously. Variations on time scales from 2 days to 2+ months are not resolved, aliasing the time series, and making it difficult or impossible to observe time scale interactions. High temporal resolution requires moored measurements, and high vertical resolution requires profiling capability. Motor driven profilers require significant power. Real-time two-way communications capability is important to detect and react to unusual events by allowing control of the sampling strategy during such events. Communications capability is also important to sustain high quality observations, as it enables detection of sensor/systems failures and scheduling of timely servicing.

2.1 Physical oceanography

Observations show that advective and diffusive processes are occurring on many time scales at ALOHA. These processes interact with each other in ways that are not well understood, and they force biogeochemical systems and ecosystems in ways that have not been well observed. Upper ocean mixing is forced by synoptic weather systems such as cold fronts, but this is subject to large spatial and year-to-year variability (Lukas, 2002b), with important remote consequences as well (Alford, 2001). Water mass intrusions appear intermittently (Kennan and Lukas, 1996; Lukas, 2002a), and the processes that control their generation and their fate are not well known. Slow variations in upper thermocline stratification associated with subducted North Pacific water mass anomalies may influence vertical turbulent fluxes of nutrients, and thus impact the biogeochemistry of overlying waters at ALOHA. Eddies generated by circulation instabilities within and external to the North Pacific subtropical gyre clearly impact biogeochemical processes (Letelier et al., 2000), but the relative importance of vertical circulation, vertical mixing, and horizontal advection are not known. Figure 2 shows that

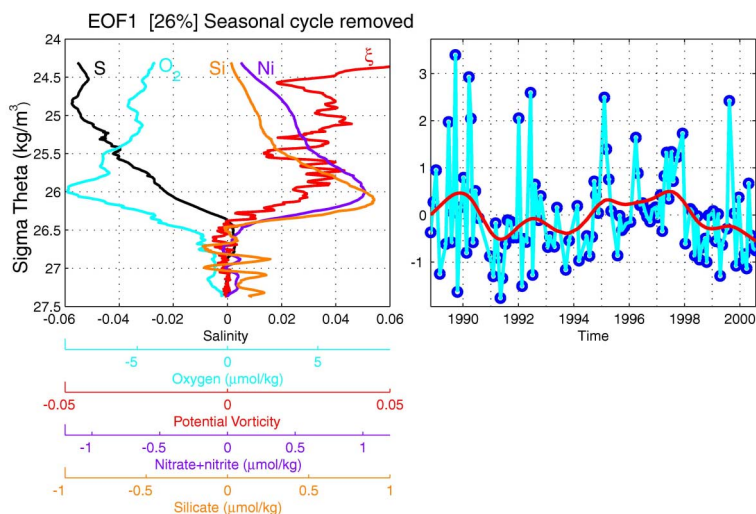


Figure 2 Multivariate EOF of HOT hydrographic profiles in potential density space (left). Red line in the time series panel (right) is a spline fit to the individual cruise values (blue dots). Intermittent appearance of anomalous water masses associated with mesoscale eddies is associated with extreme values of the EOF time series.

along-isopycnal advection of anomalous waters within eddies is significant, and must be considered along with local upwelling anomalies associated with eddy passage. These eddies have varying vertical structures and horizontal scales, and while they appear intermittently, their statistics are apparently modulated by slow ocean climate variations (Lukas and Santiago-Mandujano, 2001).

Strong internal tides have been observed near the Hawaiian Ridge, with vertical displacements of the upper thermocline by as much as 50 m, apparently enhancing vertical turbulent exchanges (Finnigan et al., 2002). These internal wave enhancements vary considerably in space (Egbert and Ray, 2000; Merrifield et al., 2001) and time, and certainly contribute to so-called “background” vertical

fluxes of nutrients. The ability to observe physical variability over the entire water column with high vertical and temporal resolution is critical to making advances in understanding these complex interactions. Research into such interactions is a high priority for improving ocean climate models, and is vital for deciding appropriate sampling strategies for the profilers on the mooring.

2.2 Particles and dissolved organic material dynamics: a biogeochemical link

The production of biogenic material in the upper ocean and their fractional removal to the deep sea determines to a large degree the distribution of the biogeochemical elements in sea water (Ittekkot, 1996). Here we propose to measure the distribution of particulate and dissolved materials with high temporal and vertical resolution using robust optical instrumentation, with the necessary physical measurements to provide context. Doing so will provide us with:

1. Description of the particulate and dissolved constituents in higher resolution than available to date.
2. Quantification of the contribution of episodic events to the vertical flux of particulate material and its rate of conversion to dissolved material.
3. Quantification of the cross-correlation of physical and optical variables so that we better understand the interaction between physics and biogeochemical fields and their contribution to particulate fluxes.

Our efforts will contribute directly to carbon science as outlined in the Ocean Carbon Transport, Exchanges and Transformations report (http://www.msrc.sunysb.edu/octet/Workshop_Report.html). For example, transmissometer measurements have already shown the importance of the ‘twilight zone’ (100–1000 m) to the recycling of carbon. The addition of oxygen measurements as well as CDOM (colored dissolved organic matter; as proposed here) will provide evidence for the transformations incurred by particulate organic carbon. The combined high spatial and temporal resolution measurements of physical and optical variables will allow us to compute eddy-correlation terms, which are needed to quantify and understand the role of physics in fluxes of dissolved and particulate material.

Traditional moorings using instruments that burst sample at fixed depths suffer from two problems when trying to achieve the above goals. The vertical resolution is coarse and there is significant uncertainty in calibration. Cross-calibration between the instruments is usually performed only at the beginning and end of each deployment forcing the user to assume a linear drift.

The proposed mooring and instrumentation is a significant improvement for measuring dissolved and particulate properties with high temporal-vertical resolution. The power and communications requirements of commercial optical instrumentation, which measures several times a second, can be easily accommodated. The use of the profilers insures high vertical resolution, particularly in areas of high vertical gradients such as the top of the bottom boundary layer and at the base of the surface boundary layers. In addition, a better degree of cross-calibration between the sensors is achieved as sensors (nearly) overlap in the vertical during profiling, insuring higher quality measurements. Periodic HOT cruises to the mooring location will contribute to the goal of absolute calibration throughout the deployment.

The selection of optical instrumentation is based primarily on maturity of the technology, its biochemical link, and its price. As other novel technology matures and becomes available commercially we will incorporate them in the mooring. For example, measurements of particulate size distribution (e.g. Sequoia’s LISST) will provide crucial information regarding particle aggregation dynamics. Novel optical nutrient sensors (e.g. Ken Johnson’s nitrate sensor; see letter in Supporting Documents) will relate the particulate field to the underlying nutrient dynamics, a cornerstone for biogeochemical interpretation.

The suite of optical properties we propose to measure, and the biogeochemical properties they are related to, is as follows:

1. Beam attenuation at 660 nm – particulate organic carbon (POC) in many areas of the open ocean (e.g. Bishop, 1999) and total suspended material in the bottom boundary layer (Spinrad et al., 1983).
2. Chlorophyll fluorescence – chlorophyll concentration (e.g., Cullen, 1982).

3. Colored dissolved organic matter (CDOM) fluorescence – dissolved organic material (DOM; e.g., Blough and Green, 1995, Blough and Del Vecchio, 2002).
4. Backscattering at 660 nm – particulate organic carbon (POC; e.g., Stramski et al., 1999); with beam attenuation it provides a proxy for the backscattering ratio that is a good indicator of the composition of the particulate material (Twardowski et al., 2001).
5. Profiling upward looking irradiance sensor and downward looking radiance sensor – reflectance, diffuse attenuations (for both measurements), and photosynthetically available radiation for the upper 200 m. These measurements have been used to estimate inherent optical properties such as absorption by phytoplankton and CDOM (Nahorniak et al., 2001). A by-product of this measurement is a validation measurement for satellite ocean color.

The relationships between optical variables and biogeochemical parameters is not unique and can vary with the composition and size distribution of the material investigated. We have investigated the relationships between beam-c and POC, and chlorophyll fluorescence and chlorophyll concentration at HOT (Fennel and Boss, 2002) and found them to be close to linear through several years of the HOT program (Figure 3). For the other variables (e.g., the CDOM-DOM relationship) the data collected as part of HOT will provide the needed relationship and its variability in time and space.

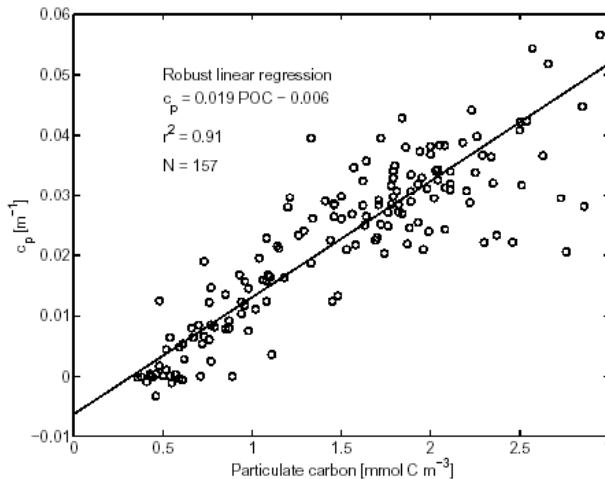


Figure 3. Beam attenuation coefficient vs. POC bottle concentration at Station from August 1991 to July 1995 (figure from Fennel and Boss, 2002). c_p represents the value of beam attenuation measured minus the average value of c_p between 250-300m. This is done in order to account for drift in transmissometer calibration.

enable us to quantify the role of mixed layer dynamics (strongly forced on diel and atmospheric weather time scales) in the redistribution of biogeochemically relevant material in the upper ocean. Upwelling of nutrients, flux of cells below the euphotic depth, and bleaching of organic material are just a few of the processes affected by the mixed layer dynamics, with important consequences for particulate and dissolved material fluxes and distributions. Contribution of horizontal processes will be assessed from ocean color images, horizontal velocity measurements, and local measurements.

From 1997 through 2000, a surface mooring (HALE-ALOHA) was maintained not far from Station ALOHA to capture high frequency, episodic variations. The temporal resolution was 10 minutes, while the vertical spacing was 25 m and larger. This mooring has been instrumental in highlighting the importance of mesoscale and mixed-layer processes in the distribution and fluxes of dissolved and particulate properties (R. Letelier, personal communication, 2002). Unfortunately, this effort was discontinued.

The optical/physical measurements proposed here will supplement and complement the HOT program by resolving both vertically and temporally the frequency domain most contributing to variability at the site. We will replicate the HALE-ALOHA radiance measurements by including two radiometers on the winched profiler, insuring that the necessary parameters for primary production studies at the site are measured. These radiometers will have the added benefit of validating ocean color algorithms at the site.

The high vertical and temporal resolution will

3. Technical Approach

We propose to integrate a suite of moored sensors for measuring physical, chemical, and bio-optic oceanographic variables. Our chosen sensors residing on various platforms will provide information that is representative of the full water column, including crucial near-surface data. The mooring and sensors will be robust and long-lived for connection to cabled ocean observatories. The mooring sensor network infrastructure will be a direct extension of seafloor sensor network infrastructure; indeed, the mooring can be regarded as a vertical cable network with connections available at various points. This infrastructure is integral to this proposal. The network infrastructure will be compatible with the NEPTUNE interface (400 V, 100 Mb/s Ethernet, timing) and adapted here for the AO instrument interface (48 V, RS-422). It will easily support other sensor interfaces and future expansion.

Figure 4 depicts the configuration of instrument packages, platforms, and junction boxes on the mooring. Other possible future components to the ALOHA Observatory are also shown. The various elements of our proposed effort are shown in Figure 5.

