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Appendix 1

MEMORANDUM OF UNDERSTANDING
between
THE ENVIRONMENTAL RESEARCH LABORATORIES
of the
NATIONAL OCEANIC AND ATMOSPHERIC ADMINSTRATION
and
THE UNIVERSITY OF WASHINGTON
concerning the establishment of the
JOINT INSTITUTE FOR STUDY OF THE ATMOSPHERE AND OCEAN AND OTHER COLLABORATIVE EFFORTS

INTRODUCTION

This memorandum represents an agreement between the Environmental Research Laboratories (ERL) of the National Oceanic and Atmospheric Administration (NOAA) and the University of Washington for the establishment of a Joint Institute for Study of the Atmosphere and Ocean (JISAO) and for the conduct of other collaborative efforts between the ERL Pacific Marine Environmental Laboratory and the University.

The intent of this memorandum is to reaffirm the common interest in oceanographic and atmospheric sciences of the University and NOAA expressed in the existing Memorandum of Understanding which became effective on 12 January 1971. Further, in recognition of the demonstrated fact that mutual collaboration of the two organizations in these areas of research has proved both fruitful and stimulating, it is appropriate now to establish a basis for stronger cooperative research efforts. This agreement for the formal establishment of the Joint Institute is designed to facilitate in the most efficient way the continuation of cooperative efforts and upon becoming effective, will replace the existing Memorandum of Understanding.

PURPOSE AND SCOPE

A. Purpose

It is the purpose of JISAO:

1. To increase the effectiveness of oceanographic and atmospheric research of mutual interest to the ERL (in particular, but not limited to, Pacific Marine Environmental Laboratory) and the relevant units of the University by promoting close multidisciplinary collaboration among scientists associated with these two institutions and visiting scientists.
2. To provide a center at which scientists working on problems of mutual interest may come together.
3. To stimulate the training of scientists in the many disciplines involved in the oceanographic and atmospheric sciences.

B. Scope

The general areas of collaborative interest will include those aspects of oceanographic and atmospheric sciences which are of mutual interest to the ERL and the University. In view of the purpose of this memorandum, participation in this program need not be limited by organizational affiliation of individual scientists but will be determined by their ability to contribute to the mutual objectives of the participating organizations. Collaboration will provide a means for identification and definition of new research projects and focus for a continuing program of research and education.

Participating members in the collaborative effort involve three primary groups.

1. Staff members of JISAO, as defined in Section IV, below.
2. Other appropriate faculty and supporting staff from the University's Division of Marine Resources, the College of Fisheries, the Departments of Oceanography and Atmospheric Sciences, the Institute for Marine Studies, and other University departments who are interested in collaboration with the ERL.
3. Other appropriate staff members of the ERL who hold appointments in the University or who otherwise collaborate closely with University faculty or staff.

Although the areas of interest of the Joint Institute extend to the limits of the atmospheric and oceanic sciences, the research activities of the Institute will be focused on a few research themes or programs (one to four). The choice of research themes will be subject to approval by an Administrative Board which is to be appointed by the parent organization. New themes may be initiated internally or by request from either parent organization.

Initially, and for the immediately foreseeable future, two themes will be pursued: mechanisms of climate change and the multidisciplinary study of estuarine processes. Each of these efforts is of major scientific, economic, and social importance and each has readily identifiable participants from both parent institutions. These criteria are expected to be typical of the criteria for other themes which may be taken up at a later stage. The selection of research themes for JISAO should not limit the scope of other collaborative efforts between participants who are not formally Institute staff members. However proposals for projects to the undertaken jointly by such participants must be approved by the Council of JISAO or its designees.

REPONSIBILITIES OF THE TWO SPONSORING INSTITUTIONS

<u>Responsibilities shared by the NOAA Environmental Research Laboratories and the University</u>

JISAO is a cooperative enterprise entered into jointly by the ERL and the University. Because its objectives are primarily scholarly and academic, JISAO is located on the University campus and operated in a manner appropriate to this location and function. Through the Administrative Board, the two parent organizations will jointly maintain control over policies and assure appropriate professional standards. Through the Council of JISAO, scientific content and selection of staff are determined.

JISAO has its own operating budget. Administrative costs of JISAO are minimal, but ERL and the University share these costs in a manner to be negotiated between the two parties. Either of these organizations may enter into an agreement with the other, subject to the regulations of each, for the supply of services, equipment, or temporary rental space. Such arrangements will be the subject of a separate agreement.

3. The University and ERL will collaborate in planning and expediting the provision of suitable housing and facilities for JISAO. It is the intent of the University and ERL that the Institute and other approved collaborative efforts be housed near the departments concerned. The Environmental Research Laboratories agree to pay a fair portion of rent covering utilities and housekeeping services to be

negotiated on a continuing basis and, within the limitations of the Economy Act of 1932, either amortization of a fair portion of the building space occupied by JISAO over a reasonable period, or upkeep on the building as appropriate.

4. University facilities temporarily leased by ERL will be the subject of separate agreements as required. It is understood that the research activities conducted with the use of University facilities by the ERL will be compatible with University purposes and, in furtherance of this objective, ERL agrees that none of the space in the building will be used to house other Major Line Components of NOAA, or other agencies, without University approval.

Responsibilities borne separately by the NOAA Environmental Research Laboratories and the University.

1. Each sponsoring organization takes full operational responsibilities for its own employees physically located in and holding positions in JISAO, and agrees to promptly consider and adjudicate any and all damage claims which may arise directly or indirectly from the operation of the JISAO. Such consideration and adjudication against the NOAA Environmental Research Laboratories may be made under the Federal Tort Claims Act, 28 USC, Section 2671, et seq.; the Federal Employees' Compensation Act, 5 USC, Section 8101, et seq.; or under other authority as may be available.
2. The University administers the Visiting Senior Fellow, Institute Scientist and Postdoctoral Fellow programs of JISAO with the advice of the Council of JISAO. Funds provided by ERL for this purpose will be used for these programs although outside funds may be sought also.
3. The Director of JISAO shall be a University faculty member. The University will provide the Director with Clerical and administrative assistance, including accounting services.
4. The Director, ERL, will appoint a NOAA/JISAO Liaison Officer who shall be the principal point of contact within ERL on administrative matters associated with JISAO. The Dean of the Graduate School shall be the principal point of contact within the University on administrative matters associated with JISAO.
5. The University will use its good offices to locate space near the present marine sciences complex which JISAO will be expected to rent until a permanent facility can be occupied.

STAFF OF JISAO

Senior Fellows are scientists of established national or international standing who hold faculty appointments in the University or who are staff members of NOAA who hold University appointments. Their assignment to JISAO requires the concurrence of both parent organizations. In making new assignments, the Provost of the University and the Director of ERL will take the advice of the Council and the recommendation of the Director of JISAO into account. Senior Fellows normally hold appointments for three years. Appointments may be made for a shorter period of time or on a part-time basis with the concurrence of the appointee and the JISAO Council. Appointment as Senior Fellow in JISAO in no way affects the status of the persons concerned as faculty members (tenured or not) or Civil Servants.

