COOPERATIVE AGREEMENT PROPOSAL

TO SPONSORING AGENCY: National Oceanic and Atmospheric Administration

FROM:

Joint Institute for the Study of the Atmosphere and Ocean
University of Washington
4909 25th Avenue NE/Box 354235
Seattle, WA 98195-4235

TITLE: Joint Institute for the Study of the Atmosphere and Ocean
Five-Year Proposal

PRINCIPAL INVESTIGATOR: David S. Battisti, Director

DESIRED STARTING DATE: 1 July, 2001

DURATION: Five Years: 7/1/01 - 6/30/06

TOTAL COST:

NOAA/PMEL:	$65,139,416
University of Washington:	$3,239,765
NOAA/PMEL, First Year:	$11,065,681
University of Washington:	$600,440

SUBMISSION DATE: 1 December 2000

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**There is no requirement in the general provisions for formal cost-sharing or reporting of these items. The figures are to be viewed as information numbers only.*

I. BACKGROUND

A. Introduction

The Joint Institute for the study of the Atmosphere and Ocean (JISAO) is a research institute in the University of Washington, Seattle, originally established within the Graduate School. JISAO was created in July, 1977 through a cooperative agreement between NOAA and the University of Washington. It was created as a mechanism by which the resources of a research-oriented state university and the Environmental Research Laboratories (ERL) and other branches of NOAA could be brought together to develop a research center of excellence in the oceanographic and atmospheric sciences. JISAO now reports to the Office of the Vice Provost for Research. It is the goal of JISAO to provide to the cooperating institutions:

1. A means to increase the effectiveness of oceanographic and atmospheric basic research of mutual interest to the NOAA Environmental Research Laboratories within the OAR (in particular, but not limited to, the Pacific Marine Environmental Laboratory, Seattle, WA) and the relevant units of the University by promoting close multidisciplinary collaboration among scientists (including visiting scientists) associated with these two institutions.

2. A center at which scientists working on problems of mutual interest may come together.

3. A means to train scientists in the many disciplines in the oceanographic and atmospheric sciences to include recruitment of fishstock and policy, impact and response strategies with respect to climate variability.

B. Research Themes:

JISAO conducts scientific investigation under research themes approved by its Administrative Board. Although the areas of interest of the Joint Institute extends to the limits of the atmospheric and oceanic sciences, the research activities of the Institute are now focused on five primary themes.

1. Climate/Climate Variability

(a) An Observational Study of Tropical Sea Surface Energy and Moisture Budgets
(b) Convection Over the Pacific Warm Pool
(c) Precipitation in the Eastern Pacific Intertropical Convergence Zone
(d) Decadal natural Variability in the Tropical Atmosphere/Ocean System
(e) Numerical Study of Deep Convection and Large-Scale Circulation over the Western Pacific Warm Pool
(f) Stanley P. Hayes Center: Diagnosis and modeling in Support of the Climate Observing System in the Pacific
(g) Dissemination of Output from Regional Mesoscale Model Forecasts for the Pacific Northwest
(h) NOAA-University Collaborative GCM Studies of the Maintenance of Regional Climates and the Atmospheric Response to Perturbation in Boundary Conditions
(i) Surface Characterization of Oceanic Drop Size Distribution
(j) Structure of Precipitation Systems Affecting the Mississippi Basin
(k) Decadal Variations in Earth's Energy Budget
(l) Measurement and Modeling the Decadal Climate Variability of the Northwest
(m) The Variable Freshwater Flux to the North Atlantic: An Integration and

Synthesis of Six Years of Measurements
(n) Bering Strait: A Vital Ocean and Ecosystem Connection
(o) A Coupled Atmospheric and Hydrological Modeling System for Flood and River Stage Forecasting in the Pacific Northwest
(p) GFDL/GCM Consortium Forced and Free Climate Variability
(q) JASMINE: The Joint Air-Sea Monsoon Interaction: A Pilot Study of Ocean Atmosphere Interaction during Active and Peak Phases of the Summer Monsoon
(r) Long-Term Measurements of Air-Sea Exchange Processes
(s) Decadal Variability Around the Atlantic Basin: The Role of Land/Atmosphere/Ocean Interaction in the Atlantic
(t) Analysis and Modeling of Intraseasonal and Interannual Variability of Warm Season Precipitation in the East Pacific, Central America, and North America
(u) Long-Term Acoustical Measurements of Air-Sea-Exchange Processes
(v) Time Series Analysis of Climatology Surrogates
(w) Evaluating Equatorial Wind Fields from Scatterometer and TAO Data in Ocean Climate Studies

2. *Estuarine Processes*

(a) Tsunami Dynamics

3. *Environmental Chemistry*

(a) University of Washington Pacific Ocean Radiocarbon
(b) Joint PNL/DOE/PMEL Chem. Ocean Project
(c) Atmospheric Aerosols and Climate Change (includes Monitoring Studies)
(d) Emissions of Aerosols from Biomass Fires in Tropical Brazil and their Effects on Climate
(e) Analysis of Airborne Doppler Radar and Cloud Physics Collected in COAST
(f) CFC Tracer Program
(g) Identification of Sources and Long-Term Trends for Pollutants in the Arctic
(h) $13^C/12^C$ of the Dissolved Inorganic Carbon in the North Atlantic Ocean
(i) Evaluation of Uncertainties in Satellite Retrievals of Aerosol Forcing using *in situ* measurements
(j) Aerosol Studies in Support of NOAA Ground and Ship Based Aerosol Measurements
(k) Oceanic CO_2 Uptake Rates Derived from an Ocean-Wide c/c-DIC Data Set
(l) Uncertainties in Satellite Retrievals of Aerosol Forcing Using *in situ* Measurements of the Surface

4. *Interannual Variability of Fisheries Recruitment*

(a) Undergraduate Student Internships
(b) Fish Ideas PC
(c) Trends in Fish Abundance and Productivity
(d) Fisheries Management Global Trends Symposium
(e) Social Aspects of Pacific Pelagic Fisheries Phase II - The Hawaii Troll and Handline Fishery
(f) Use of Semi-Intensive Mecocosms for the Rearing of Larval Lingcod

(g) Bycatch Reduction in the West Coast Shrimp Trawl Fishery
(h) El Niño 1997-1998 and Spatio Temporal Patterns of Productivity for the California Current, Gulf of Alaska, and Bering Sea Coastal Marine Ecosystem
(i) Captive Broodstocks and the Salmon Life cycle
(j) Atka Mackerel Ecology
(k) Marine Biological Interactions in the North Pacific (includes Fish-Marine Mammal Interaction Project)
(l) Pollock Growth in the Eastern Bering Sea
(m) Growth and Development of Salmon
(n) Expanding the Scope and Statement of Work for Marine Biological Interaction in the North Pacific
(o) West Coast Groundfish Resource Survey
(p) Larval Lingcod Studies
(q) Nutritional Studies of Juvenile Sablefish
(r) Biomass and Spatial Distribution of Slope Rockfish
(s) Shellfish Toxins
(t) Development of a Conceptional Model to Assess Estuarine Influence on Recovery and Resilience of Salmon Populations in the Columbia River
(u) Enhanced Estimates of Population Parameters

5. *Global Change Policy (Hayes Center)*

(a) Development and Testing of a Macroscale Hydrologic Model for the Southern Plains Region of GCIP
(b) Applying Predictions of Pacific Northwest Climate
(c) Impacts of Population and Markets on Sustainability of the North Pacific Ocean and Coastal Environment
(d) Regional Workshops on Climate Change Impacts in the Pacific Northwest
(e) Expanding the Scope and Statement of Work for Applying Predictions of Pacific Northwest Climate
(f) Development of a Hydrologically Based Land Data Assimilation System for the Continental U.S.
(g) GCIP/GAPP Missouri River Resources Demonstration Project Integrated Assessment of the Impacts of Climate Variability and Climate Change of the Pacific Northwest (Phase II)

Each of the above-mentioned themes continues to be of major scientific, economic, and social importance and each has readily identifiable participants from both parent institutions.

C. Description of Tasks:

The research program in JISAO is divided into three primary activities and corresponding budget tasks. Each task is subdivided according to the research themes and is budgeted separately.

1. **Task I** is the core program of JISAO. It provides salary, benefits, moving and travel/per diem expenses and administrative and research support for up to eight (8) post-doctoral research associates whose terms are limited to two years. Depending on the type of appointment, this task provides salary, benefits and travel/per diem expenses, as well as administrative and research support for distinguished visiting scientists, visiting scholars for shorter periods of time, and for short-term visitors. The administrative and research support costs are shared between NOAA and the University in a manner consistent with the MOU.

2. **Task II** is the complementary (collaborative) research expertise program of JISAO. It provides the support for highly specialized research scientists employed by JISAO specifically to complement existing expertise at NOAA/PMEL and the University of Washington within the established collaborative research themes of the Institute.

3. **TASK III** is the specific research program of JISAO. It provides the support for scholarly research in JISAO's theme areas by university faculty and scientists who hold appointments in or are affiliated with JISAO.

II. PROPOSED RESEARCH & SUPPORT

JISAO proposes to continue a wide range of activities in support of its five research themes: (1) Climate Variability, (2) Estuarine Processes, (3) Environmental Chemistry, (4) Interannual Variability in Fisheries Recruitment and (5) Policy, Impact and Response Strategies with respect to climate variability.