3.1 Instrumentation

3.1.1 Sensors The sensors we have chosen are robust, long-lived, and have a proven record of performance. With them we expect to continue the high standards of measurement set by the HOT program. A limited number of different types of sensors makes this demonstration project manageable with higher probability of scientific success. While some investigators may take issue with the specific sensors we have chosen, they will have the opportunity to use the infrastructure we create to add others in the future. We have intentionally not called for dual sensors (and platforms) to control cost; these trade-offs (amount of service, impact on calibration, etc.) are best made after experience is gained.

We tentatively plan to use Seabird CTDs (FastCat or ALACE style on the winched profiler and MicroCats on the subsurface float and at the bottom; all with Paro-Scientific pressure sensors) except on the MMP which, uses a Falmouth Scientific CTD and acoustic current meter (ACM). A Seabird dO_2 sensor will be used on all platforms. An RDI 75-kHz LongRanger acoustic Doppler current profiler (ADCP) will be used on the subsurface float. For the optics, we plan to use WET Labs CDOM and chlorophyll pucks and C-Star transmissometer and an OBS backscatter sensor; the upper ocean ones will have copper shutters. On the winched profiler will be Satlantic radiance and irradiance meters.

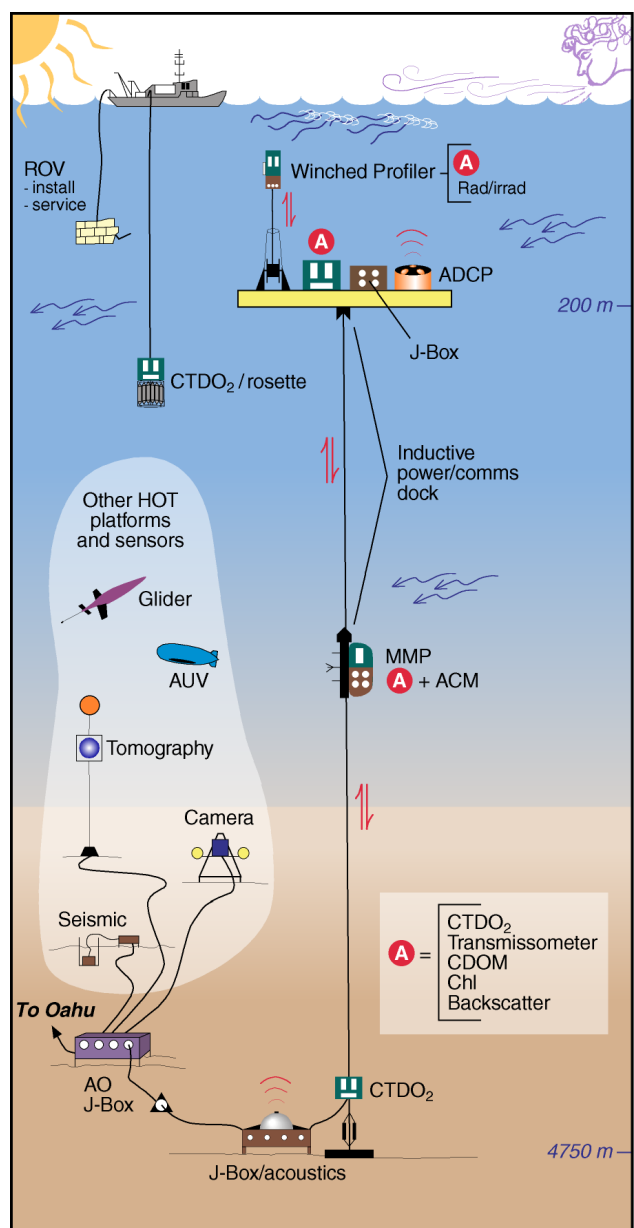


Figure 4 The ALOHA Observatory mooring system.

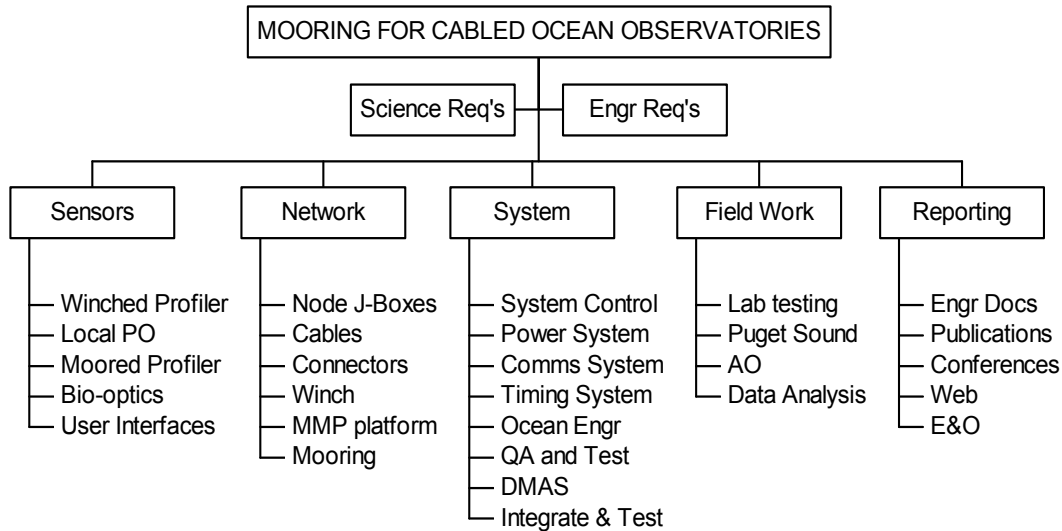


Figure 5 Project tasks.

3.1.2 Winched profiler We are using a winched profiler as opposed to a surface mooring to sample the uppermost ocean to minimize the detrimental effects of being at the surface for long periods: high wave energy with associated mechanical stresses and heave, adverse bio-fouling of sensors and platforms, frequent servicing, ship strikes, and vandalism. The profiler will be configured as a secondary junction box, with external (dry mateable) connectors for other sensors. The profiler can be serviced with a ship in dynamic positioning mode by spooling out additional cable by command through the communications system. It will then be possible to recover the profiler, connect to the mooring network and then run the entire mooring from the ship for diagnostic purposes. Real-time command and control from shore will let the scientist balance the risk of getting near the surface in extreme weather against long-term survivability, for example.

3.1.3 Subsurface float The disc-shaped syntactic foam float at 200 m will serve as the platform for the winched profiler, the ADCP, CTDO₂, the optical sensors, and the junction box (Figure 4). We note that with plentiful power, the ADCP can be run nearly continuously. The mechanical mounts on the float will permit the easy addition, removal, and servicing of sensors and the other components with an ROV or submersible.

3.1.4 Moored profilers One McLane moored profiler (MMP) will be used with the sensors shown in Figure 4. It can travel at speeds up to 0.4 m/s, which is necessary to prevent tidal signal aliasing over the ~4500 m of mooring cable (6 W average; the normal MMP travels at 0.25 m/s drawing 2 W); this is one example where the capability to obtain power from the mooring infrastructure AO is crucial. Working with McLane, we will modify the profiler to mate with a dock for inductive power and communications transfer (using electric car technology; this will be a challenge, as there will likely be some degree of mechanical alignment necessary); install a secondary node controller to be the interface between the McLane control system, the sensor payload, and the inductive power/communications transfer; switch from lithium to rechargeable batteries; and make the MMP and docking station replaceable using an ROV. The latter will permit servicing without mooring recovery, as well as make it easy to add new sensors over the long expected lifetime of the mooring. *In-situ* calibration of sensors can be done with an ROV fitted with a similar sensor payload during service calls. There should be little bio-fouling because the MMP will be greater than 200 m deep and can be parked deep between profiles. In the future, the profiler can be easily modified to carry other sensors, such as an acoustic transducer for tomography, communications, and other purposes.

3.1.5 Anchor A CTDO₂ will sit at the base of the mooring. A 10-kHz general purpose acoustic transducer will be used as an inverted echosounder, as an ambient sound receiver (wind, rain, marine mammals, shipping, tomography signals), and for acoustic communications and navigation (this transducer sits in the gray area between a science and an infrastructure element).

3.1.6 Other In the future, we expect additional instruments to be added to the system (facilitated by the junction box/ROV servicing capability). One example is a bottom-mounted ADCP to measure bottom boundary layer velocity in conjunction with the periodic MMP profiles along the mooring, relevant to understanding the Maui-Kauai overflow current. A second example is turbulence measuring ADCPs on the winched profiler and the subsurface float, relevant for studying storm induced mixing. Another example is a small spar extension to the winched profiler to allow measurements above the air-sea interface. These might include air temperature, pressure, velocity, radiation, and GPS; the latter provides an integral measure of precipitable water in the surrounding atmosphere (Chadwell, 2000, Goody et al., 2002).

3.2 Infrastructure

3.2.1 Winch Our provisional design calls for a 0.5 m/s profiling speed, requiring ~150 W peak power (assuming 50% efficiency). The budgeted average power of 25 W will allow one profile every 40 minutes. The main buoyancy element will be syntactic foam (0.5 m diameter by 0.4 m high) with the instrument frame above. The cable will be approximately 5 mm diameter, include 4 #24 conductors, have greater than 500 lb breaking strength with steel armor wires to protect it against fish bite, and have a jacket (similar to Rochester A-H-181A). The drum will be 0.25 m diameter with 0.5-m diameter flanges and 0.1 m wide. A fairlead 2 m out will keep the fleet angle $<1.5^\circ$ to optimize level winding. Oil-filled submersible slip rings will carry the electrical signals across the winch.

3.2.2 Primary junction boxes Junction boxes will be placed on the subsurface float and on the seafloor immediately adjacent to the mooring. The junction box provides access via ROV-mateable connectors to the 400 V / 100 Mb/s mooring network backbone. To be consistent with future systems such as NEPTUNE, a time distribution channel will also be included (with AO 1 ms, in the future 1 μ s). On each primary J-box, 4 ROV-mateable connector ports (or more, as needed or anticipated) will be provided. The same ports will be used for linking the backbone system as well as for sensors. If attached to sensors, ports will also provide 48 V and RS-232 options. An embedded micro-controller will be used for controlling the junction box and communicating with the shore power and communication control systems. For communications, a high reliability commercial Ethernet switch will be used that takes 8 input/outputs and sends the packets to the appropriate locations, whether commands to instruments or data going to the data archive and scientist on shore. Sensors that are “observatory-ready” (Ethernet interface, metadata storage, 48VDC or other suitable voltage) may be plugged in to the J-box directly. Other sensors (typically RS-232) will need to connect through a single or multiple channel SIIM (see below). The controller will have the ability to add instrument metadata if necessary, e.g., for instruments using the RS-232 ports. As a matter of policy, we will require all data on the backbone to have metadata attached. The user 48 and 400 V power supplies will have ground fault and overcurrent protection. Because the AO junction box can only supply a relatively limited amount of power (100 W), energy is stored in “smart” ultra-capacitors banks (<http://www.powercache.com>) that are charged from the 400 V bus and are able to buffer energy to meet peak power demands. The ultra-capacitors will connect to a junction box just like a feeder from another power source (auctioneering diodes permit this); they will be distributed through the system as appropriate to minimize cable resistive losses when high instantaneous power is required.

We emphasize that much of the engineering, hardware, and software, will directly carry over from the MARS (<http://www.mbari.org/mars>) and NEPTUNE (<http://neptune.washington.edu>) development efforts, in which we are intimately involved.

3.2.3 Science instrument interface modules The components that lie between instruments and the backbone system are collectively called science instrument interface modules (SIIMs) in the MARS/NEPTUNE engineering jargon; they are called out explicitly in the MARS NSF grant as a required component, but one which will be designed in an external effort, e.g., as proposed here. Such sensor network infrastructure will be needed for any ocean observatory, whether at a single DEOS buoy/seafloor junction box or a complete regional observatory such as NEPTUNE envisions. There are two types of SIIMs that will be used here. One is a very small (postage stamp size) chip that converts a single RS-232 device to/from Ethernet,

allows metadata to be stored or retrieved, and uses a small dc-dc converter to provide the desired voltage to the sensor, given the 48 or 400 V from the backbone. These components will be housed in very small pressure cases in-line with the instrument cable. The second type of SIIM is a small multiplexer that combines multiple RS-232 data streams (e.g., a hub), contains a microcontroller to store the metadata for the multiple sensors, and provides power, for instance to the suite of optical sensors. With this type of SIIM, only one port on a junction box is necessary to service all the sensors. Simple and easy to use SIIMs are crucial to observatory success; our work will be coordinated with NEPTUNE development.