Visiting Senior Fellows are appointed by the University with a University title after approval by the Council and recommendation the Director of JISAO. Their selection is based on JISAO program needs and upon scholarly criteria. Appointments as Visiting Senior Fellows need not be on a full-time basis; however, they will be expected to spend a significant period of time in residence at Seattle during their appointment. Visiting Senior Fellows are normally given appointments for one year.

Institute Research Scientists are appointed by the University upon the recommendation of the Director of JISAO and the Director, ERL. They should hold appointments either as University research faculty or as senior exempt staff. Although Institute Scientists are part of the JISAo scientific staff during the period of their appointments, research is normally carried out in laboratory facilities provided by ERL or by other University departments, with funds provided by special arrangement for this purpose. Institute Scientists will normally receive one-year appointments.

Research Associates Postdoctoral Fellows) and Research Assistants (Graduate Students) will join JISAO to gain research experience and to provide research assistance to the Senior Fellows. They will be appointed on advice of the Council by the Director of JISAO in conformance with University regulations.

ADMINISTRATIVE STRUCTURE OF JISAO

The Director

The Director shall be a Senior Fellow of JISAO who is not an employee or officer of the Federal Government. The Director shall be appointed by the University upon the concurrence of the Dean of the Graduate School and the Director of ERL. In making the appointment, consideration will be given to the views of the Council and the recommendations of the Administrative Board. The term for the Director shall normally be five years and is renewable. The appointment as Director may be terminated early by the appointive authority upon recommendation of the Administrative Board.

The Director is responsible to the Administrative Board for the following:

Scientific Leadership. The Director is expected to contribute actively to the development of research programs, and to involve local and visiting scientists in JISAO activities.

Review and assessment of all research proposals sent to outside agencies.

Preparation of an annual report of research results to sponsoring agencies.

Service as a member of the Council and as an ex officio member of the Administrative Board.

Routine administration.

Accountability for all funds supplied to JISAO.

The Council

The Council shall consist of seven Senior Fellows representing the major research fields of the Institute program. Excepting the Director, three of the members should be faculty of the University holding regular academic appointments and three should be ERL staff members.

Membership of the Council consists of:

a) Two Senior Fellows designated by the Dean of the Graduate School.
b) Two Senior Fellows appointed by the Director of ERL.
c) Two Senior Fellows elected by the Senior Fellows.

The responsibilities of the Council include:

a) Establishing the broad scientific content of the Institute.
b) Promotion of cooperation between the sponsoring institutions.
c) Maintenance of the high scientific and professional standards.
d) Consideration of new Senior Fellows, visiting Senior Fellows, institute scientists, and postdoctoral Fellows for appointment.
e) Adoption of appropriate rules for the operation of JISAO.
f) Approval of proposals for cooperative projects between University and ERL staff members who are not on the JISAO staff.

The Administrative Board

Membership of the Administrative Board consists of:

a) Dean of the Graduate School as Chairman
b) Dean of College of Arts and Sciences
c) Chairman of Atmospheric Sciences
d) Chairman of Oceanography
e) Director of ERL
f) Director of PMEL
g) A NOAA representative at large
h) Director of JISAO, ex officio

The Board may elect to modify or enlarge its composition as appropriate to changing needs. The Dean of the Graduate School of the University and the Director of ERL may jointly invite a panel of distinguished scientists to serve as advisors to the Board. Those persons should be well qualified to evaluate the program of JISAO, to judge performance, and to make appropriate suggestions for change. They may be members of either US or foreign institutions. If requested, the Council of JISAO will submit a slate of names for this purpose.

The Board will meet normally once a year. Other meetings of the Board may be called by the Chairman or a majority of members.

The responsibilities of the Administrative Board include:

Recommendations for the Directorship.
Evaluation of JISAO and other collaborative programs and activities.
Annual brief report of the Board's evaluation of JISAO and other programs and activities.
Recommendations of new program directions.
Review of general policies of JISAO and initiation of appropriate recommendations.
Approval of JISAO budget.
Recommendations, if any, for changes in this Memorandum of Understanding.

GENERAL POLICIES OF JISAO

All Senior Fellows, Visiting Fellows, Institute Research Scientists, Staff and Research Associates, as well as Visitors shall have free access to all parts of JISAO.

A primary purpose of this collaboration is the free interchange of scientific ideas and knowledge, therefore, no classified research will take place within the JISAO premises nor will classified material be stored there.

The ultimate maximum size envisaged for JISAO is:

NOAA/ER: staff: 10 Senior Fellows
University staff: 10 Senior Fellows
Visiting Fellows: 10
Institute Research Scientists: 10
Clerical and technical staff: 10
Graduate Students and Postdoctoral Fellows: 30

Scientific appointments in JISAO will be based on academic and research qualifications. Selections are not restricted to US citizens. All term appointments are renewable upon recommendation of the Council. All appointments may be terminated by the appointing authorities according to established procedures for cause or because of termination or contraction or change in direction of the relevant JISAO program.

Contracts, grants, or other agreements entered into pursuant to this memorandum shall contain appropriate provisions relating to Equal Employment Opportunity, E.O. 11246, Non-Discrimination in Federally Assisted Programs, Title VI of the Civil Rights Act of 1964,

Prohibition of Sex Discrimination, Title IX of the Education Amendment Act of 1972, and other appropriate acts as implemented by Department of Commerce regulations.

VII. ACADEMIC POLICY

A. Formal education, including the selection of students, remains the responsibility of appropriate instructional departments of the University.
B. Where appropriate, and subject to the approval of the Director of ERL and the Chairman of the appropriate University department, the University may appoint members of ERL to appropriate faculty7 positions so that they may offer courses, conduct seminars, and otherwise participate in University departmental affairs. ERL staff members appointed in this manner will be entitled to all faculty privilege appropriate to their rank and position. The rank and position will be determined by the University in accordance with its usual policies and procedures, but it is agreed that such appointments will be without tenure. The academic functions of ERL Fellows and other staff members holding University appointments are an essential part of their jobs, inseparable from research and planning activities.
C. Financial assistance to students shall conform to the policy of the University and to the policy of the departments that may be involved in JISAO.
D. In order to promote a sense of unity in JISAO, the University extends the amenities of the campus to all staff of JISAO.

VIII. FINANCIAL COMMITMENTS

Financial arrangements contemplated by this Agreement will be contingent upon the appropriation of necessary funds by the Congress of the United States and the Board of Regents of the University of Washington.

IX. TERM OF MEMORANDUM OF UNDERSTANDING

This Memorandum of Understanding is effective as of the date of signature by the Board of Regents, University of Washington, and the Administrator of NOAA, and will continue in force unless terminated. Termination can be by agreement or upon the failure of either party to observe the basic conditions contained in this Memorandum of Understanding. If termination is contemplated, the party initiating the action will give at least one year's notice to the other party. Proposals to modify the terms of this Memorandum of Understanding can be initiated by either the Director, ERL, or the Provost of the University.