A. Task I

A.1. Administration

Support will be provided for the JISAO administrative staff in the form of salary and benefits. A total of four permanent positions are partially supported by this task: Administrator 40% FTE, Fiscal Manager 75%FTE, Administrative Assistant 85% FTE and Fiscal Specialist 80% FTE;

A.2 Post-doctoral, Visiting Scientist/Scholar and Short-term visiting scientist program

(1) Climate/Climate Variability

This work unit provides (a) salary, benefits, moving expenses, travel/per diem expenses and research support for up to three (3) post-doctoral research associates year, on two year appointments, who will conduct research in specific areas of physical oceanography and meteorology relating to the climate variability theme; areas of research emphasis will depend on the educational backgrounds of the applicants; research topics may include but are not limited to the research themes mentioned above (Background/B. Research Theme, 1. Climate /Climate Variability Theme); (b) travel/per diem and salaries (honoraria) for short-term visitors who offer seminars and/or collaborate with JISAO Senior Fellows,

Fellows, Research Associates and Graduate Students; (c) salary/travel/per diem and research support for distinguished visitors on leave from their home institution for periods ranging from a few weeks up to a year.

(2) Environmental Chemistry

This work unit provides (a) salary, benefits, moving expenses, travel/per diem expenses and research support for one (1) post-doctoral research associate per year on sequential two-year appointments , who will conduct research on problems specific to chemical oceanography and/or geochemistry (b) travel and honoraria for short-term visitors who offer seminars and/or collaborate with JISAO Senior Fellows, Fellows, Research Associates and Graduate Students; (c) salary, travel/perdiem and research support for distinguished visitors on leave from their home institution for periods ranging from a few weeks up to a year.

(3) Estuarine Processes

If funding becomes available, this work unit provides salary, benefits, moving expenses, travel/per diem expenses and research support for one (1) research associate (post-doctoral) on two-year appointment who will conduct research in coastal estuarine processes.

(4) Interannual Variability of Fisheries Recruitment

It is not anticipated that any funding will become available for Task I to support research associates or short- and longer-term visiting scientists in this theme area.

(5) Global Change Policy Area

This work unit provides travel/per diem, salary and research support for one (1) foreign distinguished visitor per year, on leave from his/her home institution, who will present seminars and/or engage in collaborative discussions with JISAO Senior Fellows, Fellows, faculty, research associates (post-doctoral), and graduate students.

B. Task II

In addition to the research project personnel already in residence (described below) the following new positions will be added **two (2) Research Consultants, three (3) Research Scientists, one (1) Research Meteorologist, six (6) Research Associates (post-doctoral), six (6) research assistants (graduate students and 1.25% FTE administrative personnel, all of whom will be recruited and fully supported to complement the collaborative research of Senior Fellows and Fellows in the Climate/Climate Variability, the Environmental Chemistry, the Recruitment of Fishstock and Estuarine Processes themes over the course of the next cooperative agreement and **The specific areas of research will be determined by the programs funded during the next cooperative agreement.**

B. 1. *Climate/Climate Variability*

This work unit provides salary, travel/per diem and computer support for (a) three (3) new research associates (post-doctoral), (b) two (2) new research assistants who work closely with JISAO Senior Fellows and conduct collaborative research which specifically supports that of the JISAO Senior Fellows and Fellows in the area of climate and climate variability activities; (c) six(6) research consultants, fourteen (14) research scientists, one (1) research meteorologist, two (2) oceanographers, two (2) research engineers (currently in

residence, two (2) new research consultants (d) one (1) new fiscal specialist 100% FTE will be recruited to support these activities

25 Research support staff currently in residence as listed below:

(research consultants currently in residence)

(1) Participates in research with observed meteorological and oceanographic data sets, with emphasis on oceanographic and atmospheric data from the Tropical Atmosphere Ocean (TAO) array of moored buoys. Designs and implements integrated software packages to process, analyze, and access TAO instrumentation performance (including surface winds, temperatures, relative humidity, short-wave radiation, precipitation, and salinity) and calibration history. Applies software to TAO data and reports performance of both software and instrumentation to TAO scientists, technicians, and engineers. Identifies problems and suggests, designs, and/or demonstrates methods of improvement. Prepares written reports on results of analysis.

(2) Conducts and participates in research with observational oceanographic and meteorological data sets, including time series data, hydrographic data, ADCP data, etc. Leads research in computer data visualization, presentation, analysis, computing techniques, and development of software for presentation, visualization, and analysis of scientific data and information, including C, C++, Plot Plus Graphics, IDL, Java, JavaScript, and relevant World Wide Web techniques. Advises staff in technical computer systems development for display, management, visualization, presentation and analysis of varied oceanographic and meteorological data and information using state-of-the-art computer techniques and visualizations. Coordinates with scientists, administrators, professional colleagues, and users to define needs and establish future directions for system development. Investigates and advises on appropriate database server and other client-side server technologies for use with the WWW to enable web access to oceanographic data.

Presents research data and information in physical oceanography and/or meteorology and relevant ocean and physical sciences and World Wide Web pages focused on climate (El Niño) and Tsunami phenomenon and other topics. Presents results in form of presentations at professional society meetings and publications in professional journals.

(3) Performs computer application development work contributing to the research goals of the Thermal Modeling and Analysis Project (TMAP) at NOAA's Pacific Marine Environmental Laboratory. Participates in design, implementation, and maintenance for the in-house visualization and analysis application, Ferret, and for the web-based data server, the Live Access Server. Additional responsibilities include participation in NOAA-wide data access efforts. Supervises the work of one or more programmers on these projects. Participates in writing grants to fund TMAP's work and, as appropriate, publishes the results of continuing work and makes presentations at professional meetings. Responsibilities also include analysis and visualization contributing directly to scientific publications.

(4) Participates in research with observational oceanographic and meteorological data sets and numerical model results, including time series data, hydrographic data, ADCP data, etc. Performs research in and development of collaborative tools for the display and analysis of scientific data, distributed object technologies, computer data visualization, and distributed data access utilizing client/server architectures. Develops software for state-of-the-art computer techniques including Java, JDBC, CORBA, the Habanero collaborative framework, and object-oriented analysis and design principles.

(5) Participates in research with observational meteorological and oceanographic data sets, with emphasis on oceanographic and atmospheric data from the Tropical Atmosphere Ocean (TAO) array of moored buoys. Has responsibility for initial processing of data and assessments of instrument performance, analysis and interpretation of calibration information, and database design and maintenance. Contributes to the publication of technical memoranda and other publications describing instrument performance, often as principal author, and presents results at conferences and colloquia.

(6) Participates in research with observational meteorological and oceanographic data sets, with emphasis on data from the Tropical Atmosphere Ocean (TAO) array of moored buoys. Instrumentation includes surface winds, temperatures and relative humidity, ocean currents, rainfall, and radiation. Works with TAO scientists and engineers in processing, analyzing, and assessing TAO instrument performance. Also participates in maintaining and updating TAO calibration data bases. Documents new procedures that may be developed for processing of data and prepares written reports on results of analyses. Participates in ocean-going cruises as part of the TAO scientific party.

(research scientists already in residence)

(1) Conducts and participates in research with observational oceanographic and meteorological data sets with emphasis on PMEL *in-situ* data, including time series data, hydrographic data, ADCP data, etc. Performs research in computer data analysis, computing NT, and the World Wide Web. Has responsibility for technical direction and project management of computer systems development of display, management, and analysis of varied data sets using state-of-the-art computer techniques and visualizations. Provides leadership and technical direction of other programmers developing software for management, display, and analysis on *in-situ* data. Coordinates with other scientists and users of the software to define needs and establish future directions for systems development. Presents project results at scientific and professional society meetings and publishes as appropriate. Participates in developing and writing proposals to obtain funding for software development. Contacts and participates in research in physical oceanography with emphasis on large-eddy simulation models designed for oceanic applications. Participates in developing and writing proposals for this research. Presents results in the form of presentations at professional society meetings and publications in professional journals.

(2) Performs field and laboratory research in tropical oceanography, air-sea interaction, and climate studies. Laboratory work involves analysis of data from a variety of sources including but not limited to: moored time series data; expendable bathythermograph data; conductivity temperature depth (CTD) data; analyzed fields of surface wind, sea surface temperature, and surface currents; and satellite data. Laboratory tasks also include: the development of unique software systems for the calibration of a variety of oceanographic and meteorological instrumentation, the maintenance of a conductivity temperature recorder (SEACAT) calibration database, and the evaluation of sensor performance. Works with minimal supervision to accomplish research objectives and documents portions of the research in the form of technical memoranda. Utilizes and develops specialized, state-of-the-art analysis software and of manages data archives. At sea, assists in the collection and quality control of CTD station data and participates in deployment, recovery, and maintenance of instrumented oceanographic moorings. Field work is performed aboard NOAA and UNOLS vessels as well as ships of non-U.S. registry. Research results are prepared for publication in conjunction with the principal investigator.

(3) Participates in research with observational oceanographic and meteorological data sets, with emphasis on the data from the TAO array of moored ATLAS and current meter buoys. Performs research in computer data analysis, computing techniques, and development of World Wide Web pages. Leads others in advance display, management, and analysis of varied data sets using state-of-the-art computer techniques and visualizations for the TAO project. Develops documentation to be used by scientists, users and programmers. Leads others in the development of new software as needed. Has primary responsibility for the provision of real-time TAO data and graphics via the Internet and the web.