3.2.4 Mooring cable The mooring cable has 4 #18 conductors with polyethylene insulation, 4 fibers in a 2-mm diameter steel tube, Kevlar strength member, armor wires (above 1500-m water depth for fish bite protection) enclosed in a polyurethane jacket, and an overall diameter of 25 mm. The subsurface float provides 2000 lb of buoyancy to provide a taut mooring to minimize horizontal and vertical motion. All mooring components are selected for a 10-year life; titanium and non-metallic materials are used where necessary.

3.2.5 Other The AO junction box is designed for ROV underwater mateable electrical connectors. An “observatory interface” will connect to the AO junction box and will step the 48 V up to 400 V (100 W) and convert the data stream format from the AO RS-422 protocol to/from 100 Mb/s Ethernet on fiber, necessary for the 2 km distance to the mooring (clearance for ROVs). This 2-km electro-optical cable will be deployed in a cable pack at the AO J-box, unspooled using an ROV to the base of the mooring and then connected to a junction box that is in turn connected to the connector at the base of the mooring.

3.3 System

All active elements of the mooring (i.e., everything except the cable, float, and hardware) can be added or removed for service by an ROV. We stress again how crucial ROVs, and the ships that support them, are to the success of this mooring concept specifically, and to observatories in general. NSF and the community must act expeditiously so that ROV availability does not become a bottleneck. The experience we gain from this effort will help us determine the optimal balance between servicing (involving an ROV, for instance) and the number of dual/redundant sensors and platforms (e.g., 2 MMP docks, 2 MMPs, dual sensors, etc.).

The estimated power budget for the instrumentation and infrastructure is 50 – 60 W, well within the 100 W available, and with sufficient margin for future expansion. Data rates are modest and will not stress the system.

We have kept individual sensors separate because they may fail; distributed sensor units that can be unplugged are more appropriate. To the extent possible, frames and pressure housings will be made of non-corrosive materials (e.g., plastics and titanium) to minimize cost and risk of corrosion and stray galvanic electric fields that may contaminate measurements.

3.3.1 Command and control At the most basic level, the observatory control system will monitor voltages, currents, ground faults, etc., throughout the mooring infrastructure system. It will flag out-of-range values and take corrective action if necessary, such as opening a breaker on a particular junction box connector. Given power contracts with the different users, it will determine if there are conflicts; this will be especially important in coordinating the operation of the winched profiler, the MMPs, and the ultra-capacitor energy storage, given the finite amount of power available.

Instrument command and control capabilities are essential for realizing the observational power of the proposed mooring. Real-time information, along with command and control capabilities, will be used to conduct experimental sampling to determine the most appropriate “operational” sampling. These capabilities will also be critical to contingency sampling when important intermittent events are detected. Real-time sensor status will be essential for monitoring the MMP performance, and the ability to change the profiler programming will be used to diagnose, possibly even overcome, profiler system crises (e.g., fouling of the mooring line). Sensor/system failure detection will trigger alerts with AO/mooring managers and PIs.

The present design for the NEPTUNE Data Management and Archive System (DMAS; <http://www.hia.nrc.ca/pub/CADC/NEPTUNE/>) specifies a virtual instrument server (a software entity in the DMAS) be associated with every instrument. A scientist would communicate to his/her instrument via this server. All commands, data, and metadata are logged by the DMAS. The same server handles interactions between the user, the instrument, and the infrastructure system. For example, if a user wants to cycle power to an instrument, he can ask that power to the appropriate connector be turned off and on. We will be working with the DMAS development staff to construct the instrument server software for these particular sensors, so that they can be used as templates for others (S. Gaudet, see letter in Supporting Documents). This virtual instrument server supports the engineering and experimental modes of interacting with the mooring. Among other things, this server will facilitate experiments with the MMPs and winched profiler to help determine appropriate sampling strategies to capture all relevant signals and to avoid aliasing. In addition, this experimentation will help to decide what latitude exists in the “operational” profiling mode to support contingency sampling (e.g., when an eddy is detected).

3.3.2 Information management To support routine automated quality control, scientific analysis, and education and outreach functions, a real-time data management system will be built. Raw data (Level 1) will be held online in an accessible format for as long as possible, and then ported to optical media. Calibration and quality control will be conducted in two modes. Level 2 data will be available with the minimum delay associated with the modes of sampling and automated processing. Level 3 data will be delayed-mode, involving retrospective calibration and quality control procedures that will use all other information that is available within a reasonable time frame (e.g., laboratory calibrations, other *in situ* measurements). All levels of data will be archived, and Level 2 and 3 data will be accessible online along with all metadata. Designated federal oceanographic data archives will be able to access the data and products on schedules that are convenient for their staff.

To support scientific analysis and curiosity-driven browsing, we will set up a live action server based on readily available public domain software. (An example is found at the PMEL/TAO web site: <http://www.pmel.noaa.gov/tao/>.) This will enable direct Internet access to the information contained in the datasets through online plotting, as well as the ability to subset and download data.

4. Work Plan

The timeline for the project is:

Year 1	2003	Workshop Develop the winch profiler system Develop junction boxes Develop the MMP system (integrate J-boxes, new sensors, battery charging, dock) Web site development, quality control software engineering
Year 2	2004	Observatory interface development Sensor integration and software testing
Year 3	2005	Full system integration and testing on land Deployment
Year 4	2006	Analyze data, service mooring, education and outreach
Year 5	2007	Analyze data, service mooring, education and outreach, transition to operation

To mitigate engineering risk, we will have three formal design reviews with independent experts. To insure good coordination, representatives from the AO, HOT, and NEPTUNE development programs will attend (for example, see the letter from F. Duennebier in Supporting Documents). While we have been somewhat specific in describing the proposed sensors and systems here, we recognize that it will be essential to coordinate this effort very closely with HOT scientists in particular as well as the community in general, in order for the science and engineering results and lessons learned to be optimized and applicable to cabled observatories in general. To this end, we are proposing an open workshop the second week of January 2003 in Hawaii. We

anticipate that as NSF's OOI develops the Ocean Observatories community will organize annual workshops to address common issues such as governance, management, education, and public outreach. We will contribute organization expertise and the benefits of our experiences to these workshops.

4.1 Tasks

4.1.1 Development and testing What we expect to be the most difficult tasks will be tackled first: the winch design because it is a new mechanical system with moving parts; the MMP because it is a mechanical system that must be adapted for our use and also interfaced with a commercial entity/product; the primary and secondary J-box development because of the software including the command and control and interfacing to the DMAS. After 6 months the Concept Design Review (summer 2003), prior to prototyping, will be held to assure ourselves and others we are on the right track. In the second half of the first year, we will build the first prototypes and, in parallel, research the integration of all the sensors. The Preliminary Design Review will be held at the end of the first year with tested prototypes and detailed plans for sensor integration.

4.1.2 Integration and test The second year is devoted to interfacing/integrating all the various sensors, as well as continued testing of the critical elements above. At the end of year 2 (December 2004) we will hold the Critical Design Review, just prior to full system integration and testing. The latter will then take place in the first half of year 3 (2005) in preparation for deployment in the summer. Full system integration means the entire mooring system with all sensors is connected together on land (after pressure testing) with a realistic (accelerated) sampling schedule so that the winched profiler and MMPs are moving, data is flowing to the DMAS, and so on. Extensive wet tests of the winch system and MMP will be made in both the UW's test pool and in Puget Sound in depths to 200 m. Both sub-systems will be deployed and allowed to run attended for days to weeks with changes made and deployments repeated, as necessary. During this period a safety review will be held to review the deep water deployment plans. These essential steps towards deployment will be documented on the project Web site, allowing the scientific community and others to participate, either actively or vicariously in this complex process.

4.1.3 Deployment and servicing Deployment of the mooring will be in summer 2005 using ROV *Jason-2*. A special purpose winch will be used for the deployment of the mooring cable. The mooring will be deployed float first; the anchor will be lowered on a release as the mooring is towed and flown to the chosen location using the ROV and acoustic navigation net. The *Jason-2* will be used to deploy and connect the bottom cables, the AO interface, and J-box. We expect to spend several days to a week inspecting and debugging the mooring and sensors. This cruise will be coordinated with other AO activities that require the deep ROV. We will plan to make available real-time video of the shipboard and underwater activities through the project Web server. While not as visually exciting as a Space Shuttle launch, there will be educational value in this pioneering process of extending the Internet to the seafloor at 5000 m and then back up to the surface.

This mooring system is new and complicated so it is prudent to budget service calls. During the normal monthly (eventually quarterly) HOT cruises, the winched profiler can be serviced by a surface ship by spooling out extra cable. A shared cruise in summer 2006 is planned. Major service with an ROV will take place in summer 2007; the present plan is to leave the mooring in place, as we assume the process of transitioning it to an operational state will have occurred (see below). Service vehicles may be a medium-depth ROV or the manned submersible PISCES, or a deep ROV if needed.

4.1.4 Data analysis Physical and optical oceanographic data analysis supporting the development of mooring sampling strategy will be undertaken with existing observations prior to deployment. Data from sampling experiments conducted after deployment will be analyzed to support choices for ongoing operational observations. A high priority for data analysis both before and after deployment is to develop the software for data quality control. This requires the prior experience with HOT observations in terms of distinguishing signals from noise, as well as anticipating modes of possible sensor failure. Close scrutiny of sensor characteristics and data streams after deployment will be required on a continuing basis, and adaptation of software developed prior to deployment will be needed. Finally, we will analyze the QCd data from the

mooring to advance science objectives outlined earlier in this proposal. This will require integration with data streams from other platforms, such as the HOT cruises, Argo floats, satellite altimetry, and tomography. This will be pursued through collaborations with data assimilation efforts such as ECCO (Cornuelle et al., 2002).

In addition to direct comparisons with similar sensors used during HOT cruises, the optical data will be regularly inter-compared with biogeochemical variables (e.g. POC, DOC, chlorophyll, nutrients). This will allow us to evaluate how accurately we can invert optical measurements to obtain biogeochemical parameters at the ALOHA site and provide a context for with which to interpret the observed particulate and dissolved matter dynamics.

4.1.5 Instrument calibration In order to insure the retrieval of usable and high quality data, a specific effort will be mounted that will focus on:

1. Pre- and post-deployment calibrations.
2. Cross-calibration of sensors on the mooring when the MMP is parked either at the top or bottom of the mooring. This will require a deliberate sampling strategy that includes these inter-calibration episodes.
3. Cross calibration of sensors on the mooring with measurements obtained in conjunction with HOT (optical sensors used in HOT are calibrated every 6 months; R. Letelier, personal communication, 2002).

The design of the mooring will thus insure a vertical structure of high precision (through internal cross calibration). The accuracy will depend on the possibility to cross calibrate with accurate instruments, in particular those of HOT. There is a difficulty associated with comparing measurements from a vertical cast with those of an adjacent mooring; horizontal separation has to be maintained to avoid tangle resulting in a spatial difference of O(1 km). However, the instrument on the vertical cast will be compared to several cross-calibrated in-situ sensors, some of which will travel a significant vertical distance within the time ALOHA Station is occupied. Minimization of the differences between the HOT and mooring sensors will provide the information needed for an absolute calibration of the mooring sensors and an error estimate associated with the calibration. Additionally, data-comparison obtained at the less variable portions of the water column will be weighted more in the minimization procedure.