2004 Annual Report

July 1, 2003 – June 30, 2004

a technical report

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An overview of JISAO

Since 1977, the Joint Institute for the Study of the Atmosphere and Ocean (JISAO) has fostered research collaboration between the National Oceanographic and Atmospheric Administration (NOAA) and the University of Washington. On the NOAA side, the principal connection is the Pacific Marine Environmental Laboratory (PMEL), serving as host lab. JISAO is governed by 36 Senior Fellows, whose name and affiliations are listed in Appendix 1. The appointments are divided nearly evenly between University faculty and NOAA/PMEL personnel who hold affiliate faculty appointments at the University. The Director of JISAO reports to the University's Vice Provost for Research.

The research themes that JISAO has chosen to focus on reflect the particular research expertise and mutual interests of participating scientists at the University of Washington and NOAA. During the past year these themes have been revised to bring them into closer alignment with NOAA's strategic plan. The former "Estuaries" theme has been broadened to "Coastal Oceanography", and "Fisheries Recruitment" has been broadened to "Marine Ecosystems". With these changes, JISAO's four research themes become:

1) **Climate**
2) **Environmental Chemistry**
3) **Marine Ecosystems**
4) **Coastal Oceanography**

JISAO's **Climate** Theme encompasses the entire globe. Principal thrusts include tropical atmosphere-ocean interaction, global climate sensitivity, climate change in the Arctic, and the regional impacts of climate variability, with emphasis on the Pacific Northwest. It includes contributions to the global observing system, the development of climate models, and outreach to government agencies and businesses that have a stake in climate information. It is closely aligned with Goal 2 of NOAA's Strategic Plan *"Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond.*"

JISAO's **Environmental Chemistry** theme also addresses issues central to the U.S. Climate Change Science Program: namely, the carbon cycle and the sources, transformations, transports, and sinks of aerosols and trace gases. Like the Climate theme, it includes a strong observational component, with an emphasis on processes.

JISAO's **Marine Ecosystems** theme, mirrors Goal 1 in NOAA's strategic plan, *"Protect, Restore, and Manage the Use of Coastal and Ocean Resources through an Ecosystem Approach to Management."* It has a North Pacific focus, and it encompasses research on the impacts of climate variations on marine ecosystems and on ecosystems associated with underwater volcanoes -- hydrothermal vents. Hydrothermal vents support unique and poorly understood marine ecosystems that can affect the biological, chemical, and thermal variablity of the oceans. Some hydrothermal microorganisms have potential application to serve society in drug development and toxic waste management as well as serving research on the origins of life. JISAO's Marine Ecosystems theme also includes an applied research component in support of

fisheries management, with emphasis on salmon and walleye Pollock and the ecosystem of the California Current system, with particular emphasis on sardines and hake. Some of the JISAO research on Marine Ecosystems is carried out in cooperation with NOAA scientists at the Alaska Fisheries Science Center (AFSC) and the Northwest Fisheries Science Center (NFSC).

JISAO's **Coastal Oceanography** theme is currently dominated by research and development on tsunami preparedness, a major concern of residents and visitors to coastal communities in the Pacific Northwest. This activity is aligned with NOAA's Goal 3 *"Serve Society's Needs for Weather and Water Information"* and has broader implications for the safety of life and property in the coastal zone, which clearly falls within the scope of NOAA's mission.

JISAO maintains a modest ongoing research and development effort in Information Technology, which supports all four of its research themes, and serves the broader NOAA community and the geosciences community at large.

The research carried out in JISAO is divided into three tasks:

- **Task I,** the Institute's "core program", to which the University contributes, supports, on average, two postdoctoral fellows on annual appointments, which are renewable for a second year, and also senior visitors on leave from their home institutions. JISAO provides space, computer time, administrative support, and other services for these individuals. It also provides travel expenses and honoraria for short-term visitors, as documented in Appendix 2. In addition, Task I provides a percentage of the salaries for the JISAO administrator and one budget analyst, who manage and support the institute's business and financial operations.

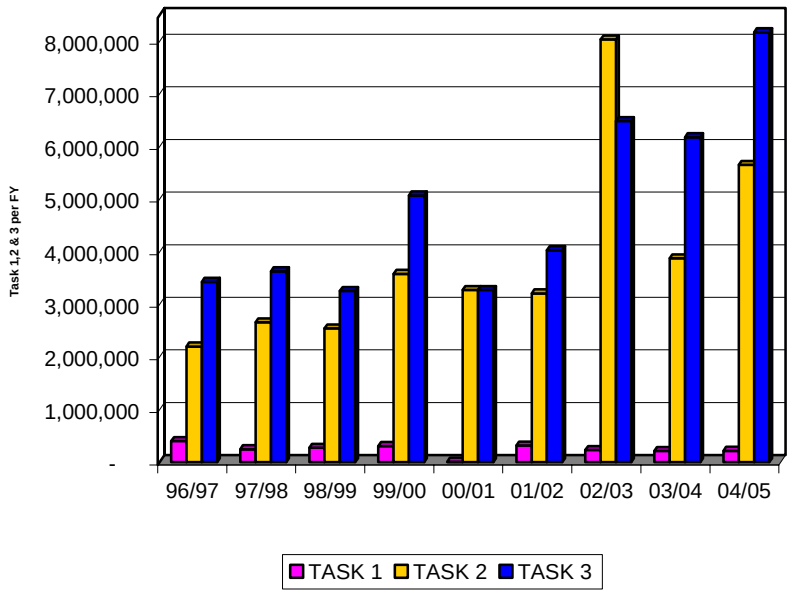
- **Task II** serves as a vehicle for funding research scientists (UW professional staff), post-doctoral research associates and graduate students through the JISAO Cooperative Agreement grant. The Task II program supports directed, collaborative research efforts between NOAA and university scientists.

- **Task III** supports University of Washington research in areas compatible with the Institute's major research themes. Along with Task II, Task III programs serve as vehicles for funding research scientists (UW professional staff), postdoctoral research associates and graduate students through the JISAO Cooperative Agreement grant.

Executive Summary

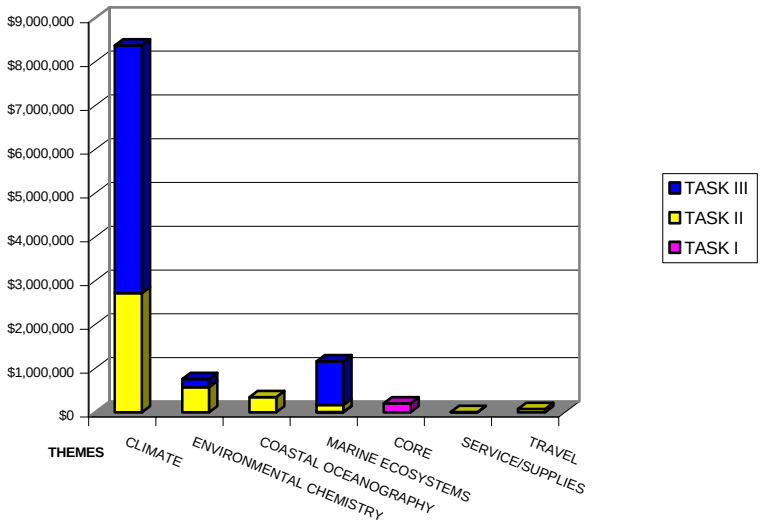
A history of NOAA funding for JISAO since 1996 is shown in Figure 1. The total for all Tasks in 2003-04 amounted to $10,257,168.