(4) Participates in research with observational oceanographic and meteorological data sets, with emphasis on the data from the TAO array of moored ATLAS and current meter buoys. Performs research in computer data analysis, computing techniques, and the development of World Wide Web pages. Leads others in advance display ,management, and analysis of varied data sets using state-of-the-art computer techniques and visualizations for the TAO project. Develops documentation to be used by scientists, users, and programmers. Leads others in developing new software as needed. Has primary responsibility for the provision of real-time TAO data and graphics via the Internet and the World Wide Web.

(5) Maintains an existing sampling program designed to characterize the chemistry of atmospheric aerosol particles at a network of northern hemisphere mid-latitude sites and on oceanographic research cruises. Specific duties include collecting aerosol samples followed by gravimetric and ion chromatography analysis, maintaining and repairing scientific instrumentation both in the laboratory and in the field, and preparing data reports.

(6) Conducts and participates in research with oceanographic and meteorological data sets, including observational data, gridded data or model output. Performs research in computer data visualization, presentation, analysis, and computing techniques. Develops software for presentation, visualization, and analysis of scientific data and information, including Fortran, C, 3-D visualizations, and/or Virtual Reality (e.g. VRML). Has a leadership role in PMEL technical computer systems development for display, management, visualization, presentation, and analysis of varied oceanographic and meteorological data and information and data using state-of-the-art computer techniques and visualizations, such as VRML, and/or 3-D visualizations and animations. Coordinates with scientists, software developers, administrators and, users to define needs and establish future directions for system and development. Leads others in exploring, applying, and operating advanced visualization devices and software for PMEL and for NOAA (e.g., leadership role for the first ImmersaDesk deployment in NOAA).

(7) Participates in research in ocean-atmosphere interaction within a numerical modeling research group: 1) enhances, maintains, and runs complex general circulation models on supercomputers and high performance Unix workstations; 2) functions as data-base manager for model runs; 3) develops, maintains, and runs scientific visualization and numerical analysis systems; and 4) acts as systems analyst for evaluating, testing, and procuring both hardware and software.

Is responsible for scientific application programming, including: 1) desktop scientific visualization systems, 2) user interfaces, 3) Web interfaces, and 4) data management systems. Provides guidance to group members in the optimal use of computer hardware and software packages.

Has system management responsibility for a network of high performance Unix workstations, Personal Computers (PC's), RAID (massive disk) systems, archival hardware, networking equipment printers, modems, etc.. This includes: 1) evaluating and selecting an upgrade path in light of changing technology; 2) installing hardware and

software; and 3) troubleshooting and overseeing the implementation of any solutions to system problems which occur. Decides where and when to utilize the services of the Computer and Network Services Division of PMEL in order to achieve group goals as efficiently as possible. Acts as liaison with the member of that division who often resolves problems of conflicting interests.

Maintains in-house software, including porting and supporting complex '-language source codes (scientific visualization, analysis, and data management software) on many operation systems. This includes the major oceanographic analysis application, Ferret, developed within the TMAP group. Operating systems include Compaq (Digital), Unix, Solaris, Linux, SGI IRIX, IBM AIX, and Win32. Oversees quality control for software that is distributed outside the group to hundreds of scientists.

(8) Participates in the ocean modeling activities of the Thermal Modeling and Analysis Project (TMAP) Group with primary research objectives to support NOAA's Seasonal-to-Interannual Prediction mission. Research involves modeling studies to advance the understanding of the mechanisms that control sea surface temperature anomalies along the oceanic equatorial waveguide and throughout the tropics, and the ability to forecast these anomalies.

(9) Conducts field and laboratory research on the sources and sinks of CO_2 in the oceans. Identifies and interprets chemical tracers of anthropogenic CO_2 in the oceans. Develops new field and laboratory methods for obtaining high precision chemical and hydrographic data onboard ships of opportunity and moored buoys designed for monitoring chemical and biological processes in the oceans. Contributes to and influences the goals and priorities of NOAA's Marine CO_2 Program. Prepares formal reports and scientific publications for publication in the peer-reviewed literature.

(10) Conducts research on tropical rainfall variability, its relation to ocean-atmosphere interactions, and its impact on climate. This research includes, but is not be limited to, analysis of rainfall data sets from the Tropical Atmosphere Ocean (TAO) mooring array in the Pacific, Pilot Research Moored Array in the Tropical Atlantic (PIRATA), and satellite missions such as the Tropical Rainfall Measuring Mission (TRMM). Specific objectives include defining the statistics of rainfall variability in the tropics, validating satellite rainfall products, documenting the co-variability of processes in the ocean and atmosphere related to rainfall, and analyzing oceanic and atmospheric boundary layer processes. Contributes to and influences the scientific goals of the TAO and PIRATA programs.

(11) Conducts and participates in research with observational oceanographic and meteorological data sets with emphasis on PMEL *in-situ* data, including time series data, hydrographic data, ADCP data, etc. Participates in and assists in developing, modifying, and running computer models of ocean processes. Performs research in computer analysis, computing techniques, and development of scientific data software, including Fortran, PlotPlus Graphics, and the World Wide Web. Has responsibility for technical computer systems development for display, management, and analysis of varied data sets using state-of-the-art computer techniques and visualizations. Coordinates with other scientists and users of the software to define needs and establish future directions for system development.

Presents research, data, and information in physical oceanography of World Wide Web pages focused on climate phenomena such as El Niño and other topics as may be required. Presents results in the form of presentations at professional society meetings and publications in professional journals.

(12) In conjunction with the Principal Investigator performs field and laboratory research in tropical oceanography, air-sea interaction, and climate studies. Works with minimal supervision to achieve research objectives and develops, implements, and utilizes new specialized software for data display, quality control, data dissemination, and data analysis. Analyzes moored wind, temperature, humidity, rainfall, short-wave and long-wave radiation, barometric pressure, salinity, and current velocity data, as well as various other data sources.

Serves as Data Manager for the TAO Project. Primary duties include real-time and delayed mode monitoring of the TAO and PIRATA arrays of ATLAS moorings; planning and documenting operational and logistical requirements for upcoming cruises; developing and monitoring automated systems for rapid identification of potential problems with the moored arrays; maintaining communications with TAO personnel on research cruises to ensure critical information is received and necessary actions are taken; providing TAO data, information, and documents to the international community; and designing and maintaining internet and intranet web pages for the TAO project and the TAO support vessel Kaiimimoana.

Real-time data monitoring and operational communications activities require an on-call duty status on many weekends. Additional key responsibilities include serving as TAO chief scientist on research cruises aboard NOAA ships, UNOLS ships, and/or ships of non-US registry; integrating new technology and sensors in data calibration, processing, and quality control procedures; and training TAO project personnel and international technicians and programmers in TAO data management procedures. Research results are prepared for publication.

(13) Provides technical and team leadership and participation in data management and software design, development, distribution, and implementation, to support ocean and atmosphere scientific research for scientists and researchers at PMEL, University of Washington, and other research institutions.

Designs and develops software applications and graphical user interface to manage, distribute, analyze and display observational data sets, including the TAO array of moored ATLAS and Current Meter buoys, EPIC profile and time series *in-situ* data sets and other data management projects within PMEL and/or NOAA.

Develops and maintains stand-alone and network-based database systems for providing oceanographic and atmospheric data access to local scientists, educational, research, and environmental management sectors as well as to the general public via the World Wide Web. This includes definition, specification, design, programming, and implementation for distributed database on-line systems and system interfaces across multiple computing platforms incorporating Web-based technology.

Designs and develops centralized data access system using distributed object technology including implementation of Java/CORBA-based client/server applications and Java Servlets web server technology.

Installs and maintains web servers which support large databases of *in-situ* oceanographic data which we access, display, and analyze, including real-time TAO buoy data, EPIC profile, and time-series *in-situ* data sets.

Participates in research activities and software development projects with other NOAA and University oceanographers and scientists. Serves as team leader for software development projects including as may as five team members. Participates in initiating and writing

proposals. Serves as primary author of professional society presentations and publications.

(oceanographers currently in residence)

(1) Performs field and laboratory research in marine and atmospheric chemistry in support of this activity, new procedures must be evaluated and modified as new instrumentation and methodology develops. Is capable of working with minimal supervision to accomplish the research objectives. Specific duties include: 1) logistical support for the science team; 2) maintaining, calibrating and repairing scientific equipment; 3) collection and analysis of seawater and atmospheric samples and 4) assisting in the reduction of data and the preparation of research reports. Spends up to 90 days per year at sea on research cruises.

(2 Processes and analyzes oceanographic data and lead field operations. Analysis includes use of existing software and will sometime require development of innovative analysis techniques. As Chief Scientist, this position requires development of cruise instructions, production of cruise reports and insuring that program objectives are met. The sea-time bis approximately 4-6 weeks a year, typically between March and October. Position provides support scientist which is a requirement in the ongoing National Science Foundation and Arctic Research Initiative programs. Co-authors papers regularly and serves as lead author of a refereed research paper approximately once every two years.

(meteorologists currently in residence)

(1) Conducts boundary layer, climatological, and synoptic meteorology research. Works closely with oceanographers associated with the Fisheries-Oceanography Coordinated Investigations (FOCI). Assists in seeking support from NOAA and other agencies to fund this position.