4.1.6 Education and outreach Education and outreach activities will be conducted as part of the UH effort. AO data will be made available in near real-time via the Internet, and we will work with colleagues in the Curriculum Research Development Group of the UH College of Education to obtain funding for their participation in developing educational products that are most useful for K-12 education. Sights and sounds in the ocean (observed by a hydrophone and video camera module attached to the AO junction box) will attract interest to displays that include information from our other observations. In addition to the undergraduate and graduate students that presently participate in HOT, we will seek to also involve UH community college students with the AO, both in the classroom and at sea. We will also network with the new NSF Centers for Ocean Science Education Excellence (<http://www.nsf.gov/pubs/2002/nsf01173/nsf01173.html>), and also with CORE and UCAR, organizations that have developed relevant science education programs. Local outreach will be achieved through a variety of partnerships, including the Waikiki Aquarium and the new Science Education Center at the Bishop Museum.

4.2 Project organization

The project will be lead by B. Howe. Assisting him are co-PIs Boss (optics), Gobat (ocean engineering), Lukas (physical oceanography, data/information management, education and outreach), McGinnis (engineering), and Mercer (cabled systems). As this is a substantial development effort, McGinnis has been designated project engineer and manager and will interface with the NEPTUNE engineering efforts (he is on the NEPTUNE system engineering team and is the system engineer for the NEPTUNE Power System development project). In addition to informal weekly meetings, there will be formal quarterly project meetings including personnel as appropriate. As mentioned, design reviews will figure prominently as milestones.

Interaction with the larger community will occur on several fronts. Sufficient travel funds have been requested to attend and present work-in-progress and results at engineering and scientific meetings, as well as to visit specific engineers. Documentation and dissemination of information is an important element of this project. We expect to publish in conference proceedings as well as technical journals. A Web page describing the project and providing electronic versions of publications and engineering documents will be maintained to inform the wider community.

During the January 2003 workshop we anticipate the establishment of an advisory body for the AO that is closely coordinated with the HOT program. We will work with them closely to insure the integration of our system, as well as its transition to an operational science tool.

5. Significance and Broader Impacts

The ALOHA Observatory, and the development work proposed here, will help the HOT program attain the long-term goal of reducing cruise frequency by increasing the use of real-time on-site systems. The latter will enable modes of sampling that will allow investigators to view their subject in new and different ways. Further additions and extensions might include direct chemical and biological sampling (see letters from K. Johnson and K. Smith in supporting Documents), small-scale turbulence and mixing studies from the bottom boundary layer to the air-sea interface, and drifters, gliders, AUVs, and tomography to extend the HOT footprint, for instance. Our goal is to make it as easy as possible for new investigators to use this infrastructure and to be able to painlessly add their particular sensors and obtain the data and related information products in a seamless way. Then, with experience, we will be better able to judge long-term service issues and costs: how should we balance frequency of ship visits with calibration needs and sensor/platform reliability? As systems like this are envisioned in one form or another at many sites around the world, this will serve as a useful first case.

Ocean observatories are established but fledgling components of our ocean science world. They are growing and multiplying, an expansion fueled by the science being done. Whether via the NSF Ocean Observatories Initiative or by other means, ocean observatories and the science they perform are clearly fundable in the competitive NSF environment.

Our sensors and mooring network infrastructure will be designed emphasizing reliability and long life. The effort is aimed at the regional and global observatories and is intimately linked with the associated engineering development efforts. These are the building blocks to conduct the oceanographic science reviewed here. This science will provide the essential, coherent context for improving our understanding of the complete ocean system.

NSF has two merit review criteria. The intellectual merit of the proposed work lies in the planned and potential scientific use of the instrumentation and infrastructure that is being developed. Long-term, reliable time series will clearly be an immediate and on-going benefit; the topics discussed in Section 2 fall into this class. But the primary premise and promise of ocean observatories is that new and different ways of doing ocean science will result. An observatory is inherently *coherent*. The change in approach is likely to be a leap, rather than an incremental step. We believe this work provides one springboard for the leap.

The broader impact of the proposed work is the enhancement of “the infrastructure for research and education, such as facilities, instrumentation, networks, and partnerships” (NSF Grant Proposal Guide, 2002). It will directly contribute to advancing techniques for distributing power to, and communicating with ocean and seafloor sensors. The proposed work will contribute to graduate and undergraduate education/training, preparing the workforce for deployment, maintenance and use of the Integrated Ocean Observing System. Further, by extending Internet connectivity (a general NSF-wide goal) to sensors and platforms on ocean observatories, students, the public, and all citizens will have access and can share in the process of scientific research.

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- Letelier, R.M, D.M. Karl, M.R. Abbott, P. Flament, M. Freilich, R. Lukas and T. Strub, 2000: Role of late winter mesoscale events in the biogeochemical variability of the upper water column of the North Pacific Subtropical Gyre *J. Geophys. Res.* Vol. 105, No. C12, p. 28,723-28,740.
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- Lukas, R., 2002a: Variability of the T-S Relationship Observed in the Hawaii Ocean Time-series. manuscript in preparation.
- Lukas, R., 2002b: Mixed layer variability in the Hawaii Ocean Time-series. Manuscript in preparation for submission to *Deep-Sea Res.*
- Lukas, R. and F. Santiago-Mandujano, 1996: Interannual variability of Pacific Deep and Bottom Waters observed in the Hawaii Ocean Time-series. *Deep-Sea Res. II*, 43, 243-255.
- Lukas, R. and F. Santiago-Mandujano, 2001: Extreme Water Mass Anomaly Observed in the Hawaii Ocean Time-series. *Geophys. Res. Lett.*, 28, 2931-2934.
- Lukas, R., F. Santiago-Mandujano, F. Bingham and A. Mantyla, 2001: Cold bottom water events observed in the Hawaii Ocean time-series: Implications for vertical mixing. *Deep-Sea Res. I*, 48 (4), 995-1021.
- Lukas, R., F. Santiago-Mandujano, and L. Zamudio, 2002: Eddy transport of anomalous waters in the Hawaii Ocean Time-series. Manuscript in preparation for submission to *J. Geophys. Res.*
- Merrifield, M.A., P.E. Holloway, and T.M.S. Johnston, 2001: The generation of internal tides at the Hawaiian Ridge. *Geophys. Res. Lett.*, 28, 559-562.

- Munk, W.H., 2002: The evolution of physical oceanography in the last hundred years. *Oceanography*, 15, 135-141.
- Nahorniak, J. S., M. R. Abbott, R. M. Letelier, and W. S. Pegau, 2001. Analysis of a method to estimate chlorophyll-a concentration from irradiance measurements at varying depths, *J. Atmos. Ocean. Tech.*, 18, 2063-2073.
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- NEPTUNE Phase 1 Partners (University of Washington, Woods Hole Oceanographic Institution, Jet Propulsion Laboratory, Pacific Marine Environmental Laboratory), 2000 *Real-time, Long-term Ocean and Earth Studies at the Scale of a Tectonic Plate: NEPTUNE Feasibility Study* (prepared for the National Oceanographic Partnership Program), University of Washington, Seattle. See also <http://www.neptune.washington.edu>.
- Ocean Sciences Decadal Committee, P. Brewer and T. Moore, co-chairs, *Ocean Sciences at the New Millennium*, University Corporation for Atmospheric Research, 2001.
- Orcutt, J., and A. Schultz, Working Group Co-Chairs, *DEOS Global Working Group Report: Moored Buoy Ocean Observatories*, 1999. See DEOS web page and links at <http://www.coreocean.org>.
- Petitt, R., D. W. Harris, B. Wooding, J. Bailey, J. Jolly, E. Hobart, A. D. Chave, F. D. Duennebieer, R. Butler, A. Bowen, and D. Yoerger, The Hawaii-2 observatory, *IEEE J. Oceanic Engineering*, 27, 245-253, 2002.
- Schneider, K., C-C. Liu, T. M. McGinnis, B. M. Howe, and H. Kirkham, Real-Time Control and Protection of the NEPTUNE Power System, *Proceedings of the Oceans 2002 MTS/IEEE Conf.*, Biloxi, Mississippi, October, 2002.
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- Spinrad, R. W., J.R.V. Zaneveld, and J. C. Kitchen, 1983. A study of the optical characteristics of the suspended particles in the benthic nepheloid layer of the Scotian Rise. *J. Geophys. Res.* 88 (C12): 7641-7645
- Stramski, D., R. A. Reynolds, M. Kahru, and B. G. Mitchell. 1999. Estimation of particulate organic carbon in the ocean from satellite remote sensing. *Science*, 285, 239-242.
- Twardowski M., E. Boss, J. B. Macdonald, W. S. Pegau, A. H. Barnard, and J. R. V. Zaneveld, 2001. A model for estimating bulk refractive index from the optical backscattering ratio and the implications for understanding particle composition in case I and case II waters. *J. Geophys. Res.*, 106, 14,129-14,142.

BIOGRAPHICAL SKETCH

Bruce M. Howe

14 August 2002

Birth 19 July 1954, Luxembourg

Citizenship United States

Address Applied Physics Laboratory howe@apl.washington.edu
University of Washington
1013 NE 40th Street
Seattle, WA 98105-6698

Degrees 1978 BSc, Mechanical Engineering, Stanford University
MSc, Engineering Science, Stanford University
1986 PhD, Oceanography, University of California, San Diego

Experience

College of Ocean and Fishery Sciences, University of Washington
Applied Physics Laboratory

1998 – Principal Oceanographer
1992 – 1998 Senior Oceanographer
1987 – 1992 Oceanographer
School of Oceanography

1994 – Research Associate Professor
1988 – 1992 Research Assistant Professor

1986 – 1987 Postgraduate Researcher, Institute of Geophysics and Planetary
Physics, University of California, San Diego

1981 – 1986 Research Assistant, Scripps Institution of Oceanography,
University of California, San Diego

1979 – 1981 Research Associate, Institut für Hydromechanik,
Universität Karlsruhe

1976 – 1979 Research Assistant, Department of Civil Engineering,
Stanford University

Synergistic Activities

2000 – 2003 Acoustical Oceanography Technical Committee, ASA, Member
1999 Fellowship, Science and Technology Agency, Japan,
1997 – present NEPTUNE planning and technical activities
1992 – 2002 Scientific Use of Undersea Cables, Member of IRIS Steering Committee
1991 – 1995 Tomographic Data in Ocean Models, Chairman of ONR Committee

Professional Societies

American Geophysical Union American Meteorological Society
The Oceanography Society (charter life member) Acoustical Society of America
American Association for the Advancement of Science Sigma Xi