Fig. 1 JISAO Task 1, 2 & 3
Funding History 1996-2005



A breakdown of funding for 2003-04 by Task and Theme is shown in Figure 2:

Fig. 2
JISAO FUNDING BY TASK & THEME 2003/2004



Task I funding supported one postdoc (Andrew Rice) and the 17 short term visitors listed in Appendix 2. Task II funding supported a total of 65 professional staff housed at NOAA/PMEL, whose names and titles are listed in Appendix 3. It also supported four postdocs (Carlos Alvarez-Flores, Lorenzo Ciannelli, Yong Woo Lee, and Franz Mueter.), who are housed at the Alaska Fisheries Science Center. Task III supported four postdocs (Jennifer Boldt, Jesús Jurado-Molina, Carolina Parada-Veliz, and Yungbing Shi. University of Washington grants and principal investigators on NOAA grants funded through Task III are listed in Appendix 4.

Here we highlight some of the more prominent accomplishments of the research supported under the respective themes.

Climate

- deploying and maintaining key components of the Global Ocean Observing System in support of seasonal to interannual climate prediction and the monitoring of longer term natural and human-induced climate change. A total of 105 Argo floats were deployed, 60 of which were placed in remote regions of the southwest Pacific. The Tropical Atmosphere and Ocean (TAO) array of moored buoys in the tropical Pacific and the Pilot Research Moored Array in the Tropical Atlantic (PIRATA) were maintained.

- constructing and field testing the "Seaglider", an autonomous undersea vehicle capable of carrying out over a thousand hydrographic sections to a depth of 1000 meters in a single voyage.

- providing real time data from TAO and related buoy arrays to the scientific community via a state-of-the-art web site. As a measure of the success of this effort, the TAO Project was awarded the Grace Hopper Government Technology Award for innovative application of information technology in December 2003.

- analyzing data from the TAO array and a variety of other tropical atmosphere and ocean datasets, with emphasis on ENSO and other phenomena that contribute to year-to-year and decade-to-decade climate variability, as well as the pronounced week-to-week variability in tropical rainfall that is observed within individual seasons.

- coordinating of a national effort to reduce the uncertainties in estimates of present and future greenhouse warming due to cloud feedbacks, in support of the U.S. Climate Change Science Program.

- characterizing climate change over the Arctic, and placing it in a long term historical context. Elements examined include sea-ice, extent of tundra, sea surface temperatures in the Bering and Beaufort Seas and the exchange of fresh water between the Arctic and North Atlantic Oceans.

- developing an experimental hydrological forecast system suitable for use over the western United States.

- Assessing the impacts of climate variability and human-induced climate change on the availability of water and other resources in the Pacific Northwest.

Environmental Chemistry

- estimating the amount of carbon that has accumulated in the World Ocean from the time of the Industrial Revolution up until 1994 as a result of the burning of fossil fuels and deforestation.

- estimating the rate of dissolution of calcium carbonate in the World Ocean. The estimated rate has proven to be high enough to raise concerns about the future health of coral reefs and other shell forming organisms.

- participating in and synthesizing measurements from recent field campaigns designed to characterize the chemical composition of aerosols over specific regions such as New England.

- making automated measurements of dimethylsulfide (DMS) concentrations in sea water on board the R/V Ronald H. Brown.

- hosting the International Global Atmospheric Chemistry Program Office.

- streamlining field measurements of isotopic hydrogen and developing a method for measuring the concentration and isotopic composition of formaldehyde in the atmosphere, and characterizing the spatial and temporal variability of these species.

Marine Ecosystems

- developing the computer code and infrastructure required to embed simple ecosystem models within physically based, grid-point models that resolve currents, regions of upwelling and downwelling, and the chemical makeup of ocean water with varying degrees of spatial resolutions, along with the software required to visualize the complex time varying spatial fields generated by these models.

- developing a suite of more quantitative indicators for characterizing the status of the North Pacific ecosystem as it responds to climate variability and human intervention.

- evaluating the performance of the various statistical methods used to predict the recruitment of species such as walleye Pollock on the basis of environmental indicators.

- assessing whether climate variations may have contributed to the recent decline of Steller sea lion populations in the Aleutian Islands.

- obtaining and analyzing water samples from two hydrothermally active sites on the sea floor where conditions are quite different from those encountered in the better

documented mid-ocean ridge (divergent plate margin) environment.

- participating in field expeditions in the Marianas Volcanic Arc, which provided the first direct observations of volcanic activity in the deep sea, overlapping hydrothermal and photosynthetic ecosystems, and the venting of liquid carbon dioxide.

- participating in a multi-year field program linking chemical and microbiological processes along the Juan de Fuca ridge.

Coastal Oceanography

- providing measurements in support of Project DART (Deep-ocean Assessment and Reporting of Tsunamis) and the U.S. National Tsunami Hazard Mitigation Program.

- developing community-specific inundation maps to assist states and municipalities in assessing tsunami hazards.

- developing the methodology for providing tsunami forecasts in real time to provide guidance in issuing warnings.

Information Technology

Cutting across JISAO's four themes is a suite of activities that can best be described as Outreach, in the broad sense of the term. Included in this category are websites designed to make

- observations from the TOGA TAO array,
- other frequently used climate datasets,
- data on climate impacts in the Pacific Northwest,
- ocean carbon dioxide data from PMEL/JISAO and elsewhere,
- DMS measurements, and
- Bering Sea ocean data readily accessible to the scientific community.

The JISAO Information Technology group is also developing and refining web-based tools for accessing, managing, graphically representing, visualizing, and interactively exploring today's voluminous multi-dimensional datasets. Outreach also includes the countless personal interactions, like the ongoing dialogue between the Climate Impacts Group and stakeholders in the Pacific Northwest, conversations with the press and the public on the topic of the day, and service on the numerous national and international committees that plan and manage programs that NOAA has an interest in.

JISAO Research Projects

Climate

Global Ocean Observing System

(Tasks II and III, S. Riser and G. Johnson, co-PI's)[1]

This international Argo program, a central component of the Global Ocean Observing System, is designed to deploy 3000 profiling floats in the world ocean (approximately 300 km resolution over the globe) that will collect profiles of temperature and salinity over the upper 1000 m of the world ocean at approximately 10-day intervals. This is the first subsurface global ocean observing system. The United States is committed to providing about half of these floats. For the past 2 years, the US has been providing about 300 floats per year. Responsibility for deploying the floats is split among Scripps Institution of Oceanography, Woods Hole Oceanographic Institution, and University of Washington.

Goal 1: To deploy profiling floats in support of NOAA's contribution to the international ARGO Program.