Three different types of research programs are being carried out. The first type consists of climatological analysis of air-sea interaction in the Bering Sea and North Pacific Ocean, with the objective of better understanding the nature of short-term climate variations in the atmospheric forcing and the oceanís response. The second category involves collecting and analyzing observations of the planetary boundary layer in the eastern equatorial Pacific. The third type consists of analysis of research aircraft observations and high-resolution numerical weather prediction model output of mesoscale and synoptic storm structures over the North Pacific Ocean and their modification as they encounter coastal terrain.

(2) Research is conducted on climate processes in middle and high latitudes of the Northern Hemisphere and their influence on variability in the Pacific basin and western Arctic on seasonal to decadal time scales. Research goals are pursued through analyses of gridded and *in situ* data sets, such as the NCEP/NCAR re-analyses, SST and sea ice fields, satellite data, and station observations. Ongoing projects include decadal climate modes in the North Pacific, mechanisms and impacts of the Arctic Oscillation, and the connection between radiative and dynamical processes in the Arctic and Bering Sea. Supports climate research in collaboration with two principal investigators. Contributes to or leads journal publications, research grant proposals, and conference presentations.

** *In this theme area seven (7) new positions will be added during the new cooperative agreement: 3 research associates (post-doctoral), 2 graduate students, and 1 full-time Fiscal Specialist.* ***The specific areas of research within this theme area will be determined by the programs funded during the next cooperative agreement;*** *2 research consultants to conduct and participate in research with observational oceanographic and meteorological data sets, including time series data, hydrographic data, ADCP data, etc., performing research in*

computer data visualization presentation, analysis, computing techniques, and the development of software for presentation, visualization and analysis of scientific data and information, including FORTRAN, C, Plot Graphics and relevant World Wide Web techniques. No sea duty will be required; 1 research meteorologist to perform numerical analysis of large scale data sets such as the NCEP reanalysis. No sea duty will be required.

B.2. *Environmental Chemistry*

This work unit provides salary, travel, and computer support for (a) two (2) new research associates (post-doctoral), (b) one (1) new research assistant (graduate student) (c) eight (8) research support staff (currently in residence) and one new research support staff, all of whom will work closely with JISAO Fellows and conduct research which specifically supports that of the JISAO Fellows in the area of environmental chemistry. A 25% FTE clerical/administrative position is included in this proposal

8 Research support staff (5 research scientists, 3 oceanographers)

(research scientists currently in residence)

(1) Performs laboratory and field research in the study of atmospheric aerosol chemistry and physics, and operates aerosol sizing and optical instrumentation at sea and in laboratory tests, develops models for the calculation of aerosol chemical and optical properties, maintains and repairs scientific instrumentation, reduces data, and prepare data reports.

(2) Provides data analysis and model development and technical support of computer operating systems and related software for determining the exchange of CO_2 across the air-sea interface

Provides modifications of software systems to meet the requirement of the principal investigator and co-workers. Provides new software to compute CO_2 exchange across the air-sea interface employing CO_2 temperature and wind data. Provides the necessary system programming support and software tools to interface analytical instrumentation with desktop computer systems. Utilizes diagnostic software to isolate the source of problems between analytical instrumentation system software and applications programs. Modifies code as necessary. Coordinates work with others to modify programs to process and model CO_2 and hydrographic data, and prepares visual displays of the processed data. Technical support activities including consultation, documentation, and training to ensure smooth operations. Studies and recommends changes to computer hardware systems to improve efficiency of data processing and through-put.

(3) Performs research in the field and laboratory to characterize and understand the geochemistry of submarine hydrothermal venting systems. Applies state-of-the-art methods currently used by PMEL for the collection, preservation, and analysis of hydrothermal particulate plume species for trace metals and major elements. Reviews these methods and, in consultation with NOAA VENTS program Principal Investigators, improves them by designing (or adapting from emerging geochemical technologies) and implementing more efficient and/or sensitive procedures as they become attainable. Calibrates, operate, and maintains the PMEL energy dispersive x-ray flourescence (XRF) and scanning electron microscope (SEM) systems. Coordinates and participates in the staging, conducts (up to 3 months per year) and destages field operations using surface and submersible vessels to collect samples of dissolved, particulated vented species and deployment and recovery of mooring arrays. Trains and oversees support personnel in the performance of routine analytical and field collection activities. Assists in the preparation of formal reports and research papers suitable for publication in scientific journals.

(4) Conducts field and laboratory research on the chemistry of hydrothermal vents and their resultant hydrothermal plumes. Understand, identify and detect tracers of hydrothermal activity in these plumes. In particular, detect elemental tracers in hydrothermal plumes and vents using both bench-top and in situ chemical technologies involving flow injection analysis and other chemical instrumentation. Develop new field and laboratory procedures

and equipment in support of hydrothermal research. Contribute to and influence the goals and priorities of the NOAA VENTS program. Prepare formal reports and research papers for publication in peer-reviewed publications.

(5) Performs research in the field and laboratory to characterize and understand the geochemistry of submarine hydrothermal venting systems. Applies state-of-the-art methods for the collection, preservation, and analysis (at sea and in the laboratory) of hydrothermal vent fluid and hydrothermal plume dissolved trace metals and major elements. Reviews these methods and in consultation with NOAA VENTS program principal investigators, improves upon them by designing or adapting from emerging geochemical technologies more efficient and/or sensitive procedures as they become available. Calibrates, operates, and maintains the PMEL atomic absorption spectrophotometer, ion chromatograph, and ultrapure water supply. Maintains trace metal-clean sampling and analytical workspaces. Develops methods to analyze trace metals by inductively coupled plasma-mass spectrometry. Maintains vent fluid chemistry databases, including definition and tracking of quality-control standards. Coordinates and participates in the staging (including packaging and shipping of classified hazardous materials), conducting (up to three months per year), and de-staging of field operations using surface and submersible vessels to collect samples of dissolved and particulated vented species. Trains and oversees support personnel in the performance of routine analytical and field collection activities. Trains other PMEL personnel in the proper methods of shipping and packaging classified hazardous materials. Assists in the preparation of formal reports and research papers suitable for publication in scientific journals.

(oceanographers currently in residence)

(1) Conducts research on the systematics of hydrothermal fluid chemistry and related geochemical and hydrothermal issues, including the effects of volcanic activity and microbial activity on fluid chemistry; influences the goals of the hydrothermal chemistry group within the NOAA VENTS Program by means of demonstrated expertise and publications productivity; directs the development and implementation of both laboratory and field research studies on the chemistry of submarine hydrothermal systems. Requires high-level oral and written communications skills, a broad knowledge of geochemistry and analytical chemistry, computer skills, and the ability to interpret complex data sets. Conducts chemical oceanographic field operations for the exploration and sampling of submarine hydrothermal systems; develops new laboratory and field equipment and procedures for sample collection and chemical analysis; analyzes samples for major elements and trace metals both shipboard and in shore-based laboratories; supervises laboratory technicians assisting with the collection and analysis of samples; prepares formal reports and research papers for publication in scientific journals; seeks extramural funding for research projects; and develops partnerships and external collaborations to expand the range of research carried out within the VENTS Program.

(2) Conducts atmospheric research (50% of time). Conducts atmospheric chemistry measurements on research cruises. Prepares results from these measurements for presentations at scientific meetings and for publication in refereed scientific journals. Provides day-to-day guidance to graduate students and/or technicians in the Atmospheric Chemistry group.

Performs ancillary data acquisition, data management, and system administration (50% of time). Develops software and interfaces hardware to the Atmospheric Chemistry group's data logging system. Manages data logger sensor calibration, quality control, data reduction, and data archival. This activity periodically involves the day-to-day guidance of technicians in the Atmospheric Chemistry group. Administers the Atmospheric Chemistry

group's work station and computer network. Maintains and regularly updates the Atmospheric Chemistry group's homepage.

(3) Leads the collection of dissolved nutrient data sets as part of ongoing research programs at PMEL. Has strong background in analytical chemistry, is experienced in the high-precision automated analyses of dissolved nutrients (phosphate, silicate, and nitrate-nitrate) in seawater, has skills in computer programming (on DOS and UNIX computers), works with large, complex oceanographic data bases, and independently processes, checks quality, evaluates, and prepares oceanographic data reports.

** *In this theme area two 2 new research associates and 1 graduate student will be recruited;* ***The specific areas of research will be determined by the programs funded during the next cooperative agreement.*** *One new research scientist will be recruited who will perform research interpreting carbon dioxide and CFC measurements using numerical models. Sea duty will be required.*

B.3. *Estuarine Processes*

This work unit provides salary, travel, and computer support for (a) one (1) new research associate (post-doctoral), (b) one new (1) research assistant (graduate student) (c) two (2) research support staff (currently in residence) who work closely with JISAO Fellows and conduct research which specifically supports that of the JISAO Fellows in the area of estuarine processes as they relate to the Tsunami dynamics and one (1) new research scientist in area will be recruited.

2 Research support staff currently in residence

(research scientists currently in residence)

(1) Participates in research on tsunami and sea level dynamics. Acquires and archives bathymetric and topographic Digital Elevation Models. Generates, edits, and checks quality of merged bathymetry/topography DEMs for tsunami inundation models. Develops, maintains, and documents databases and computer codes for modeling, data analysis, and display. Runs MOST tsunami propagation model, interprets results for reasonableness, and troubleshoots code. Develops and manages web pages and FTP data repositories. Participates in the preparation of research papers. This appointment is dependent on available funding.