Selected Publications

- Howe, B. M.**, H. Kirkham, and V. Vorperian, Power system considerations for undersea observatories, *IEEE J. Oceanic Engr.*, **27**, 267-274, 2002.
- B. Dushaw, et al., Observing the ocean in the 2000's: A strategy for the role of acoustic tomography in ocean climate observation, Proceedings of the First International Conference on the Ocean Observing System, San Rafael, France, 18-22 October 1999, in: *Observing the Oceans in the 21st Century*, C.J. Koblinsky and N.R. Smith (eds), Bureau of Meteorology, Melbourne, Australia, 2001.
- Delaney, J. R., G. R. Heath, A. D. Chave, **B. M. Howe**, and H. Kirkham, NEPTUNE: Real-time ocean and earth sciences at the scale of a tectonic plate, *Oceanography*, **13**, 71–83, 2000.
- ATOC Consortium: A. B. Baggeroer, T. G. Birdsall, C. Clark, J. A. Colosi, B. D. Cornuelle, D. Costa, B. D. Dushaw, M. Dzieciuch, A. M. G. Forbes, C. Hill, **B. M. Howe**, J. Marshall, D. Menemenlis, J. A. Mercer, K. Metzger, W. Munk, R. C. Spindel, D. Stammer, P. F. Worcester, and C. Wunsch, Observing ocean climate change: Comparison of acoustic tomography, satellite altimetry, and modeling, *Science*, **281**, 1327–1332, 1998.
- Howe, B. M.**, K. Runciman, and J. A. Secan, Tomography of the ionosphere: Four-dimensional simulations, *Radio Science*, **33**, 109–128, 1998.
- Dushaw, B. D., P. F. Worcester, B. D. Cornuelle, **B. M. Howe**, and D. S. Luther, Barotropic and baroclinic tides in the central North Pacific Ocean determined from long-range reciprocal acoustic transmissions, *J. Phys. Oceanogr.*, **25**, 631–647, 1995.
- ATOC Instrumentation Group: **B. M. Howe**, S. G. Anderson, A. Baggeroer, J. A. Colosi, K.R. Hardy, D. Horwitt, F. Karig, S. Leach, J. A. Mercer, K. Metzger, Jr., L. O. Olson, D. A. Peckham, D. A. Reddaway, R. R. Ryan, R. P. Stein, K. von der Heydt, J. D. Watson, S. L. Weslander, and P. F. Worcester, Instrumentation for the Acoustic Thermometry of Ocean Climate (ATOC) prototype Pacific Ocean array, *Proc. Oceans '95 MTS/IEEE*, San Diego, California, 1483–1500, 1995.
- Worcester, P. F., B. D. Cornuelle, J. H. Hildebrand, W. S. Hodgekiss, Jr., T. F. Duda, J. Boyd, **B. M. Howe**, J. A. Mercer, and R. C. Spindel, A comparison of measured and predicted broadband arrival patterns in travel time-depth coordinates at 1000-km range, *J. Acoust. Soc. Am.*, **95**, 16,365–16,378, 1994.
- The AMODE–MST Group, Moving Ship Tomography in the Northwest Atlantic Ocean, *Trans. Am. Geophys. Un., EOS*, **75**, pp 17, 21, 23, 1994.
- Howe, B. M.**, P. F. Worcester, and R. C. Spindel, Ocean acoustic tomography: Mesoscale velocity, *J. Geophys. Res.*, **92**, 3785–3805, 1987.

Collaboration: Collaborators are reflected in the publications list.

Graduate student advising: Chris Walter, Keith Curtis, and Christian Parker.

Post-graduate advising: Brian Dushaw.

Graduate advisors: Walter Munk and Peter Worcester. Post-graduate advisor: Peter Worcester.

Biographical Sketch

Jason Gobat
Oceanographer, Applied Physics Laboratory, University of Washington
1013 NE 40th St., Seattle, WA 98105
(206) 543-2439; jgobat@apl.washington.edu

Professional Preparation

University of California, San Diego, Structural Engineering/Philosophy, B.S./B.A., 1993
MIT/WHOI Joint Program, Oceanographic Engineering, M.S., 1997
MIT/WHOI Joint Program, Oceanographic Engineering, Ph.D., 2000
Woods Hole Oceanographic Institute, Physical Oceanography, Post-doctoral, 2000-2001

Appointments

2001 - present	Oceanographer, University of Washington Applied Physics Laboratory
2000 - 2001	Postdoctoral Investigator, Department of Physical Oceanography, Woods Hole Oceanographic Institution
1994 - 2000	Research Assistant, Department of Applied Ocean Physics and Engineering, Woods Hole Oceanographic Institution
1993 - 1994	Development Engineer, Scripps Institution of Oceanography

Significant publications most closely related to project

Gobat, J., R. Weller, B. Way, and J. Lord. A compact coastal ocean observing system. In *Proceedings of Oceans 2001*, Honolulu, HI, Vol. 2, 1283-1289.

Other significant publications

Gobat, J.I., and M.A. Grosenbaugh (2001). Application of the generalized- α method to the time integration of the cable dynamics equations, *Computer Methods in Applied Mechanics and Engineering*, 190, 4817-4829.

Gobat, J.I., and M.A. Grosenbaugh (2001). Dynamics in the touchdown region of catenary moorings. *International Journal of Offshore and Polar Engineering*, 11, 273-281.

Gobat, J.I., and M.A. Grosenbaugh (2001). A simple model for dynamic tension in catenary moorings. *Applied Ocean Research*, 23, 159-174.

Anderson, S.P., R. Trask, R.A. Weller, W. Ostrom, B. Way, B. Butman, M. Grosenbaugh, J. Gobat, and W. Paul (1999). Measuring temperature and velocity variability from a horizontal mooring. In *Proceedings of the IEEE Sixth Working Conference on Current Measurement*, San Diego, CA.

Simpson, J.J., and J.I. Gobat (1994). Robust velocity estimates, stream functions, and simulated Lagrangian drifters from sequential spacecraft data, *IEEE Transactions on Geosciences and Remote Sensing*, 32, 479-493.

Collaborators within last 48 months

Craig Lee (University of Washington), Mark Grosenbaugh (WHOI), Robert Weller (WHOI)

Graduate and Postdoctoral Advisors

Dr. Mark Grosenbaugh, Woods Hole Oceanographic Institution, Graduate Advisor
Dr. Robert Weller, Woods Hole Oceanographic Institution, Postdoctoral Advisor

Thesis Advisor and Postgraduate Scholar Sponsor

None

BIOGRAPHICAL SKETCH

Tim McGinnis
University of Washington
Applied Physics Lab
1013 NE 40th St
Seattle, WA 98105-6698
tel: 206-543-1346
fax: 206-543-6785
e-mail: tmcginnis@apl.washington.edu

Education

BSE, Ocean Engineering, University of Washington, Seattle, WA, 1983.

Employment History

May 2001 – present	Senior Engineer Applied Physics Lab, University of Washington, Seattle, WA
1994 - May 2001	General Manager, Engineering Manager, Williamson & Associates, Inc., Seattle, WA
1990 - 1994	Engineering Manager Williamson & Associates, Inc., Seattle, WA
1983 - 1990	Ocean Engineer Williamson & Associates, Inc., Seattle, WA
1980 – 1983	Electronics Technician International Submarine Technology, Ltd., Redmond, WA

Significant publications most closely related to project

Robotic Drill Workshop, Keynote Speaker – Recent Robotic Drill Developments, Texas A&M University, 2000

Advances in Deep Ocean Seafloor Coring, Sea Technology Magazine, June, 2000.

A New Deep Seafloor Rock Coring Drill (co-author), Marine Technology Society Conference, 1991.

Design and Applications of a Versatile Multiplexed Telemetry and Power System, Oceans 93.

BMS, a Special Purpose ROV for Deepwater Core Sampling, Underwater Intervention, 2000.

Remote Control Seafloor Coring in the West Mariana Basin, Oceans 99.

BIOGRAPHICAL SKETCH

James A. Mercer

14 August 2002

Birth 15 August 1947, Seattle, WA

Citizenship United States

Address Applied Physics Laboratory mercer@apl.washington.edu
University of Washington
1013 NE 40th Street
Seattle, WA 98105-6698

Degrees 1968 BSc, Physics, University of Washington
1983 PhD. Geophysics, University of Washington

Experience

College of Ocean and Fishery Sciences, University of Washington
Applied Physics Laboratory

1998 – Principal Physicist
1981 – 1990 Senior Physicist
1979 – 1981 Physicist IV
1976 – 1979 Associate Physicist
1968 – 1976 Assistant Physicist

College of Arts and Sciences
Department of Earth and Space Sciences

1993 – Research Associate Professor
1991 – 1993 Research Assistant Professor

Synergistic Activities

2002 – Scientific Use of Undersea Cables, Member of IRIS Steering Committee
1994 Associate Editor US Navy Journal of Underwater Acoustics
2000 – 2003 Underwater Acoustics Technical Committee, ASA, Member
1998 – 2001 Acoustical Oceanography Technical Committee, ASA Member
1986 – 1988 The American Society for Engineering Education Faculty Award

Professional Societies

American Geophysical Union
The Oceanography Society
Acoustical Society of America

Selected Publications

Mercer, James, Brian Dushaw, Bruce Howe, and Robert Spindel, Acoustic ocean monitoring in the NE Pacific at megameter ranges (U), *U.S. Navy J. Underwater Acoust.*, **49**, 781-790, 1999.

Orcutt, J., C. deGroot-Hedlin, W. Hodgkiss, W. Kuperman, W. Munk, F. Vernon, P. Worcester, E. Bernard, R. Dziak, C. Fox, C.-S. Chiu, C. Collins, **J. Mercer**, R. Odom, M. Park, D. Soukup, and R. Spindel (2000). "Long-term observations in acoustics — the Ocean Acoustic Observatory Federation," *Oceanography*, **13**, 57–63.

Dushaw, Brian D., Bruce M. Howe, **James A. Mercer**, Robert C. Spindel, and the ATOC Group, Multimegameter range acoustic data obtained by bottom hydrophone arrays for measurement of ocean temperature, *IEEE J. Oceanic Eng.*, **24**, 202-214, 1999.

Curtis, Keith R., Bruce M. Howe, and **James A. Mercer**, Low-frequency ambient sound in the North Pacific: Long time series observations, *J. Acoust. Soc. Am.*, **106**, 3189-3200, 1999.

Colosi, J. A., E. K. Scheer, S. M. Flatte, B. D. Cornuelle, M. A. Dzieciuch, W. H. Munk, P. F. Worcester, B. M. Howe, **J. A. Mercer**, R. C. Spindel, K. Metzger, T. G. Birdsall, and A. B. Baggeroer, Comparisons of measured and predicted acoustic fluctuations for a 3250-km propagation experiment in the eastern North Pacific Ocean, *J. Acoust. Soc. Am.*, **105**, 3202-3218, 1999.

The **ATOC Consortium**, The general circulation and heat budget of the North Pacific Ocean from acoustic tomography, satellite altimetry, and a general circulation model, *Science*, **281**, 1327, 1998.

Odom, Robert I. and **James A. Mercer**, Spectral diffusion of elastic wave energy, *Geophys. J. Int.*, **127**, 111-124, 1996.

Odom, Robert I., Minkyu Park, **James A. Mercer**, Robert S. Crosson, and Pauline Paik, Effects of transverse isotropy on modes and mode coupling, *J. Acoust. Soc. Am.*, **100**, 2079-2092, 1996.

Mercer, J.A., Non-reciprocity of simulated long-range acoustic transmissions, *J. Acoust. Soc. Am.*, **84**, 999-1006, September 1988.

Mercer, J.A., Geoacoustic parameters and the depth-dependent Green's function for a silty sediment at 100 Hz in shallow water, *J. Acoust. Soc. Am.*, **83**, 611-616, February 1988.

Mercer, J.A., Acoustic oceanography by remote sensing, *IEEE J. Oceanic Eng.*, OE-11, 51-57, 1986

Mercer, J.A., and J.R. Booker, Long-range propagation of sound through oceanic mesoscale structures, *J. Geophys. Res.*, **88**, 689-699, 1983.

Collaboration: Collaborators are reflected in the publications list.

Graduate student advising: Chris Walter, Keith Curtis, Pauline Paik, .

Graduate advisors: John Booker.

Biographical sketch

Emmanuel Boss

Assistant professor of Oceanography

School of Marine Sciences, University of Maine, 5741 Libby Hall, Orono, ME 04469

Tel.: (207) 581-4378/ Fax: (207) 581-4388/ Email: emmanuel.boss@maine.edu

<http://www.ume.maine.edu/%7emarine/Boss/cv.html>

a. Professional Preparation.

- 1990 B. S. Hebrew Univ., Math, Physics, Honors
- 1991 M. S. Hebrew Univ., Oceanography, Highest honors, (advisor Nathan Paldor)
- 1996 Ph. D. Univ. of Washington, Oceanography (advisor Luanne Thompson)
- 1997 Postdoctoral Studies, Univ. of Washington., Oceanography (advisor MJ Perry)
- 1998 Postdoctoral Studies, Oregon State Univ., Oceanography (advisor JRV Zaneveld)

b. Appointments.