Accomplishments:

- **Deployments.** A total of 105 floats were deployed in the Indian, Antarctic, and South Pacific Oceans. Until recently, relatively few Argo floats have been deployed in the South Pacific, where few ships or aircraft are available to support deployment operations. To remedy this situation, NOAA channeled funds through JISAO to charter a vessel for several months. Original plans were to use a Russian research vessel for this work. After investigating the availability of vessels, it was decided instead to use a small research vessel based in Wellington, New Zealand, operated by the National Institute of Water and Atmospheric Research of New Zealand. In all, this vessel deployed 60 Argo floats supplied by JISAO and 80 floats supplied by Scripps in the South Pacific region during calendar year 2004. These floats greatly increase the available database for the South Pacific, and their data are already being assimilated into climate models.

Goal 2: To use data from the floats to monitor ocean climate.

Accomplishments:

- **Preliminary analyses** using Argo data are being used to examine the state of the Indian Ocean Dipole and the Pacific Decadal Oscillation in the North Pacific. Long-term (decade to century) scale of variability of salinity in the North Pacific is also under investigation.

[1] PIs and NOAA personnel are listed in plain text. JISAO project personnel are listed in boldface, and graduate students are in bold italics.

Tropical Atmosphere-Ocean Interaction

(Task II: M. McPhaden, D.E. Harrison, **G. Vecchi**, **P. Ahearn, W. Cheng, D. Dougherty, C. Fey, M. McCarty, D. McClurg, S. Noor, T. Sawatzky, Y. Serra, L. Stratton, D. Zhang, D. Zimmerman**, ***X. Zhang*****)**

JISAO research on tropical atmosphere-ocean interaction seeks to improve understanding and prediction of El Niño and the Southern Oscillation (ENSO). The centerpiece of the ENSO observing system is the Tropical Atmosphere Ocean (TAO) mooring array, designed to monitor variability in the tropical upper ocean and at the surface. The TAO array is maintained by NOAA and JISAO scientists at PMEL. In combination with the TRITON array maintained by Japanese scientists in the western Pacific, it is comprised of 70 moorings at 11 different longitudes, spanning the equator from 8°S to 8°N. In addition to monitoring ENSO, data from the array are used for ENSO forecasting and a variety of oceanographic and climate research studies. The array provides long-term, large-scale context for process oriented field studies such as the Eastern Pacific Investigation of Climate (EPIC). It also supports carbon cycle studies in the Pacific, by providing access to ship and buoy platforms and by providing a physical oceanographic and meteorological context in which to interpret chemical measurements.

Complementing the TAO array in the tropical Pacific is the Pilot Research Moored Array in the Tropical Atlantic (PIRATA), maintained by NOAA and JISAO scientists at PMEL in collaboration with institutions in Brazil and France. This array of 10 moorings provides data to advance our understanding and ability to predict intraseasonal-to-decadal variations in the climate of the Atlantic sector. Together, TAO and PIRATA are managed through the TAO Project Office at PMEL.

Goal 1: To ensure high quality and timely access to moored time series data for climate research.

Accomplishments:

- **Providing TAO data to the scientific community via the Internet.** Research carried out at JISAO and elsewhere using data from the TAO/TRITON and PIRATA arrays depends critically on the collection, quality control, archival, and web-based display and dissemination of mooring data sets. At JISAO, considerable effort is devoted to providing easy access to high quality multi-variate time series through the TAO web page (*http://www.pmel.noaa.gov/tao/*). As a measure of success, the TAO Project Office was awarded the Grace Hopper Government Technology Award for Innovative Application of Information Technology in December 2003.

Goal 2: To contribute to our understanding of the ENSO cycle.

Accomplishments:

- **Westerly wind events and ENSO.** The role of large-scale dynamics and of episodic westerly wind forcing in governing the evolution of the 2002-03 El Niño was examined. A fundamental scientific question is whether or not ocean-atmosphere feedbacks in the tropical Pacific lead to a self-sustaining ENSO cycle. In other words, does ENSO represent an intrinsic instability of the coupled ocean-atmosphere system with natural

oscillations between unusually cold and warm conditions? Or is ENSO better thought of as a series of discrete warm events punctuating periods of neutral or unusually cold conditions? In the latter case, ENSO can be characterized as a damped or stable oscillator, in which atmospheric forcing associated with weather variations is required to initiate and sustain individual El Niño events. Weather phenomena are inherently unpredictable more than a few weeks in advance. Thus, they represent a source of noise that limits ENSO predictability. While results from a single case study cannot be definitive, it is clear that episodic westerly wind forcing played a significant role in the timing, amplitude, and termination of the 2002-03 El Niño. This episodic forcing also confounded seasonal forecasting efforts, particularly during the onset phase of the event.

Goal 3: To better understand intraseasonal variability and its links to climate.

Accomplishments:

- **Westerly wind events and the Madden-Julian Oscillation (MJO)**. Westerly wind events (short duration episodes of equatorial westerly wind anomaly) are not synonymous with the westerly phase of the MJO. Although westerly wind events occur preferentially during the convectively active phase of the MJO over the western and central equatorial Pacific, it is shown that the probability of a westerly wind event occurring during the westerly phase of the MJO is statistically indistinguishable from it occurring at other times. It is further shown that there is equatorial Pacific SST warming in the cold tongue following the westerly phase of the MJO only when it was coincident with a westerly wind event.

- **Intraseasonal variability in the Atlantic.** Significant intraseasonal variability in surface atmospheric and oceanic properties with periods of 30-70 days was discovered. This variability is evident in the North Atlantic Oscillation and its Southern Hemisphere counterpart; it may in part be related to the Madden-Julian Oscillation, which originates over the Indian Ocean. Fluctuations at periods of 30-70 days significantly affect tropical surface winds, latent heat fluxes, and sea surface temperatures. Like intraseasonal variability in the tropical Pacific Ocean, it may affect the evolution of longer-term seasonal-to-decadal time scale variability in the Atlantic.

Goal 4: To advance our understanding of decadal variability in the tropical oceans.

Accomplishments:

- **Observational studies.** Dramatic changes in the shallow meridional overturning circulation in the Pacific Ocean over the past half century have been documented and related to variations in the depth of the equatorial thermocline, tropical Pacific SSTs and global scale climate. Changes in dissolved oxygen in the Pacific basin and its relation to changing ocean circulation have also been investigated. A new finding is that the shallow meridional overturning circulation in the Pacific has rebounded to levels not seen since before 1976-77. Decadal trends and variations in water mass anomalies in the tropical and subtropical thermocline in the tropical Atlantic have also been investigated as well as the communication between the subtropical and tropical Atlantic through ocean currents

and its connection with the global thermohaline circulation as it passes through the Tropical Atlantic.