(2) Participates in research on tsunami dynamics as a member of the Tsunami Research Project. Uses the supercomputer of the Maui High Performance Computing Center to implement and utilize the Method of Splitting Tsunami (MOST) model. Develops an optimum R&D infrastructure for the use of this model and associated databases needed to run the model. Conducts research aimed at developing hazard mitigation tools and products through the application of the MOST model, such as inundation maps for coastal communities and numerical databases of relevant scenarios that could be used as guidance for short-term forecasts in the event of a tsunamigenic earthquake. Serves as Co-Director of NOAA's Center for Tsunami Inundation Mapping Efforts (TIME). This activity is an important component of the U.S. National Tsunami Hazard Mitigation Program, which seeks to reduce tsunami-related losses of life and property in Alaska, California, Hawaii, Oregon, and Washington. TIME is responsible for overseeing and participating in the development of site-specific inundation maps for pre-disaster planning and hazard mitigation by emergency managers in each community.

*** In this theme area 1 new research associates and 1 graduate student will be recruited;* ***The specific areas of research will be determined by the programs funded during the next cooperative agreement.*** *One new research scientist will be recruited for this theme area who will be a member of the NOAA/PMEL Center for Tsunami Inundation Mapping Efforts (TIME) He/she will work with other Tsunami Program members and academic collaborators at the University of Washington to develop inundation models and flooding maps for the five Pacific States: Alaska, California, Hawaii, Oregon and Washington.*

B.4. *Interannual Variability of Fisheries Recruitment*

This work unit provides salary, travel, computer support and, where applicable, moving expenses (a) two (2) research assistants (graduate student) (b) eight (8) research support staff (currently in residence) who work closely with JISAO Senior Fellows and conduct research which specifically supports that of the JISAO Senior Fellows in the area of Fisheries Recruitment and one new research scientist to be recruited.

(b) 8 Research Support Staff

(research consultants currently in residence)

(1) Participates in research with observational oceanographic and meteorological data sets with emphasis on data from the Tropical Atmosphere Ocean (TAO) array of moored buoys. Acts as systems programmer for the TAO group scientists and programmers and develops, modifies, and implements new software to process and analyze real-time data from the TAO array. Performs research in computer data analysis, computing techniques, and data quality control issues in primarily VAX/VMS environment.

(2) Develops and maintains a scientific database accessible through the World Wide Web and develops and maintains an interagency WWW site for promulgation of science plans and results for study of the Bering Sea ecosystem. Tasks include but are not limited to: Developing computer techniques for presenting and analyzing data on the World Wide Web; searching for environmental data applicable to the North Pacific Ocean and Bering Sea using conventional and internet-based search methods; developing and maintaining contact with a variety of government, academic, and private institutions for the purpose of promulgating and communicating data, scientific plans, and scientific results for the North Pacific Ocean and Bering Sea; developing and maintaining scientific relational databases; incorporating scientific methods and results for data records obtained from searches and contacts; and developing WWW-based tools and sites to maintain, extract, and display environmental data and science plans and results from relational databases.

(3) Examines applications of acoustic technology to investigate the population biology and ecology of fish. Research activities will include analysis and visualization of field, laboratory and computer simulation data; development of computer software for acoustic backscatter model applications; and participation in research surveys in the North Pacific. Support activities include integration and maintenance of acoustic and computer technologies and development of software analytic tools. Works under minimal supervision, is team-oriented, has strong organizational skills, and displays an interest in learning.

(research scientists currently in residence)

(1) Performs numerical modeling studies of decadal-scale changes in oceanographic circulation and biology of the coastal Gulf of Alaska as part of the ecosystem program (GLOBEC) of NSF/NOAA. The duties of this position are twofold: 1) To customize, develop, debug, and execute numerical models; prepare and evaluate input data; manage output files; create animations of output; and participate in model validation; and 2) To act as systems administrator for a variety of UNIX workstations. Contributes to the publication of scientific articles resulting from these studies, presents results at professional conferences, and maintains World Wide Web pages describing the project. Is responsible for the day-to-day maintenance of UNIX systems, as well as operating system installations, upgrades, and system purchases. Work at sea is occasionally necessary.

(2) Completes work on age and growth of age-0 pollock collected annually, since 1994, in the vicinity of the Pribilof Islands, by preparing the results for publication. This project was part of an ecological investigation of habitat variability in frontal regions around the Pribilof Islands and their importance to juvenile pollock growth and survival in the Bering Sea - a component of the South East Bering Sea Carrying Capacity research program.

Functions primarily as a P.I. in a collaborative program of research to analyze an extensive set of ichthyoplankton data spanning 23+ years (1977-1999 and beyond) and encompassing the South East Bering Sea, the western Gulf of Alaska, and the U.S. West Coast. This project is funded by U.S. GLOBEC (Global Ocean Ecosystem Dynamics) and is being carried out by the FOCI (Fisheries Oceanography Coordinated Investigations) group at the NOAA Alaska Fisheries Science Center. Takes the lead in investigating spatial and temporal patterns in occurrence and abundance of species of fish eggs and larvae in these three regions and relates the observed patterns to the oceanographic environment of the three sampling regions. In addition, a proposal to continue and expand this work beyond the year 2000 was prepared for submission to U.S. GLOBEC in April 2000, for funding in the years 2001-2005.

(3) Conducts research on the population biology and ecology of marine fishery resources, particularly schooling pelagic resources in walleye pollock of the North Pacific, primarily using the acoustic technology. Conducts at-sea acoustic surveys over the fishing grounds of the North Pacific. Develops and tests new methods to expand the acoustic tool box to investigate the role of dominant fish stocks in marine ecosystem and to evaluate assumptions relevant to the application of the technology. Contributes to and influences the goals and priorities of NOAA, NMFS, RACE, and groundfish research. Develops cooperative research and supports academic training of students in the UW School of Fisheries in cooperation with NOAA, NMFS, and RACE scientists.

(4) Engages in collaborative research with scientists in the Fisheries-Oceanography Coordinated Investigations (FOCI) program. FOCI is an ongoing interdisciplinary research program whose goal is to gain an improved understanding of the influence of the physical and biotic environment on the recruitment of selected fish stocks in Alaskan waters.

Works directly with the FOCI Director , the project leader for ship-mounted acoustic Doppler Current Profiler (ADCP) studies, and other senior FOCI researchers. Tasks will include processing of data collected from various oceanographic and meteorological sensors and implementation and evaluation of shipboard and laboratory procedures to provide accurate assessment of ocean and climate variability. Oceanographic and meteorological data sensors include conductivity-temperature-depth (CTD) probes, current meters, pressure gauges, and self-contained and ship-mounted ADCP's. Designs and implements multi-platform computer software to realize efficient and timely processing of sensor data. Performs interactive data processing and analysis with senior FOCI scientists

and researchers for publication in scientific journals. Other development tasks associated with processing, analysis, and Web/Internet access/presentation of oceanographic data may be assigned. May be required to participate in a research cruise during the period of this project appointment.

(oceanographer currently in residence)

(1) Develops and implements regional ocean circulation models, collaborates with fisheries and biological oceanographers on the development and coupling of biological models with physical models, develops techniques for visualizing three-dimensional model output, compares output with field data, and publishes results in peer-reviewed scientific journals. This work contributes to explorations of how physical factors on multiple time scales affect the dynamics of coastal marine ecosystems in general and economically important fish stocks in particular.

***In this theme area two new research assistants (graduate students)* will be recruited. *The specific areas of research will be determined by the programs funded during the next cooperative agreement. One new research scientist will also be added in this theme area to conduct observational work to be performed in the North Pacific and Bering Sea. Sea duty will be required.*

B.5. *Global Change Policy*

No positions for this theme area will be funded under TASK II. during the next cooperative agreement.

C.TASK III

C.1. *Climate/Climate Variability*

This work unit consists of specific research proposals to NOAA's climate-related programs: GOALS, OGP, PACS, STACS, WOCE and the Vents Program, etc.

(1) **David Battisti**, principal investigator: *Abrupt Climate Changes Over the Past 100,000 Years*

We propose a five year study to investigate the mechanisms that might be responsible for the remarkable abrupt climate changes over the past 100,000 years. These climate changes are equivalent in amplitude to changes going from glacial to interglacial conditions, only the transitions have happened on time scales of 30 years, or less. The growing paleo data for several of these abrupt transitions is sufficient to exclude the leading hypothesis for these abrupt climate changes: that they are driven by changes in the ocean thermohaline circulation.

We propose a study to develop and evaluate several alternative hypotheses for these abrupt climate changes. The theories will be based on the constraints levied by existing paleo data and by the foundations of climate theory, including feedbacks. We will test various hypotheses through a rigorous experimentation with appropriate coupled climate models.

(2) **David Battisti**, principal investigator: *Decadal Variability Around the Atlantic Basin*

This project will continue earlier efforts to examine the hypothesis that coupled atmosphere/ocean/land interactions in the tropical Atlantic are integral for the predominant pattern of sub-interannual (decadal) climate variability in the tropical Atlantic, including the profound low frequency variability in rain and drought over the Nordeste Brazil, the Amazon basin and the Sahel. We will use models of varying complexity, ranging from fully coupled atmosphere and ocean GCMS to intermediate coupled atmosphere/ocean/land models to isolate various feedbacks and domain interactions, and finally to relatively simple didactic models that can be used to explore the sensitivity of the coupled system to changes in the strength of the processes that are found to be important for the simulation of realistic variability by the coupled full-physics models (the GCM's).