- 1999-2002 Assistant Professor (Sr Res), Oregon State Univ., Oceanography
- 2002-present Adjunct Professor, Oregon State Univ., Oceanography
- 2002-present Assistant Professor, School of Marine Sciences, Univ. of Maine

c. Five related publications

- Boss E. and J. Ron V. Zaneveld, 2001. The effect of bottom substrate on inherent optical properties; evidence of biogeochemical processes. *Limnology and Oceanography*, in press.
- Pegau W. S., E. Boss and A. Martinez, 2001. Ocean color observations of eddies in the Gulf of California during the summer. *Geophysics review letters*, in press.
- Twardowski M., E. Boss, J. B. Macdonald, W. S. Pegau, A. H. Barnard, and J. R. V. Zaneveld, 2001. A model for estimating bulk refractive index from the optical backscattering ratio and the implications for understanding particle composition in case I and case II waters. *Journal of Geophysical Research*, 106, 14,129-14,142.
- Boss, E., W. S. Pegau, J. R. V. Zaneveld and A. H. B. Barnard. 2001. Spatial and temporal variability of absorption by dissolved material at a continental shelf. *Journal of Geophysical Research*, 106, 9499-9508.
- Boss, E., W. S. Pegau, W. D. Gardner, J. R. V. Zaneveld, A. H. Barnard., M. S. Twardowski, G. C. Chang and T. D. Dickey, 2001. The spectral particulate attenuation and particle size distribution in the bottom boundary layer of a continental shelf *Journal of Geophysical Research*, 106, 9509-9516.

d. Five other significant publications:

Mobley, C. D., Sundman, L. K. and E. Boss, 2001. Phase function effects on oceanic light fields. *Applied Optics*, 41, 1035-1050.

Boss E. and W. Scott Pegau, 2001. The relationship of light scattering at an angle in the backward direction to the backscattering coefficient. *Applied Optics*, 40, 5503-5507.

Zaneveld, J. R. V., E. Boss and Paul A. Hwang, 2001. The influence of coherent waves on the remotely sensed reflectance. *Optics Express*, 9, 260-266.

Boss E., M. S. Twardowski and S. Herring, 2001. The shape of the particulate beam attenuation spectrum and its relation to the size distribution of oceanic particles. *Applied Optics*, 40, 4885-4893.

Zaneveld, J. R. V., E. Boss and A. Barnard. 2001. Influence of surface waves on measured and modeled irradiance profiles. *Applied Optics*, 40, 1442-1449.

e. Synergistic Activities

Instructor, Ocean Optics summer class (U. of Maine, previously at Friday Harbor Labs, UW).

Committee service: Member, SCOR working group on New Technologies for Observing Marine Life. Invited participant of the NSF workshop on Coastal Observatory Science.

f. Collaborators

M. Behrenfeld (NASA Goddard), B. Bergamaschi (USGS, Sacramento), K. Fennel (OSU), P. Hill (Dalhousie), S. Pegau (OSU), M. J. Perry (U. Maine), S. Riser (U. Washington), C. Roesler (Bigelow), M. S. Twardowski (WetLabs), R. J. V. Zaneveld (OSU).

g. Graduate Students:

S. Hearing (MSc. OSU)

h. Graduate and postdoctoral advisors

Nathan Paldor, LuAnne Thompson, Mary Jane Perry, Ron Zaneveld

Roger B. Lukas

Professor of Oceanography
School of Ocean and Earth Science and Technology
University of Hawaii at Manoa

(808) 956-7896 (Office)

(808) 956-9222 (Fax)

rlukas@iniki.soest.hawaii.edu

<http://www.soest.hawaii.edu/~rlukas>

a. Education

Ph.D., Oceanography, 1981, University of Hawaii
M.S., Oceanography, 1977, University of Hawaii
A.B., Mathematics, 1973, University of Southern California

b. Employment

07/91—Present	Professor, Dept. of Oceanography, University of Hawaii
01/87—06/91	Associate Professor, Dept. of Oceanography, University of Hawaii
07/86—12/86	Associate Oceanographer, Hawaii Institute of Geophysics, U. of Hawaii
04/84—Present	Senior Fellow, Joint Institute for Marine and Atmospheric Research, U. of Hawaii
10/82—06/86	Assistant Oceanographer, Hawaii Institute of Geophysics, University of Hawaii
12/81—09/82	Visiting Scientist, Joint Institute for Marine and Atmospheric Research, U. of Hawaii
01/75—12/81	Graduate Research Assistant, University of Hawaii
09/74—01/75	Graduate Teaching Assistant, University of Hawaii
01/74—04/74	Laboratory Assistant, Woods Hole Oceanographic Institution

c. Five related publications

Finnigan, T.D., D.S. Luther and R. Lukas, 2002: Observations of enhanced mixing near the Hawaiian Ridge. *J. Phys. Oceanogr.*, in press.

Letelier, R.M, D.M. Karl, M.R. Abbott, P. Flament, M. Freilich, R. Lukas and T. Strub, 2000: Role of late winter mesoscale events in the biogeochemical variability of the upper water column of the North Pacific Subtropical Gyre *J. Geophys. Res.* Vol. 105, No. C12, p. 28,723-28,740.

Lukas, R., 2001: Freshening of the Upper Thermocline in the North Pacific Subtropical Gyre Associated With Decadal Changes of Rainfall. *Geophys. Res.Lett.*, 28, 3485-3488.

Lukas, R. and F. Santiago-Mandujano, 2001: Extreme Water Mass Anomaly Observed in the Hawaii Ocean Time-series. *Geophys. Res. Lett.*, 28, 2931-2934.

Lukas, R., F. Santiago-Mandujano, F. Bingham and A. Mantyla, 2001: Cold bottom water events observed in the Hawaii Ocean time-series: Implications for vertical mixing. *Deep-Sea Res. I*, 48 (4), 995-1022.

d. Five other significant publications

Meehl, G.A., R. Lukas, G.N. Kiladis, K.M. Weickmann, A.J. Mathews and M. Wheeler, 2001: A conceptual framework for time and space scale interactions in the climate system. *Climate Dynamics*, 17, 753-775.

Feng, M., P. Hacker, R. Lukas, R. Weller and S.P. Anderson, 2000: Upper ocean heat and salt balances in the western equatorial Pacific in response to the intraseasonal oscillation during TOGA COARE. *J. Climate*, 13, 2409-2427.

Soloviev, A., R. Lukas and P. Hacker, 2001: An approach to parameterization of the oceanic turbulent boundary layer in the western Pacific warm pool. *J. Geophys. Res.*, 106, 4421-4435.

Lukas, R., 2001: Pacific Equatorial Currents. In: *Encyclopedia of Ocean Sciences*, J.H. Steele, S.A. Thorpe, and K.A. Turekian, eds., Academic Press, London.

Anderson, S.P., R.A. Weller, and R. Lukas, 1996: Surface buoyancy forcing and the mixed layer of the western Pacific warm pool: Observations and 1-D model results. *J. Climate*, 9, 3056-3085.

e. Synergistic Activities

- Developed graduate course on physical oceanographic instruments and methods in conjunction with monthly HOT cruises
- Developed the HOT hydrographic database and web site
- Co-chaired the US-Japan committee that led to the establishment of the International Pacific Research Center at U. Hawaii, and drafted its Science Plan
- NRC and other committee service: co-Chair, COARE Science Working Group, US CLIVAR Pacific Implementation Panel, NAS Ocean Studies Board, Committee on Seafloor Observatories, Committee on Major Ocean Programs.

f. Collaborators and other affiliations

M.R. Abbott (OSU), S. Anderson (Horizon Marine), M. Baker (JHU/APL), F. Bradley (CSIRO), S. Chen (U. Miami), F. Duennebie (UH), M. Feng (CSIRO), E. Firing (UH), P. Flament (UH), M. Freilich (OSU), D. Frye (WHOI), P. Hacker (UH), D. Karl (UH), G.N. Kiladis (UC/CIRES), G. Lagerloef (ESR), R. Letelier (OSU), D. Luther (UH), A. Mantyla (SIO), A.J. Matthews, J. McCreary (UH), M. McPhaden (PMEL), G. Meehl (NCAR), G. Mitchum (USF), J. P. Niiler (SIO), J. Picaut (Goddard), L. Rothstein (URI), A. Soloviev (Nova), D. Stammer (SIO), T. Strub (OSU), J. Toole (WHOI), P. Webster (GTech), K.M. Weickmann (NOAA/CIRES), R. Weller (WHOI), M. Wheeler (), T. Yamagata (U. Tokyo)

g. Students and Postdoctoral fellows supported and graduated

2000-01, Tatsuo Suzuki, postdoc; 1998, Jim Potemra, Ph.D. (advisor); 1997, Ming Feng, Ph.D. (co-advisor); 1996-97, Bin Li, postdoc; 1992-94, Fred Bingham, postdoc; 1993, Toshiaki Shinoda, Ph.D. (advisor); 1993, Sean Kennan, M.S. (advisor); 1988-90, Steve Chiswell, postdoc; 1986, June Firing, M.S. (co-advisor); 1985, Ren-Chieh Lien, M.S. (co-advisor); Stewart Reid, Ph.D. 1994, 2 years support

h. Graduate and postdoctoral advisors

K. Wyrtki, E. Firing

Budget Justification

In this 5-year project we will integrate a suite of sensors on a mooring for measuring oceanographic variables, adapting existing components or developing new ones, as necessary. The mooring network infrastructure that is required to link an array of these instruments to the cabled ALOHA Observatory is integral to this proposal. This is a collaborative research proposal with three institutions: UW Applied Physics Laboratory (Howe et al.; \$3,347K), University of Hawaii (Lukas; \$522K), and University of Maine (Boss; \$281K). Here we describe the UW part; please see the other respective Budget Justifications. The total requested amount for all institutions is \$4,150K.

A major part of this project's expenses are in equipment fabrication (including salaries associated with development) that does not carry indirect cost overhead (17% at APL-UW). Major fabrication items include the winched profiler, the modified moored profiler with dock, junction boxes, mooring cable, and float. The NSF budget sheets combine non-fabrication and fabrication together. The non-fabrication part of the budget (includes science, management, and most travel, for instance) amounts to \$1,106K, spread roughly uniformly over time. The fabrication portion amounts to \$2,237K, heavily weighted in the first years.

Within the fabrication budget, equipment in the normal sense (sensors, pressure cases, electronics, cables, etc.) is listed under supplies, accounting for \$852K of the \$2,237K total. The former amount could be regarded as an estimate of the replication or recurring parts cost, and the difference, \$1,385K, can be regarded as an estimate of the labor costs. We estimate that about \$250K of this labor cost is what it would take to replicate the mooring, not including sea trips. The major development items are the winched profiler, the modified MMP, and the junction boxes; the first two involve mechanical systems. The following tables summarize the fabrication and non-fabrication portions of the project.

Summary of Fabrication Effort (parts, \$K; labor, man months)

Fabrication Item	Year 1		Year 2		Year 3	
	Parts	Labor	Parts	Labor	Parts	Labor
Winched Profiler	31	6.0				
Profiler Sensors	47	0.5				
Winch	31	2.0		4.0		
Float Infrastructure		5.5	35	2.2		1.0
Float Sensors	89	0.5				
Moored Profiler	200	10.3		1.0		
Junction Boxes		9.5	67	1.5	67	1.0
Observatory Interface			50	3.0		
Anchor, Cables & Connectors			212		9.5	
Anchor Sensors			15	0.5		
Testing				7.7		
Deployment Cruise						4.5
Assembly		6.0		5.6		2.5
Total	\$397K	40.3	\$379K	25.5	\$77K	9.0

Summary of Non Fabrication Effort (man months)

	Year 1	Year 2	Year 3	Year 4	Year 5
Admin/Management	3.0	2.5	1.3	0.7	0.7
Science,Coordination	4.5	5.0	7.0	4.5	5.3
Cruises (Non Fab)	0.3			0.5	1.0
Support (intern)	3.8	3.6	4.0	3.6	3.5
Total	11.5	11.1	12.3	9.3	10.5

Personnel and Roles

The major personnel and their roles and responsibilities are as follows:

Bruce Howe, project PI. Howe will be responsible for overall coordination of the project, coordination within the NSF OOI effort and NEPTUNE, and the analysis of the ambient sound data. He is currently PI on the NSF-funded NEPTUNE power system design project, and on the NEPTUNE Program Office staff.