- **Coupled atmosphere-ocean modeling.** A coupled ocean-atmosphere general circulation model comprised of the (NCAR Community Climate Model, Version 3 [CCM3] and the Miami Isopycnal Ocean Model--MICOM), has been developed and used to produce a 500 year simulation of decadal variability in the tropical oceans. Both coupled and uncoupled ocean only model simulations were analyzed to test hypotheses and results inferred from observations. The mechanisms connecting the subtropical subduction zones and the equatorial ocean via the Subtropical Overturning Circulations (STC) and the role of STCs on long-term climate variability in the equatorial Pacific were investigated. Observations have been compared with the CCM3 MICOM model simulation and NCAR coupled model (CCSM) results to assess the model performance in the North Pacific, in particular in terms of sea surface salinity and mixed layer depth biases and resulting implications for climate prediction. Cheng is also the principal analyst in a study analyzing an eddy resolving N. Pacific simulation using the HYCOM model (Hybrid Coordinate Ocean Model) and altimeter data from Topex/Poseidon. This model will be used to study the heat budget in the Kuroshio Extension and its relationship to surface forcing as well as lateral heat transport by the ocean.

Goal 5: To document the diurnal cycle of rainfall and surface salinity on the basis of moored buoy measurements in the tropical oceans.

Accomplishments:

- **Rainfall.** An analysis of the diurnal cycle in tropical rainfall over open ocean regions using moored buoy self-siphoning rain gauge data has been completed. The analysis indicates the tendency for an early morning maximum, followed by a secondary maximum in the afternoon. Superimposed upon this overall pattern, there is significant regional and seasonal variability. These results have been compared with those of previous studies of short-term tropical rainfall variability. Some significant discrepancies with recent satellite studies have been pointed out and discussed. This study also provides a baseline for future studies with the buoy rainfall data.

- **Surface salinity.** An analysis of the effect of the diurnal cycle in fresh water forcing on surface salinity variability and upper-ocean mixing processes is nearing completion. The surface buoyancy flux, corresponding to the heat and fresh water fluxes measured at the buoys, indicates negative (stable) values during the day and positive (unstable) values at night. Thus the overnight cooling of the surface water overwhelms any negative stability related to the early morning maximum in rainfall. The corresponding diurnal cycle in surface salinity at the buoys has a maximum in the early morning and a minimum in the afternoon. It has been found that this variability is primarily a function of wind speed, with a tendency for the largest diurnal amplitudes to occur during low wind conditions when turbulent mixing is a minimum.

Goal 6: To investigate the role of the atmospheric boundary layer and upper-ocean in maintaining east Pacific synoptic scale disturbances.

Accomplishments:

- **Using TAO buoy data, together with a regional model, to study boundary layer processes.** Westward propagating synoptic scale disturbances, commonly named African waves or easterly waves, are the primary source of hurricanes in both the Atlantic and east Pacific. The origin of these disturbances in the eastern Pacific is not well understood. The convection coupled to these waves is known to be important for maintaining the initial efforts that have focused on the role that warm sea surface temperatures and unstable boundary layers in the east Pacific intertropical convergence zone region play in coupling convection to synoptic scale waves.

Goal 7: To better understand the morphology of Indian monsoon rainfall and its relationship to Indian Ocean sea surface temperature.

Accomplishments

- **Relating Indian monsoon rainfall indices to sea surface temperature.** Various indices of rainfall over the Indian subcontinent were related to Indian Ocean sea surface temperature. Regional indices describing rainfall anomalies in the west and central/east regions of India exhibit stronger relationships with Indian Ocean sea surface temperature variability than all India rainfall. The main region of near-equatorial SST variability to which the monsoon rainfall is coupled is south of the equator, where the thermocline and mixed layer are shallowest. The Indian Ocean is quite different from the Pacific Ocean in this respect, because it does not have persistent equatorial upwelling, as is found in the Pacific.

- **Categorizing the subseasonal variability of monsoon rainfall.** Southwest Monsoon rainfall breaks have been shown to be strongly related to subseasonal variability in the Bay of Bengal, involving a local coupled air-sea interaction process. Southwest monsoon break variability has been attributed to the MJO, but the processes involved here appear to be distinct from it.

- **Categorizing subseasonal sea surface temperature variability.** A new mode of summer subseasonal SST variability has been identified in the southern hemisphere, which involves the Indian Ocean. Plausible physical mechanisms have been proposed to account for its existence.

Long-term measurements of oceanic rainfall using underwater sound

Task III: J. Nystuen, PI)

Goal: To demonstrate the feasibility of making rainfall measurements at sea based on acoustics.

Accomplishments:

- Ambient sound measurements were made on NOAA TAO moorings in the Eastern Tropical Pacific Ocean at 8, 10 and 12 N, along 95 W during 1999-2003. The period over which the measurements were taken includes the EPIC field program period in September 2001. These measurements demonstrate the acoustic detection and measurement of rainfall at sea. Comparisons with ancillary rainfall measurements show promising agreement.

Low-Latitude Cloud Feedbacks on Climate Sensitivity

(Task III: C. S. Bretherton, PI, M. Wyant)

Goal 1: To contribute to the coordination of Cloud Process Team (CPT) activities.

Accomplishments:

- **Organizing team meetings.** Coordinated an initial CPT group meeting on 20-21 November 2003 at NCAR, with approximately 35 participants including all the funded CPT investigators and all but two advisory group members. Team members include NOAA/GFDL, NCAR, and NASA Global Modeling and Assimilation office (GMAO). A series of talks and discussions led to the formation of three focus groups on the formulation of subgrid microphysical and radiative processes, boundary layer clouds, and deep tropical convection, specification of column locations for column oriented analyses, and discussion of PI tasks.

- **Setting up a CPT web page (***www.atmos.washington.edu/~breth/CPT-clouds.html*) to provide general information about the CPT project and a password-protected CPT web page for exchange of results and information.

- **Coordinating a model archive** on NCAR's mass store including control and perturbed-climate simulations using recent versions from all three participating modeling centers, with access instructions on the CPT web page.

- **Hiring an NCAR liaison scientist.**

Goal 2: To compare simulations of tropical clouds in different climate models.

Accomplishments:

- **Comparing model simulations of clouds.** A full-time research scientist hired to work with the principal investigator has analyzed how the tropical clouds simulated by the three models respond to climate perturbations using a dynamical binning scheme based on monthly mean 500 mb vertical velocity that naturally distinguishes between deep convective and subsidence regimes of the tropics. The three models have dramatically

different longwave and shortwave cloud forcing changes to tropical warming, and that their responses are significantly dependent on the geographic pattern of warming. The NCAR, GFDL, and NASA/GMAO have substantially different vertical distributions of cloud in different tropical climate regimes. The NCAR model has much more supercooled liquid water and substantial cloud very close to the sea-surface, compared to the GFDL model. ISCCP data suggest reality lies somewhere in between these models. The three models also have different cloud responses to climate change, even though the NCAR and GFDL models have similar climate sensitivities. The GMAO model has a very strong positive cloud feedback on climate warming.

- **Simulating the Walker Circulation**. Work is underway to produce a set of model simulations of an idealized tropical Walker circulation over a mixed layer ocean, run to a radiative-convective steady state with and without doubled CO2.

Goal 4: To improve the simulation of clouds in the NCAR Climate System Model

Accomplishments:

- **Improving the NCAR Climate System Model:** specifically the representation of subgrid cloud microphysical, moist convective and radiation processes. This project is being undertaken in coordination with the Community Climate System Model and the Atmospheric Model Working Group.