Our deliverables will be a better understanding of the observed climate phenomena in the tropical Atlantic (and of any related variability in the N. Atlantic) on interannual to decadal time scales, including a rigorous examination of the processes that are responsible for this variability and the sensitivity of the system to the treatment of these processes in the coupled climate models. Documenting and understanding the mechanisms responsible for the observed climate variability are the foundation for prediction. (3) **Dennis L. Hartmann**, principle investigator: *GFDL Consortium*

Analysis of experiments with the GFDL GCM will be conducted to study intraseasonal and interannual variability and its dependence on internal atmospheric dynamics, forcing from sea surface temperature variations such as those originating in the ENSO phenomenon, and interaction with an oceanic mixed layer model. Natural modes of variability simulated by the GCM will be compared with observations and the GCM will then be used to better understand how these of variability are sustained in the model. Very long integrations of the model will enable studies of the structure and statistics of natural variability that are not possible with the much shorter observed record.

Understanding of intraseasonal and interannual variability and their simulation in global climate models will be useful for both seasonal forecasting and for predicting and detecting the climate response to external forcing such as greenhouse gas increases and ozone depletion.

(4) **Dennis L. Hartmann**, principle investigator: *Prediction of American Summer Climate Variability*

Modeling and data analysis will help t understand predictability of North, Central and South American climate versions on intraseasonal and interannual time scales. Involves the analysis of understanding the mechanisms as well as modeling. We will use a combination of global models, regional-high-resolution models and data. We will use the 40-100 year data record to provide guidance. We will investigate the relationships among ENSO, MJO, precipitation and storms in the Americas.

(5) **Dennis L. Hartmann**, principle investigator: *Dynamics of Low-frequency Variability*

Modeling and analysis of dynamically induced global weather variability, including annular modes and local oscillation such as the NAO. Work will be done collaboratively with GFDL laboratory, and will involve analysis of long GFDL climate model runs combined with analysis of simpler global models that we will run locally. The objective is to better understand the underlying dynamics of global variability, its dependence on the mean climate state and the potential interaction of global dynamical modes with tropospheric and stratospheric global change.

(6) **Robert A. Houze**, principle investigator: *Tropical Precipitation*

The proposed and anticipated research focuses on precipitation over the tropics. Residual funding from previous projects will continue work on precipitation over the tropical eastern Pacific and over the South American continent. TRMM satellite data will contribute to these efforts. A funded proposal entitled "Further Analysis of the Data: Relation of ITCZ Convection to Large-scale Cross-equatorial Flow" will investigate further the physical processes of precipitation in the eastern Pacific ITCZ. Professor Houze is on a committee to oversee the used of the precipitation radar aboard the NOAA ship Ronald H. Brown. During the next five years this radar will continue to obtain data on precipitation over the tropical oceans. Research will be built around these ongoing ship radar measurements. We anticipate that research on the Indian monsoon will be one of the specific efforts in which the ship radar participates and that we will continue to relate these ship measurements to TRMM and other satellite data.

(7) **Dennis Lettenmaier**, principal investigator: *Development of a Hydrologically-Based Land Data Assimilation System for the Continental U.S.*

The central objective of the project is to develop a Land Data Assimilation System (LDAS) to provide soil moisture and snow fields for the initialization of numerical weather prediction models. The basic structure of the University of Washington portion of the LDAS is being built around the Variable Infiltration Capacity (VIC) model, which is run off-line for the continental U.S., using observed meteorological data to generate the initialization of fields.

(8) **Dennis Lettenmaier**, principal investigator: *GCIP/GAPP Missouri River Water Management Demonstration Project*

It is proposed to continue the experimental ensemble and water resources forecast activity in the Missouri River basis, which will contribute to commitment to deliver products useful for water resources management. The proposed activity will evaluate the capabilities of ensemble climate forecasts produced using NCEP/CMB ensemble climate forecasts and similar products of other cooperative climate forecast centers; in turn, to predict streamflow for lead times up to one year.

(9) **Cliffort Mass**, principal investigator: *A coupled Atmospheric and Hydrological Modeling System*

It will be proposed to continue efforts to couple the output from a high-resolution mesoscale model for (the MM5) to a distributed hydrological model for the major rivers that drain into Puget Sound. The proposed project will take advantage of several ongoing efforts here in the Pacific Nothwest.

(10) **Jeffrey A. Nystuen**, principle investigator: *Long-term Acoustical Measurements of Air-Sea Exchange Processes: Rainfall, Stratiform Drizzle, Ambient Bubbles and Wind Speed*

A weak link in atmospheric and oceanic modeling are currently the coupled air-sea models. Part of the problem is identifying appropriate parameterizations of the crucial air-sea fluxes of heat, fresh water and momentum which dynamically drive the models. In order to develop and verify coupled atmosphere-ocean models, long-term observations of these fluxes are needed. This need has been clearly identified, and is one of the program priorities for PACS and EPIC (Eastern Pacific Investigation of Climate). The ambient sound field offers a means to make these measurements as the processes associated with precipitation and wave breaking are the principal sources and modifiers of underwater sound in the frequency band from 500-50,000 Hz. Specifically, the ambient sound field provides quantitative measurements of rainfall, rainfall type (heavy convective rain versus stratiform drizzle), wind speed (+ 1 m/s) and ambient bubble populations (near-surface void faction). The ambient sound measurement can be made from ocean moorings and will compliment measurements made from more traditional sensors on such moorings.

Of particular interest is the measurement of precipitation, including its detection, the identification of rainfall type and quantification. The hydrological cycle of the upper ocean layer is an important part of the mixing, both lateral and vertical. The hydrological cycle in oceanic regions is particularly poorly sampled because of the difficulty of obtaining salinity and precipitation measurements. Rainfall is also responsible for a unique underwater acoustic signal easily distinguished from other common sound sources (breaking waves, biology, etc.) and, furthermore, the sound levels produced by rain are much louder, by orders of magnitude, than these other sources. This allows detection and measurement of rainfall at sea. To take advantage of this signal, Acoustic Rain Gauges (ARGs) have been designed and built at the Applied Physics Laboratory. These instruments are now deployed on NOAA PMEL moorings (the TAO array) in the Eastern Tropical Pacific Ocean and another ARG will be deployed in the fall of 2000 on a WHOI mooring in the stratiform deck region of the southern tropical Pacific Ocean off the coast of South America.

Current Activity: Data are being collected from ocean moorings in the Eastern Tropical Pacific Ocean. ARG Deployments and recovery are ongoing, in collaboration with PMEL (McPhaden, Cronin, Freitag). A new mooring will be deployed in the fall of 2000 (Anderson/Weller at WHOI).

Future Activity: This project is ongoing. It is likely to be extended indefinitely, provided that the data obtained are useful. The next two years of the monitoring and data analysis program are funded. Future funding is likely to be at the same general level.

(11) **Peter Rhines**, principle investigator: *Model Studies of the High-Latitude Ocean/Atmosphere Climate Dynamics*

We propose to carry out model studies of the high-latitude ocean/atmosphere climate dynamics. This is in connection with the development of a climate project within the School of Oceanography, initialized with foundation support. Two aspects of climate will be emphasized: a) The fresh water cycle at high latitude and its interaction with high-latitude sinking processes in a coupled climate model and b) The role of high-latitude orography in the dynamics of annular oscillations of the atmosphere. A long-term goal is to use models to constrain future observations of high-latitude fresh-water transport and circulation. (a)

Fresh-water dynamics and Arctic/Sub-Arctic Exchange

Coupled numerical models now play an enormously important role in global and regional climate studies. As everyone realizes, these models have many compromises in unresolved physical processes (and, as well, in unresolved chemical/biological and land-surface processes). We bring to this problem experience with isopycnal numerical ocean models, which offer the hope of more accurate computation of high latitude sinking processes. Many studies (including the DYNAMO project, an intercomparison of three prominent ocean models (MOM, a version of MICOM and SPEM) showed graphically the need to improve representation of sinking branches of the ocean circulation. Isopycnal- and sigma-coordinate models have typically done better (although they do have their own generic problems). The Bleck MICOM model and Halberg's HIM model both allow sinking as layers naturally outcrop at high-latitude. High-brid versions in which mixed layer models and geometric levels are added to the top of isopycnal models, are now under development.

Specific science issues. In numerical and laboratory experiments, our group has demonstrated the crucial role of continental slope topography in guiding the deep ocean circulation (Hallberg and Rhines 1996). Oceanic topography has a demonstrable effect on the strength of the overturning circulation (see also Winton, 1996). In the context of a coupled model, the rapid establishment of the meridional circulation of the ocean is potentially important to atmospheric feedback at lower latitude.
Here we propose to use the Bleck/Cheng coupled climate model (an NCAR CCM-3 atmosphere and MICOM isopycnal ocean model) and include a simple hierarchy of ice models. These will initially be purely thermodynamic. The use of the present Kraus-Turner mixed layer will be re-evaluated and compared with the mixed-layer/buffer layer formulation now operating in the HIM isopycnal model. This work will be carried out by the PI, with post-doctorals Wei Cheng and David Bailey.

In addition to coarsely resolved (20x16 layer ocean, T42x18 level atmosphere) global experiments we will carry out simplified process studies in which higher resolution is applied to examine the detailed relationship between ice cover, deep convection and meridional overturning in a simplified geometry.