Jason Gobat will be responsible for the mooring and winched profiler design analyses, and integration of the physical and optical sensors into the infrastructure framework, including interfacing the MMPs. He has extensive experience in the design of innovative oceanographic moorings, including both mechanical and hydrodynamic forcing aspects and integration of complex sensor and telemetry suites.

Tim McGinnis, project engineer and manager, will contribute to all aspects of the development work. He recently joined APL-UW specifically to work on ocean instrumentation and sensor network infrastructure for cabled ocean observatories. He is presently system engineer for the NEPTUNE power system project and is a member of the NEPTUNE system engineering team.

Jim Mercer (APL-UW) will work with Fred Duennebier (UH, ALOHA Observatory) as our primary point of contact with the AO. He is currently building a shore power supply for the similar IRIS H2O cable system and has over 30 years of experience with underwater cable systems and acoustic technology.

Others at APL: Mike Kenney will be responsible for hardware/software work associated with the various micro-controllers and for the instrument server software providing the interface between the sensors and the scientists; he is working on similar topics for the NEPTUNE power system. Vern Miller will be responsible for mechanical engineering, including the winch, MMP docking, and mooring designs.

Emmanuel Boss (UMaine) will lead the moored optical data analysis and supervise a post-doc who will devote six months per year to this project. The post-doc will interface with APL's engineers to insure proper integration and deployment of the optical sensors. See the UMaine Budget Justification for detail.

Roger Lukas (UH) is the co-founder of the Hawaii Ocean Time-series, and has studied the ocean around Hawaii for nearly 30 years. He will be responsible for the development of the information management system, including real-time data management and quality control, product generation, and distribution via the Web. He will work with other groups to pursue education and outreach objectives for the AO. He will lead the moored physical data analysis, in conjunction with analysis of other physical measurement at and around Station ALOHA. See the UH Budget Justification for detail.

Equipment

The estimated costs for the various elements are:

Year 1 – Winched profiler (\$31K, includes secondary junction box, flotation, frame); winched profile sensors (\$47K; Seabird CTDO₂, \$15K; Optics, \$32K); winch (\$31K); subsurface float sensors (\$89K; ADCP \$50K, CTDO₂, \$15K; Optics, \$18K); moored profiler (\$200K; basic MMP, \$54K; McLane NRE, \$50K; Falmouth CTD and ACM, \$21K; O₂, \$5K, Optics; \$18K; secondary junction box, \$19K; batteries, dock, ultra-capacitors and controller, \$34K). Optics breaks down as follows: CDOM, \$4K; transmissometer, \$4K; chlorophyll, \$4K; backscatter, \$6K; and radiance/irradiance (on winch profiler only), \$14K. The total for Year 1 is \$397K.

Year 2 – Anchor, cables and connectors (\$212K; mooring cable \$120K; connectors: dry \$60K, wet \$26K), Observatory Interface (\$50K); subsurface float parts (\$35K; float; \$18K; hardware, \$7K; ultra-capacitors, \$10K); subsurface float junction box (\$67K), anchor sensors (Seabird CTDO₂, \$15K). The total for Year 2 is \$379K.

Year 3 – Anchor junction box (\$67K; includes acoustic transceiver, \$21K); Anchor (\$10K).

The total cost of the sensors (no platforms) is \$237K.

Travel

Funds are requested to attend science and engineering meetings, visit engineers associated with existing ocean observatories, provide coordination with on going ocean observatory development efforts, provide travel for consultants for the three design reviews, sea trips (including one HOT cruise the first year to gain familiarity with the program), and to brief program officers at NSF. The total travel request is \$86K, of which \$22K is for the deployment cruise, within the fabrication budget. Per diem rates used at specific locations are set by the state of Washington.

Services and Supplies

A total of \$60K is allocated for compensation and costs for design review consultants (based on the Power System Concept Design Review mentioned in the Results from Prior NSF Support) and for the January 2003 workshop. Various other services include journal page charges, communications, computer services, test tank rental, pressure testing, APL utility boat charges, shipping, and machine shop; the last three make up most of the fabrication services.

General Notes:

Section B: Other Personnel The amount budgeted for administrative, clerical, or secretarial support will cover services directly related to the grant/contract. APL-UW is considered a “major project,” and thus such charges are in full compliance with OMB Circular A-21, Section F.6.b. Reference 30 Sept. 1994 letter (ser 4330/247) from June Hawley, Administrative Contracting Officer, Office of Naval Research, Seattle Regional Office, to William Bakamis, APL-UW General Manager, Business and Finance.

Section C: Fringe Benefits The benefit and leave rates included in the budget are in accordance with UW’s negotiated rates approved by HHS and UW policy on proposal budgets.

Section G-6: Other Included in this section are services and APL-UW Prorated Direct Costs (PDC). The University Indirect Cost rate applied to APL-UW is lower than the rate elsewhere on campus (17% vs 52%) and does not recover the Laboratory’s central costs. These are recovered by applying PDC to total salaries. PDC includes such expenses as salaries and employee benefits for central service employees, administrative data processing, communications, and some facilities costs. APL-UW’s PDC has been reviewed and accepted by the Navy’s resident administrative contracting officer. Reference 24 Oct. 01 letter (ser 4330/247) from C. C. Everley, Administrative Contracting Officer, Office of Naval Research, Seattle Regional Office, to David Low, Dept. of Health and Human Services, San Francisco, CA.

Summary of Other Charges (\$K)

	Year 1	Year 2	Year 3	Year 4	Year 5
Non Fabrication PDC	37	37	43	32	39
Fabrication PDC	144	85	29	3	3
Computer Service	2	2	3	1	1
APL Machine Shop	63	63	16	16	16
Communications	2	2	2	1	1
Other *	0	24	33	0	6
Total	\$247K	\$212K	\$123K	\$52K	\$65K

*Other: Year 2: Testing costs (Pressure testing \$3.6K utility vessel \$19.5K & test tank \$1.2K
 Year 3: Deployment costs (Shipping \$22.5K, sensor calibration \$5K & pier services \$5K)
 Year 5: Shipping \$6K

Section I: Indirect costs APL-UW’s negotiated indirect rate is 17% of Modified Total Direct Costs (MTDC). Other departments at UW have an indirect rate of 52% MTDC. MTDC includes all direct costs less equipment, and the amount of sub awards above the initial \$25K. **Indirect charges are not applied to cost associated with equipment design and fabrication for equipment for which the UW will retain title.**

UNIVERSITY OF MAINE: BUDGET JUSTIFICATION

A. Senior Personnel:

Dr. E. Boss will act as principal investigator for this project, responsible for the general oversight of the project and responsibility for ensuring delivery of the products. He will be responsible for the interpretation of measured data. He will dedicate 0.5mo/yr for the first 3 years and 1mo/yr (E. Boss's appointment at the U. of Maine is for 9 months a year of which 70% is dedicated to research and 30% to teaching, i.e. including summers, he dedicates more than 9 month per year to research). E. Boss will supervise a postdoctoral researcher (see below) who will dedicate 6 months/year to this project. Emmanuel got hired at the U of Maine in March 2002. Previously he has been a research scientist at Oregon State U.

B. Other Personnel:

Support for 26 months of a postdoc is requested (4mo/yr for the first 2 yrs and 6mo/yr thereon). There are currently two candidates to postdoc with E. boss beginning in the fall-winter 2002-03. 1. Trish Bergman of Rutgers will visit in Maine in July to discuss postdoc opportunities. She is a specialist in marine optics and phytoplankton physiology. 2. Iain McCallum (PhD, University of Strathclyde, Glasgow) would like to come and postdoc at U. of Maine if funding is available. He is a specialist of both laboratory and theoretical aspect of scattering. Both candidates are well versed in ocean optics and instrumentation and will enhance the proposed program.

C. Other Direct Costs:

Travel: Funds \$9300 are requested for Dr. Boss + Postdoc to cover yearly PI meetings on the west coast (Hawaii or Seattle) and one national meeting. These funds will cover flights, per-diem and hotel/motel accommodations.

Materials & Supplies: \$4300 are requested to cover costs of a computer for the postdoc and needed software and hardware used to analysis the data. It will also be used to cover costs of supplies for testing instrument calibrations at U. of Maine (including filters for NANOpure system and Gelman filters for in-situ deployments).

Computer use: Nominal funds \$1,900 to cover software upgrades (including MATLAB tool boxes).

Other: Nominal funds \$2,900 to cover costs associated with long distance phone and fax charges associated with this project as well as shipping costs associated with instrumentation.

Publication/Dissemination: We request \$2600 to cover page charges and other publication costs associated with one anticipated publication (JGR).

D. Indirect Costs and Fringe Rate:

The overhead rate is 47% charged on all Direct Costs. This is the negotiated rate for the University of Maine. The Fringe Rate of the University of Maine is 37.4% and includes benefits and retirement.

Roger Lukas is the co-founder of the Hawaii Ocean Time-series, and has studied the ocean around Hawaii for nearly 30 years. He will be responsible for the development of the information management system, including real-time data management and quality control, product generation, and distribution via the Web. He will lead the mooring physical data analysis, in conjunction with analysis of other physical measurements at and around Station ALOHA. He will work with other groups to pursue education and outreach objectives for the AO. He will be assisted by Sharon DeCarlo, a computer specialist who has successfully developed real-time ocean data acquisition systems, managed many different types of ocean and atmospheric data (including the HOT database), developed complex websites, and has assisted Lukas in oceanographic data analysis for 20 years. An MS candidate will work with Lukas and DeCarlo, learning about the cabled mooring observations, data handling, Internet tools, and information product generation. We anticipate graduating two such students over the course of the project. Undergraduate students will participate in developing QC procedures and in the data analysis, as well as routine web site maintenance and data entry. Nancy Paquin will provide secretarial assistance in various project-related tasks.

We will use two existing workstations from the HOT project during the first two years. We include funds for a capable multi-processor server with large storage capacity in year 3 in anticipation of the handling of the numerous data streams and multi-user interaction with these data and other information. We budget for network access fees and maintenance on the workstations and server. Travel support is included for interaction of UH participants with UW/APL participants for planning and implementation of software systems during the development phase, that will be needed both for development support and for transition of the mooring system to “operational” status. Travel is also included for presentation of mooring science results at national meetings.

UNOLS Ship Time Request Form - Section ONE

UNOLS Request ID #: 20020807201630BZ
 Version #: 003
 Last Modified: 2002/08/14 15:38 EDT
 Date Issued: 2002/08/14 16:14 EDT

P.I. Name Last: Howe First: Bruce MI: M

Institution: University of Washington, Applied Physics Lab
 Address: 1013 NE 40th St Seattle, WA 98105
 Research vessel required for:
 Ancillary Only
 Principal Use
 No Ship Required
 Long Range Planning

Document

Phone: 1-206-534-9141 Fax: 1-206-543-6785 Email: howe@apl.washington.edu

Co P.I. Name	Institution	Co P.I. Name	Institution
Emannual Boss	University of Maine	Roger Lukas	University of Hawaii

Proposal Title:

Collaborative Research: A Mooring for Cabled Ocean Observatories

Large Program Name: None Research Purpose: Instrumentation
 If Other, specify: If Other, specify:

New Proposal? Y Agency Submitted to: Foreign EEZ? N
 Funded Grant? N NSF/OCE/OTIC
 Institutional Proposal #: Amount Requested: Area(s) of Operation:
 \$4.1M NP12

Agency Proposal #:

Renewal? N Start Date: Jan 1, 2003 Begin: 22N 158W
 Grant #: End Date: Dec 31, 2007 End: 22N 158

Year	Ship(s) Requested (Name or Size)	# Science Days Req.	Optimum Dates	Alternate Dates
2005	Large	15	summer	summer
2007	Large	7		

Total Science & Ship Days Needed: 22 PORTS
 Start: Intermediate: End:
 Number in Science Party: 8 Hawaii Hawaii

Equipment Required:

Vans P-Code GPS MCS Alvin DSL 120
 Dynamic Positioning Multibeam SCS ROV 680 Cond.
 Helicopter Operation

=====
Other Special Equipment; Comments:
=====

In 2005, we will require use of JASON 2 or similar deep ROV for installing instrumentation at a seafloor junction box on the Aloha Observatory and for installing and servicing a mooring. We will need the vessel's trawl wire capable of 5000m depth.