Arctic Climate Change

(Task II: J. Overland, PI, **N. Bond, K. Wood, S. Rodionov, M. Wang**)

Goal 1: To place the recent warming of the Arctic in terms of a historical context.

Accomplishments:

- **Resurrecting 19th century observations.** Historical records from explorations and surveys carried out in the 19th century have been examined to describe how sea-ice extent during that era compares with that during recent decades. The data assembled thus far suggest that the retreat of sea-ice since the late 19th century may not be as dramatic as widely believed.

- **Analyzing mid-20th century surface air temperature data.** It has been found that the recent warming of surface air temperature over the Arctic is especially pronounced during spring, and that it was much braoder in spatial extent than the warming that took place during the 1920s and 1930s.

Goal 2: To understand the mechanisms responsible for recent environmental change in the Arctic.

Accomplishments:

- **Retreat of tundra**. Analysis of NDVI data has revealed a pronounced retreat of Arctic tundra, particularly over regions of Alaska and Canada. A strong correspondence has been demonstrated between the regions in which the tundra has retreated and regions in which midsummer surface air temperatures have climbed above 10° C.

- **Warming of the Bering and Beaufort Seas.** An analysis of sea surface temperatures over the Bering and Beaufort Seas shows substantial warming during the past decade. Analysis of the ocean heat budget indicates that this warming is due primarily to the advection of warmer water from lower latitudes rather than to changes in the local radiative balance, as would be the case if it were simply a manifestation of greenhouse warming.

- **Gulf of Alaska.** A comprehensive review of the meteorology and oceanography of the northern Gulf of Alaska was published. *[113]*[2] An analysis of atmospheric and oceanic conditions over the last decade has revealed that a major change that occurred around 1998 differs in character from the other major changes of the last 50 years.

Monitoring the Eurasian Basin of the Arctic Ocean

(Task III: I. Rigor PI**,** J.M. Wallace)

Goal 1: To deploy drifting buoys (2 per year) in the Eurasian Basin of the Arctic Ocean which monitors surface meteorological, sea ice, and ocean conditions which affect the mass balance of sea ice.

Accomplishments

- **Deployments.** Five buoys have been deployed since September 2003, and 3 more have been purchased and are ready for deployment.

Goal 2: To explain the large extent of open water in the Arctic off the coast of Alaska during recent summers.

Accomplishments:

- **Ice model.** A simple model was constructed that uses the observed drift of sea ice (buoys) to estimate the age of sea ice drifting on the Arctic Ocean. Experiments with this model indicate that the decline in Arctic sea ice extent during recent summers may be interpreted as a delayed response to changing surface wind patterns over the Arctic over the past 15 years. This model shows that most of the older, thicker sea ice was flushed out of the Arctic Ocean and into the North Atlantic Ocean, following the "regime shift" in the Arctic Oscillation in 1989, leaving the Arctic with younger, thinner ice that is more prone to melt away during summer. In recent summers, thin ice, formed along the Eurasian coast the previous autumn, has been drifting into the coastal region north of Alaska and melting. The age (thickness) of sea ice explains over 50% of the year-to-year variability in summer sea ice extent in the Arctic.

[2] Bracketed number refers to a publication associated with the project that are listed at the end of this report.

Model Output Analysis for Designing a Long Term Observing System for Ice Thickness

(Task III: R. Lindsay, PI)

Goal: To use model-based simulations of the sea ice thickness to help guide the selection of the optimal locations in which to deploy moorings with upward looking sonars that measure ice thickness.

Accomplishments:

- **Choosing representative locations.** Locations have been identified that are well correlated with the basin-wide mean ice thickness. Simulations, based on 56 years of retrospective analysis, indicate that the North Pole is a suitable site for the first measurement system and, given the existence of measurements at the North Pole, a second site in the Chukchi Sea would do most to improve the basin-wide mean ice thickness estimates.

- **Representing the dominant patterns of variability.** The model was used to determine the locations that best identify the major modes of spatial variability of the annual mean thickness. This was accomplished with empirical orthogonal functions and additional locations were determined that would best complement the two existing measurement sites at the North Pole and in the Chukchi Sea.

- **Implementing the sampling strategy.** The North Pole site was established by the UW/APL Polar Science Center through NSF funding and the Chukchi Sea site was established by NOAA.

Correction of Systematic Errors in TOVS Radiances over the Arctic

(Task III: Jennifer Francis, Rutgers, PI; Axel Schweiger, UW; Tony Reale, NOAA-NESDIS).

Goal: To identify, quantify, and mitigate errors caused by changes to satellite orbits, instruments, and/or calibration method and ultimately to produce a record of TOVS radiances and retrieved products from 1979 onward that minimizes known errors.

Accomplishments:

- Compiled a large collection of radiosondes previously not available through the GTS system with a significant Arctic coverage.
- Compiled a global TOVS Level-1b data sets for HIRS and MSU.
- Assembled a suite of radiative transfer models for intercomparison to identify RT model biases.
- Investigated TOVS retrieved cloud trends over the Arctic seas and compared with other satellite retrievals and surface observations.

Fresh-Water Dynamics Connecting The Arctic and Atlantic

(Task III: P. Rhines, PI)

Goal: To assess the interaction between Arctic and Atlantic regions, using observations and laboratory simulations.

Accomplishments:

- Analyzed oceanic transport of volume, heat and fresh-water through Davis Strait, west of Greenland.
- Analyzed current meter mooring observations on the Labrador Slope
- Analyzed the subpolar Atlantic circulation using Topex/Poseidon satellite altimetry, together with our mooring observations of circulation, and ship-based hydrography.
- Analyzed observations and laboratory simulations of the polar atmospheric circulation, under the influence of mountainous continents.

Ocean Climate Observations West of Greenland.

(Task III: P. Rhines, PI)

Goal 1: To support the deployment of an acoustic-Doppler current profiler in Barrow Strait, as part of the International Arctic-Subarctic Ocean Flux (ASOF) monitoring of Arctic outflows.

Accomplishment:

- The deployments were carried out as planned in summer of 2003.

Goal 2 : To support field work in the Labrador Sea, making use of "Seagliders".

Accomplishments:

- **Two Seagliders were successfully launched** 100km offshore of Nuuk, Greenland, in October 2003. These autonomous undersea vehicles carried out hydrographic sections totaling about 4000 km in length, making 1550 hydrographic vertical profiles from surface to 1000m depth, during 4 months of winter. It was a dramatic success, the first such deep ocean deployment of this new instrument vehicle. The Seagliders were built using funds from NOAA and from support from the Office of Naval Research, who have subsequently ended their funding of the project after seeing it through many years of development. A poster describing the Seaglider expedition can be viewed at *http://www.ocean.washington.edu/research/gfd/Seaglider-poster-iva.pdf*

Center for Science in the Earth System

(Task III: E. Sarachik PI, D. Battisti, J.M. Wallace, I. Kamenkovich, R Morss, **T.P. Mitchell, *W. Roberts, K. Takahashi, J. Booth***)

Goal 1: To investigate the role of the Southern Ocean in climate variability and change.