(b) *The Role of High-latitude Orography in the Dynamics of Annular Oscillations of the Atmosphere*

There has been great interest in the broad-spectrum variability of the atmosphere in zonal or nearly zonal modes. The strong connectivity with the stratosphere, nearly barotropic form,

and extensive impacts of annular oscillations have been demonstrated (e.g. Thompson and Wallace 1998). In the far north, the dominant orography is the Greenland ice mountain. While coarse atmospheric general circulation models tend to put most emphasis on smoother or envelope topography in western US and central Asia, there is possible ducting of the westerly winds and cold-air outbreaks by Greenland. The Icelandic Low is the accumulation of cyclonic energy that often involves stagnation and intensification of storms near Cape Farewell. We have initiated a series of simply shallow-water integrations on a sphere, to look at interaction of a solitary mountain at 600N with a solid-body super-rotation. At short times this is a standard Rossby wave problem, yet its life cycle becomes more interesting as frictional damping is decreased. The single 500km wide mountain can then 'insonify' the entire globe with zonal jets, upstream blocking, following a suppression of Rossby waves.

The annular jets found here are related to '(-plane jets' that arise spontaneously in a turbulent atmosphere. We propose to carry out a hierarchy of sparse 'dry dynamical gcm core' experiments in which the EOF structure of time-variable, orographically forced jets is examined. Energetics and climatology of the model will be studied and storm-track behavior in its relationship with the orography.

Personnel: We are just now hiring two outstanding young scientists, for post-doctoral positions. Wei Cheng, with Rainer Bleck, at Los Alamos National Laboratory, has developed a coupled climate model based on the NCAR CCM-3 and the Black MICOM isopycnal model. David Bailey, also a skilled model-builder, has worked with Amanda Lynch at CIRES, University of Colorado, developing high-latitude ice-ocean-circulation models.

Related Activities: The School of Oceanography is establishing a program in ocean climate studies, with support from the Vetlesen Foundation. This has provided seed support for two post-doctoral fellowships and the joint purchase of two multi-processor alpha-based Compaq computers. There is considerable expertise in high-latitude dynamics, atmospheric climate and the biogeochemical components of climate at University of Washington.

Annual Budget Estimate: $125,000. We propose a NOAA contribution to this activity largely to support in-house computing resources, graduate student support and for a 1/2 time scientific programmer. Computing resources in-house will be enhanced by this grant and we will seek to maintain or establish collaborations with NOAA laboratories which can provide access to high-end computing. The School of Oceanography has recently take delivery of a pair of 4-processor Compaq-alpha computers, to this end.

(12) **Edward S. Sarachik**, principal investigator and Director for **the Stanley P. Hayes Center for the Study of Climate Variability, an Applied Research Center** which is jointly administered between scientists at JISAO, University of Washington and the NOAA/Pacific Marine Environmental Laboratory. The Center was initiated in 1994 and had its first full year funding and activity in 1995. It is funded jointly by the Climate Diagnostics and Experimental Prediction program of NOAA/OGP and by NOAA/OAR. In 1997, the Hayes Center expanded its activity to include the Pacific Nothwest Climate Impacts Group (CIG) headed by Prof. Ed Miles and thereby added an assessment and policy function with which the physical climate aspects of the Hayes could mutually interact.

The original purpose of the center was to analyze and model Pacific observations, especially those connected with the TOGA TAO array in the equatorial Pacific. With the addition of the PNW Climate Impacts Group, the Hayes Center achieves an end-to-end aspect---from data to prediction, to assessment to applications---that we expect will broaden

the scope of the Hayes Center and make it crucial to ongoing regional assessment activities in the U.S. The new goal of the Hayes Center is, therefore, to engage insofar as possible, on end-to-end activities with a view towards understanding the advantages and difficulties inherent in the end-to-end process. From this point of view, the Hayes Center contributes to the overall goal of the NOAA Climate and Global Change program: *To establish a new national information service based on the achievement of reliable assessments and quantitative predictions of changing global climate and its regional implications.*

A secondary purpose of the Hayes Center is to provide the directed research support for various NOAA programs (especially PACS and other US contributions to CLIVAR-GOALS and CLIVAR-DecCen and to the IPCC); for the maintenance of the TOGA TAO Array, and for the support of seasonal-to-interannual prediction and its relationship to the IRI.

To illustrate the interdisciplinary focus of the Hayes Center, the participating senior scientist at the University of Washington are listed: David Battisti, Ed Miles, Ed Sarachik, Brad Smull and Mike Wallace with t he participation of associated post-doctoral researchers and graduate students. At PMEL, the senior scientists are Ed Harrison, Billy Kessler and Mike McPhaden with associated researcher Meghan Cronin and associated graduate students and professional staff. Ed Sarachik serves as the director of the Hayes Center. The participating scientists at the Pacific Northwest Climate Impacts Group are Dave Fluharty (Fisheries), Bob Francis (Fisheries), Jerry Franklin (Forestry, Anne Marie Kimball (Human Health), Dennis Lettenmaier (Hydrology), Nate Mantua (Physical Climate), Phil Mote (Physical Climate), Ed Miles (Marine Policy) serving as Head, and associated postdoctoral researchers and graduate students.

C.2. *Environmental Chemistry*

(1) **David Covert,** principal investigator: *Observational Research on the in-situ Measurement of Physical/Chemical and Optical Properties of Atmospheric Aerosol*

Observational research on the *in situ* measurement of physical, chemical and optical properties of atmospheric aerosol will be continued cooperation with NOAA PMEL and NOAA/CMDL researchers. This topic is important and relevant to the understanding of climate forcing by natural sources and anthropogenic emissions of greenhouse gases and various types of aerosols.

Research to continue to develop *in situ* instrumentation and to operate this instrumentation in regional and global scale field experiments with NOAA and NASA to integrate the satellite measurements and modeling. The integration of these three approaches to understanding radiative transfer in the earth atmosphere system and possible climate forcing is key to progress in this field. Laboratory work will involve improvement of the integrating and lidar nephelometer for aircraft measurements in the free air and improvement of the absorption photometer. The combination of these instruments will continue to be used to develop a data base of lidar ratio which is central to measurements. The *in-situ* measurements provide the link between directly measured aerosol properties that can only be made infrequently and on a geographically limited basis to the global data set from satellites. These properties are needed for radiative transfer calculations based on satellite data.

The Principal Investigator is currently involved in the NSF, NOAA and ONR funded ACE Asia project. In the future he will be involved with the PICASSO-CENA lidar satellite and NOAA field projects on the NOAA RV Brown and at NOAA CMDL sites.

(2) **Richard Gammon**, principle investigator: *Underway PCO2 Measurement of Coast Guard Vessels (Antarctic Re-supply)*

Plans to use Seattle-based USCG vessels (e.g. *Polar Sea*) for continuous, underway long-line PCO2 measurement with automated systems developed at PMEL/NOAA.

C.3. *Estuaries*

It is not anticipated that any funds will be requested for this theme.

C.4. *Fisheries Recruitment*

(1) **Walton Dickhoff**, principle investigator: *Captive Broodstocks and the Salmon Life Cycle*

The immediate goal of this research project is to assess the development of captive broodstock technology to aid in the recovery of salmon listed under the Endangered Species Act. Results of the project can be applied to a better understanding of how the environment may affect the life cycle of the salmon and other teleosts with similar seasonal reproductive cycles. The salmon populations of the North Pacific Ocean show significant interannual variation and decadal trends in fish numbers, body size and age at maturity. It is not clear to what extent these fluctuations are caused by external changes in climate or ocean productivity, such intrinsic changes as genetic drift, or more direct anthropogenic effects on salmon populations. For example, some stocks of salmon are highly influenced by captive rearing (hatcheries), especially during their juvenile rearing. Captive rearing could influence survival, growth rare and maturation age, through environmental mechanisms. It is difficult to sort out ocean environmental effects unless we have a better understanding of the underlying mechanisms affecting adult survival, growth and maturation. The goal of this study is to conduct laboratory studies of salmon to better understand the factors affecting their survival and age and size at maturation.

Although the life cycle of anadromous salmonids is relatively simple, consisting of migration of juvenile fish to the ocean and their return to rivers and streams as they mature, there is a great deal of plasticity in age of maturation in some species. For example, chinook salmon may mature at ages of 2, 3, 4, 5, or 6 years. Male chinook salmon can mature at even earlier ages, for example, age one or less. Age at reproduction is affected by fish size and growth rate such that large and faster growing fish mature earlier than smaller, slower-growing fish. Rapid growth at an early age in fresh water often carries over to rapid growth in the ocean. Laboratory studies will focus on spring chinook salmon that are reared at differing growth rates. The status of the reproductive endocrine system will be analyzed by determining blood and pituitary gland concentrations of reproductive and growth-regulating hormones. It is anticipated that critical periods of reproductive maturation decisions will be determined by periods of elevated hormones. We also anticipate that higher growth rates will results in earlier ages at maturation. The large range in body sizes expected in this experiment should provide the most precise data on growth rate effects on maturation rate.

Substantial Involvement: This project is a collaboration between the University of Washington, School of Fisheries and Northwest Fisheries Science Center, NMFS, NOAA. Professor Walton Dickhoff will oversee the UW part of the project. The National Marine Fisheries Service will provide laboratory and office space and daily interaction between project personnel and Center staff. NMFS biologist Dr. Penny Swanson will devote 50% of her time; NMFS biologist Dr. Michael Rust will devote 10% of his time; NMFS

biologist Dr. Karl Shearer will devote 50% of his time; NMFS biologist Dr. Jeffrey Hard will devote at least 10% of this time to overseeing and conducting experiments. Students and staff biologists of the University of Washington will use NMFS facilities and operate NMFS boats and vehicles as part of their work on the project.