We will also will need a real-time Internet connection to shore.

=====
UNOLS Ship Time Request Form - Section TWO
=====

Other Scientists Involved in Multi-P.I. Program:
=====

Table with 4 columns: Name, Institution, Phone, E-mail. Rows include Roger Lukas, Emmanual Boss, Tim McGinnis, and Jason Gobat.

Are there special considerations of the science party or cruise scheduling? Consider science time constraints; coordination of equipment shipping; two-ship operations; weather windows; mooring turn-around; teaching schedules and others that will affect scheduling decisions.

In 2005, we will be installing a mooring and using Jason II or similar deep ROV to connect it to the new Aloha Observatory junction box. We will require JASON II or similar and will also need to install a large winch for storage and deployment of a 25mm mooring cable.

In 2007, we will be returning to service the mooring sub-surface float at a depth of 200m. We will need a ROV or manned submersible (PISCES or similar) cabable of working at possible depths of 200 - 5000m (unknown at this time).

Both cruises will try to coordinate with other activities related to the HOT site or Aloha Observatory (Fred Dunnebier).

SCUBA Diving? X No _ Yes -- Designate Lead Institution:
Individual dives: # Divers on board:
A list of all divers and their certification information must be submitted to the ship's marine superintendent.

Special Science Party Considerations
_ Foreign Nationals _ Medical Conditions _ Disabled Persons _ Other
Please explain:

Use of Hazardous Materials? X No _ Yes
If Yes, List type, quantity, and disposal plans:

Radioactive? Type: Quantity:
Disposal Plan:

Explosives? Type: Quantity:
Disposal Plan:



August 14, 2002

Dr. Bruce Howe
Applied Physics Laboratory
University of Washington
1013 NE 40th Street
Seattle, WA 98105-6698

Dear Bruce,

Thanks for the update on your proposal plans to develop a mooring system at the HOT site with vertical profiling capabilities. I believe that such systems will be of wide interest to the oceanographic community for a variety of reasons. As one example, we are very interested in deploying nutrient sensor systems on such a mooring. We have deployed osmotically powered nitrate sensors at 180 m (base of the euphotic zone) on the HALE-ALOHA mooring at HOT from 1997 to 1999. These instruments have produced very interesting data, which show the passage of mesoscale eddies that cause large changes in euphotic zone nitrate concentrations and large changes in ecosystem structure (C. Sakamoto et al., in prep.). It would have been much more beneficial to have continuous vertical profiles of nitrate during these events, however.

We have recently developed an optical nitrate sensor (Johnson, K. S. and L. J. Coletti. 2002. In situ ultraviolet spectrophotometry for high resolution and long term monitoring of nitrate, bromide and bisulfide in the ocean. *Deep-Sea Research I*, 49, 1291-1305) that would allow us to collect continuous nitrate profiles over a long-term deployment. The mooring efforts that you describe would be the perfect platform for deploying these sensor systems at HOT or any other location with cabled observatories that would support vertical profiling systems. I know it would fit in nicely with the MARS cabled observatory that we are hoping to construct in Monterey Bay.

Best of luck with your proposal. I think this is an important step for the community and we would be very interested in collaborating on sensor deployments at this facility.

Sincerely yours,

A handwritten signature in black ink that reads "Kenneth S. Johnson". The signature is written in a cursive, flowing style.

Kenneth S. Johnson
Senior Scientist & Science Department Chair

Fred K. Duennebie
Dept. of Geology and Geophysics
University of Hawaii, Honolulu, Hawaii 96822
Phone: (808) 956-4779 FAX: (808) 956-4780 EMAIL: fred@mano.soest.hawaii.edu



SCHOOL OF OCEAN AND EARTH SCIENCES AND TECHNOLOGY

August 9, 2002

Roger Lukas
Dept. of Oceanography
University of Hawaii
Honolulu, HI 96822

Bruce Howe
Applied Physics Lab
University of Washington
Seattle, WA

Dear Roger and Bruce,

Thank you for the information on the mooring you are proposing for installation at the Station ALOHA Observatory. As P.I. on the installation of the observatory infrastructure, I want to assure you of the highest possible level of support for this endeavor. The mooring you are proposing will benefit greatly from the access to electrical power, command capability, and real-time data transmission provided by the cabled system. While the power and bandwidth available at the junction box will be far from unlimited (approximately 1 KW of power and 7 MHz data bandwidth), it should be sufficient for a considerable number of experiments.

We expect to install the initial system in late summer or fall of 2004, with proposed ROV support shortly after. While the initial junction box will have limited capabilities, the evolution to a highly functional junction box will depend strongly on the success of proposals such as yours and the demands of the users.

Please keep me informed as your proposal progresses so that we can coordinate your designs with the capabilities of the observatory.

Sincerely,

Fred K. Duennebie



SCRIPPS INSTITUTION OF OCEANOGRAPHY
MARINE BIOLOGY RESEARCH DIVISION, 0202
4170 HUBBS HALL

LA JOLLA, CALIFORNIA 92093-0202
TELEPHONE: (858) 534-4858
FAX: (858) 534-7313

Dear Bruce,

We are very excited about the long term cable installation at Sta. ALOHA and especially your proposed development of an ocean mooring system for this observatory as well as other cabled observatories. We have completed a time-series study of sediment community activity at Sta. ALOHA (K. Smith et al., 2002) and we are proposing to continue such measurements on a long term basis using an autonomous bottom crawler and camera system (ROVER II) with docking capabilities to a cable link.

We would also like to monitor Sta. ALOHA with the same instrumentation now funded for inclusion at the Hawaii-2 Observatory (H2O) site. Our instrument platform for H2O consists of a time-lapse camera and sensor package for quantifying settling particles and phyto-pigments (NSF, OCE- 0002385). A strong coupling exists between benthic community processes and pelagic production at Sta. ALOHA (Smith et al., 2002) where long-term changes in plankton community structure and productivity (Karl et al., 2001) combined with episodic settling of diatoms (Scharek et al., 1999) are documented. Your proposed water column mooring with real-time data acquisition on particulate and dissolved material throughout the water column will greatly enhance our ability to interpret biogeochemical processes in the benthic boundary layer measured with our proposed benthic sensor systems.

I enthusiastically support your proposed water column mooring systems which fully complement our proposed benthic monitoring systems at Sta. ALOHA, H2O and other proposed cabled observatory sites.

Sincerely,

Ken Smith

References:

Karl, D.M., Bidigare, R.R., Letelier, R.M. (2001) Long-term changes in plankton community structure and productivity in the North Pacific Subtropical Gyre: The domain shift hypothesis. *Deep-Sea Res. Part II*, 48: 1449-1470.

Scharek, R., Tupas, L.M., Karl, D.M. (1999) Diatom fluxes to the deep sea in the oligotrophic North Pacific gyre at Station ALOHA. *Mar. Ecol. Prog. Ser.* 182: 55-67.

Smith, K.L., Jr., Baldwin, R.J., Karl, D.M., Boetius, A. (2002) Benthic community responses to pulses in pelagic food supply: North Pacific Subtropical Gyre. *Deep-Sea Res. Part I*, 49:971-990.



National Research Council
Canada

Conseil national de recherches
Canada

Herzberg Institute
of Astrophysics

Institut Herzberg
d'astrophysique

NRC-CMRC

Bruce M. Howe
Principal Oceanographer
Applied Physics Laboratory (APL)
University of Washington
1013 NE 40th Street
Seattle, WA 98105-669

Dear Bruce,

I am very pleased to hear about the NSF proposal you are submitting for an ocean observatory mooring, and that data and information management are being included.

The work I have done on the design of the NEPTUNE Data Management and Archive System (DMAS) is documented on the web site: <http://www.hia.nrc.ca/pub/CADC/NEPTUNE/>. The two major documents are the draft requirements and conceptual design study. It should be clear that the work has only begun. Some of the material will be relevant to your proposed work.

The work Roger Lukas intends to do regarding quality control and information products will be especially relevant, as this is where the scientist wanting to use the data often finds the product wanting; to obtain the highest quality data requires a wealth of experience and continual vigilance. The mooring and its sensors will be excellent early test cases for the "instrument servers", the direct interface between the user and the instrumentation. The fact that several of the platforms you are proposing (the winched profiler and MMP crawler) are only intermittently connected to the network, with sampling strategies changing with time, will be very interesting.

It is clear that there will need to be a significant coordination effort within the ocean observatories community to come up with standards and to minimize duplication of effort with regard to DMAS. The timing of all the various efforts calls for coordination. I will look forward to working with you and your colleagues on this project. Just today we heard that the VENUS project (a NEPTUNE testbed in the Straits of Georgia and Juan de Fuca) obtained the required matching funds, so that my group can begin work in earnest.

Sincerely

Séverin Gaudet
Project Lead
VENUS and NEPTUNE Data Management and Archiving Systems
Canadian Astronomy Data Centre

Dominion Astrophysical
Observatory
5071 W. Saanich Road
Victoria, B.C. V9E 2E7

Telephone: (250) 363-0001
Fax: (250) 363-0045

Email:
Firstname.Lastname@NRC.CA

Observatoire fédéral
d'astrophysique
5071, chemin Saanich.O.
Victoria, (C.-B.) V9E 2E7

Téléphone: (250) 363-0001
Téléfax: (250) 363-0045

Courrier électronique:
Prénom.Nom@NRC.CA

Canada

0242273



Falmouth Technology Park
121 Bernard E. St. Jean Drive, East Falmouth, Massachusetts 02536 USA
Telephone: (508) 495-4000 • Fax: (508) 495-3333
E-Mail: mclane@mclanelabs.com

August 15, 2002

Dr. Bruce Howe
University of Washington
Applied Physics Laboratory
1013 NE 40th Street
Seattle, WA 98105

Subject: Letter of Support for the proposal entitled "A Mooring for Cabled Observatories"

Dear Dr. Howe:

McLane Research Laboratories, Inc. will be pleased to support your proposal to modify two McLane Moored Profilers to a mooring that will be attached to a cabled seafloor observatory. The technical support that would be required from our software and mechanical engineering staff would involve assistance with the following tasks.

- software modifications for the increase in profiling speed
- software modifications for MMP – node controller communications and data offload
- assistance/recommendations related to the mechanical modifications for additional sensors, the inductive pottle, and ROV servicing issues
- assistance/recommendations related to modifications of the drive wheel and guide wheel assemblies to fit the cable

The cost for McLane engineer time would be \$100.00 per hour or \$16,000.00 for 160 hours per year, beginning January 1, 2003. The total cost for 480 hours over the three-year period of the project would be \$48,000.00. Only actual hours requested by UW/APL are to be charged. Invoices would be submitted every three months for the total hours requested during the prior period. Work performed by our staff would take place at our facility in East Falmouth, Massachusetts. Any supplies, components or travel and related costs requested from McLane staff by UW/APL are not covered by this agreement and would be an additional cost.

We look forward to working with you on this project.

Sincerely yours,

C.L. Roy Smith
General Manager

McLANE WEB SITE: <http://www.mclanelabs.com>