(2) **Walton Dickhoff**, principle investigator: *Growth Development and Salmon*

The long range goal of this project is to understand the control of salmon growth and development by internal and external factors. Results of the project can be applied to a better understanding of how climate change may affect the growth of salmon. The salmon populations of the North Pacific Ocean show significant internannual variation and decadal trends in fish numbers, body size and age maturity. It is not clear to what extent these fluctuations are caused by external changes in climate or ocean productivity. The immediate goal of this study is to conduct studies of the endocrine and physiological systems controlling growth to better understand factors affecting the salmon life cycle and body size. Analysis of levels of growth hormones and growth factors in the blood of salmon caught on the high seas of the North Pacific Ocean will be performed.

A trend of declining size of Pacific salmon has been observed in recent years (Bigler et al. 1996). It has been suggested that the decrease in size of adult salmon is due to changing conditions of the ocean ecosystem during the final life stage of salmon (Ishida et al., 1993; Rogers and Ruggerone, 1993). Although the changes in body size of adult salmon are well documented, there is little data on the physiological growth status of fish in the ocean. In earlier work, we found a significant correlation between fish seize and blood levels of insulin-like growth factor ((IGF-I) for salmon sampled during winter (Myers et al., 1998). Recently we have had the opportunity to begin analysis of growth factors in the blood of juvenile salmon caught in the near shore Pacific Ocean off Vancouver Island, Puget Sound and Strait of Georgia. Dr. Brian Beckman of the National Marine Fisheries Service has obtained blood samples of juvenile Pacific salmon during the last 2 years. We plan on determining blood levels of growth hormone, insulin, IGF-I and IGF-I binding proteins for these nearshore and estuarine ocean-caught salmon. Hopefully, this information will give us a good profile of the growth status of the fish during different seasons. Furthermore, we will analyze our data within the context of seasonal variation in the activity of the endocrine systems regulating growth (Dickhoff et al., 1997).

Our studies of regulation of growth rely on dependable methods of measuring the major growth controlling endocrine axis in fish, which is the growth hormone (GH) ñ IGF axis.

In order to better interpret differences in circulating levels of IGF in salmon blood, we propose to examine the short and long-term dynamics of changes in plasma IGF during fasting and feeding. Furthermore, the identification of different IGFBPs and their probable significance in modifying growth regulation by IGF offers an additional avenue for research that we intend to pursue.

(3) **Walton Dickhoff**, principle investigator: *Undergraduate/Graduate Student Internships*

Funding is requested to support undergraduate and graduate student interns to work with research staff at the Northwest and Alaska Fisheries Science Centers of the National Marine Fisheries Service. Research will be focused on a variety of topics in the general areas of fisheries recruitment, stock assessment, sustaining fish populations and recovery of stocks listed under the Endangered Species Act.

(4) **Faye M. Dong**, principle investigator: *Nutritional Studies of Fish*

An important first step in developing feeds for new aqua-cultured species it to determine the digestibility of specific protein ingredients. This project will examine the in vivo digestibility of animal-based (e.g. fish meal, poultry byproduct meal) and plant-based (e.g. soybean meal) protein ingredients in Atlantic salmon (Salmo salar) as the control, and in sablefish (Anoplopoma fimbria), ling cod (Ophiodon elongatus), rockfish (Sebastes sp.) and Pacific halibut (Hippoglossus stenolepis). It is important to test several non-fish meal protein sources because of the need to produce sustainable feeds made with ingredients from abundant renewable natural resources. The feed should be highly digestible so that there will be maximum conversion into fish biomass, minimum wastage of feed in the water and minimum pollution from fecal material. In addition, the feed should support high product quality of the marketable fish.

This project will screen some commonly used ingredients in the aquaculture industry to determine their suitability in feeds for new aquaculture species. The information will help lead to the development of diets that will be tested in longer term feeding trials of 3ñ4 months, where the nutritional quality of the feed and the product quality of the fish will be evaluated. Future feeds need to be environmentally sound and cost-effective in order to advance aquatic food production through agriculture.

(5) **Don Gunderson**, principle investigator: *Atka Mackerel*

Develop methods for estimating abundance: Investigate Reproductive Biology.

(6) **Don Gunderson**, principle investigator: *Enhanced Population Parameters*

Improve estimates of population parameters (growth rates, age at maturity, gonadosomatic index, natural mortality and fertility) for use in population and ecosystem modeling.

(7) **Bruce S. Miller**, principle investigator: *Larval and Juvenile Lingcod Studies*

From 1998 ñ 2000, we have developed the techniques to successfully spawn and rear lingcod. This project will continue to improve upon this technique and to combine lab and field experiments to fully and completely describe the reproductive biology and ecology of lingcod, with emphasis on understanding recruitment in this extremely valuable species.

(8) **Bruce S. Miller**, principle investigator: *Marine Biological Interactions in the North Pacific: Fish Trophic Interactions*

This project provides quantitative estimates regarding the food habits, biogenetics and other biological parameters of key groundfish species in the North Pacific. These data are used to estimate predation impact of these predator populations on the abundance of important prey, which may help us understand and separate predation versus climate influences on recruitment dynamics of fish populations. At times it may also be necessary to directly sample prey populations by plankton nets or benthic grabs to determine the composition and abundance of food available to groundfish predators. Lastly, incorporation of these parameters into multispecies and ecosystem model that include other predators, trophic levels, and effects of environment is an important facet of integrating knowledge on trophic dynamics.

(9) **Marc Miller**, principal investigator: *Case Study Characterization of the Hawaii Pelagic Fisheries*

The overall goal of this multi-phase project is a case study characterization of the Hawaii pelagic fisheries.

Continuing objectives are: To reveal the cultural and social organization of the troll and handline pelagic fisheries; to describe the institutional environment in which fishery management policies are designed and implemented; to identify fishery issues and problems perceived by the harvesting sector.

C.5. *Global Change Policy*

(1) Edward L. Miles, principal investigator: *An Integrated Assessment of the Impacts of Climate Variability and Climate Change on the Pacific Northwest: Phase II*

A growing recognition of natural climate variability and concerns about potential future climate change have stimulated the desire to better understand these climate fluctuations, their predictability, their potential impacts, and how society can best prepare for them. The University of Washington's Climate Impacts Group (CIG) was established to address these issues for the Pacific Northwest region of the United. CIG is an interdisciplinary group of researchers from the physical, biological, and social sciences working together to examine climate and its consequences at the regional level ñ where trees grow, streams flow, and people live and make decisions.

In the regional assessment of climate impacts, CIG strives to understand the consequences of both climate variability and change for natural and human systems. We seek to answer the questions: How do fluctuations in climate affect biological and ecological systems? What do shifts in climate imply for human socioeconomic and political systems? We approach these problems using an integrated, holistic evaluation of how climate, natural resources, and human socioeconomic systems affect each other, a process we call 'climate impacts science'.

CIG looks to the recent past to define the natural rhythms of climate variability in the Pacific Northwest (PNW) and how they have played out in four sectors: the region's water resources, aquatic ecosystems, forests, and along the coasts. We are expanding to also include impacts on human health, and on irrigated agriculture. This analysis provides an essential ñ but often overlooked ñ quantitative basis for making future projections. We look to the future and ask how these rhythms will sound when climate changes, as a result of

human-caused emissions of greenhouse gases, and what that would imply for the natural resources of the region. Throughout our assessment, we evaluate whether the region's planners and decision-makers could better incorporate an understanding of these fluctuations into their operations, and we work to provide them the tools to do so through expanding outreach efforts. We hope to increase the harmony between how natural systems are affected by climate fluctuations and how humans manage and depend on those natural systems, in order to increase the resilience.

III. PERSONNEL

(Please see Appendix ___ which identifies the individuals by name)

TASK I, II, III (all themes)

Senior Fellows - 30 (effective 2/1/01); not salaried
Fellows - 1; not salaried

**(currently in residence)*

Permanent Faculty - 7
Research Associates (post-doctoral) - 10
Public Information Specialist - 1
Research Consultants - 9
Research Engineers - 2
Research Meteorologists - 4
Research Scientists - 28
Oceanographers - 6
Visitors - 4
Administrative Staff - 5
Graduate Students - 28
Hourly Staff - 7

Hourly staff and graduate students who are in residence but are not being supported by NOAA grants, are excluded from this count.

IV. DELIVERABLES

Annual Reports which include all JISAO-sponsored activities, personnel and visitors will be submitted in a timely manner to NOAA/OAR. For Published articles and papers document JISAO-sponsored research results and visiting scientists, please see appendices ____. Copies of these publications are on file in the JISAO Offices. JISAO was formally reviewed on March 31 - April 1, 1998. The five (5) outside Reviewers were Dr. Jagadish Shukla and Dr. Paul Schopf, Center for Ocean-Land-Atmosphere Studies (COLA), Dr. Barry Huebert, School of Ocean and Earth Science Technology, Department of Oceanography, University of Hawaii, Dr.Maurice Blackmon, Director, Climate and Global Dynamics Division, National Center for Atmospheric Research, and Dr. J. Robert Toggweiler, Geophysical Fluid Dynamics Laboratory, Princeton University Forrestal Campus. Appendix ___ includes review letters from four (4) of the outside reviewers and the review program