Accomplishments:

- **Evaluating the role of surface wind stress in ocean variability.** A study has been completed of the role of the day-to-day variability of the wind stress at the air-sea interface the Southern Ocean. It was found that daily fluctuations in the surface wind stress reduce summer-time stratification in the upper ocean and deepen the mixed layer. Daily variability in the air temperature and humidity plays a secondary role. Daily fluctuations in the surface wind also explain a major part of high-frequency variability in the ocean temperature in the uppermost 50 meters.

- **Investigating the dynamics of water masses in the Southern Ocean.** The role of the Antarctic Intermediate Water in affecting the stratification in the tropical Pacific is currently being investigated, and a plan is being developed to study the interaction of the Antarctic Bottom Water with rough topography in the Atlantic and Pacific.

Goal 2: To determine the degree to which it is essential to resolve mesoscale eddies in the ocean models used in climatic research.

Accomplishments:

- The effects of **mesoscale eddies** on climate variability and their role in distributing heat, salt and chemical tracers are being investigated. Preliminary results show several important differences between mean circulations in eddy-resolving and non-eddy-resolving numerical simulations.

Goal 3: To advance the state of the art of statistical prediction of ENSO.

Accomplishments

- Using **linear inverse modeling** techniques, a model with comparable skill to current operational dynamical ENSO models was developed. By decomposing this model into its Principal Oscillation Patterns it was found that the decay time of the linear ENSO mode is longer than previously believed, although highly dependent upon the dataset used. Most of the skill in predicting the state of ENSO lay in the evolution of this one mode.

Goal 4: To improve the understanding of the annual cycle of the sea surface temperature in the southeast tropical Pacific.

Accomplishments

- Estimating the advective terms in the heat content budget in the Peru Current region.
- Estimating the net surface heat fluxes as residual from the budget calculations and comparing them with the COADS climatology from Southhampton Oceanographic Center, which proved to be favorable.
- Performing harmonic analysis of the budget terms and diagnosis of their relative importance in producing the annual cycle in heat content.

Goal 5: To reassess whether El Niño events are becoming more frequent and more intense, as reported in the Third Assessment Report of the IPCC.

Accomplishments

- The apparent shift of tropical climate toward the warm phase of the ENSO cycle as reported in the Third Annual Assessment Report of the IPCC is less prominent when data for the past decade are taken into account. The findings cited by the IPCC were largely based on the Darwin sea-level pressure record. The observed trends in the Arctic and Antarctic Oscillations towards their high index polarities have contributed to the rise in sea-level pressure at Darwin over the past 50-years. When these contributions are taken into account, the evidence of a "regime shift" toward the warm polarity of the ENSO cycle is less compelling.

Goal 6: To explore the relative priorities of various kinds of observations with respect to the prediction of ENSO.

Accomplishments:

- Observing system simulation experiments were conducted using a linear, stochastically forced ENSO model. Forecast simulations were carried out for a number of observing network configurations, and forecast skill was compared based on averages over 1000 years of
  simulated ENSO events. It was found that subsurface ocean observations are relatively unimportant for ENSO prediction when good information about sea surface temperature (SST) is available; adding subsurface observations primarily improves forecasts initialized in late summer. For forecasts longer than a few months, the most important region for observations is the eastern equatorial Pacific, south of the equator; a secondary region of importance is the western equatorial Pacific. The results demonstrate that several decades of data are sufficient for comparing the relative effectiveness of different observing networks in the context of ENSO prediction.

Goal 7: To make widely used datasets more readily available to the research community.

Accomplishments

- **Improving the data archive.** JISAO's web-based data archive is being incorporated into the CSES web-based data archive. Some of the less widely used time series that were formerly offered will no longer be available, while Pacific Northwest glacier time series and extensive hydrological datasets are being added. Live Access Server software that will enable users to make simple pictures and subset gridded data sets on the WWW is being added. The archive is being restructured in such a way as to enable remote local and remote users to ingest JISAO datasets within MATLAB, GrADS, and Ferret software, and through the NOAA Climate Diagnostics Center's compositing web page.

- **Expanding utility of NCEP-NCAR Reanalyses.** Five-day mean and covariance quantities have been computed from the NCEP-NCAR daily reanalyses, suitable for use in investigations of intraseasonal climate variability.

- **Incorporating new datasets.** Gridded fields of marine chlorophyll and aerosols based on satellite remote sensing have been added to the archive.

An Experimental Hydrologic Forecasting System

(Task III: D. Lettenmaier PI, E. Wood)

Goal 1: To expand NOAA's hydrological prediction capability.

Accomplishments:

- **Expanding the domain.** The real-time monthly to seasonal hydrologic forecasting system that was implemented as a pilot project during winter 2002-03 for the Pacific Northwest has been expanded to the western U.S. domain. Additional streamflow forecast locations in California were activated, and additional locations in the Colorado and upper Rio Grande River basins and the Great Basin are under development. Forecasts extending six months to a year are produced monthly, using both Extended Streamflow Prediction and climate model-based approaches.

- **Augmenting the data set.** The real-time index station dataset used to drive the spin-up simulation of initial conditions was expanded first from 21 to 102 stations, and then to 280 stations; and the snow water equivalent (SWE) observation station network used to adjust the initial forecast state (a one-time assimilation each forecast cycle) was extended to include a greater number of stations in Canada (which are important for Columbia River Basin forecasts).

- **Upgrading the model.** The system was upgraded to run a newer version of the VIC hydrologic model, which required recreating a suite of ancillary datasets used for interpreting the forecasts.

- **Expanding the suite of products.** Forecast and nowcast products were expanded to include spatial plots of temperature, precipitation, runoff, soil moisture and SWE values, anomalies and percentiles.

- **Incorporating ensemble forecasts.** NSIPP-1 ensemble forecasts were added to the climate model-based forecasting approach, which previously included the ensembles from NCEP Global Spectral Model (GSM). A retrospective analysis comparing the skill of GSM and ESP-based forecasts is now in review for publication in the *Journal of Geophysical Research*.

- **Upgrading the distribution system.** The web site for distribution of forecasts has evolved to reflect the additional components. It can be viewed at *http://www.hydro.washington.edu/Lettenmaier/Projects/fcst/*

Climate Assessments for the Pacific Northwest

(Task III: E. Miles, PI; D. Fluharty, R. Francis, D. Lettenmaier, R. Palmer, D. Peterson, A. Hamlet, R. Leung, **N. Mantua**, **P. Mote**, R. Norheim, D. Reading, **E. Salathé**, R. Slaughter, **A. Snover**, L. **Whitely-Binder**, ***V. Agostini, M. Andersen, A. Ball, J. Littell, S. Morlock, B. Trask, N. Van Rheenan***)

Goal 1: To extend the past record of climate variability over the Pacific Northwest, using proxy data.

Accomplishments

- **Identifying controls.** Work was completed on the identification of atmospheric, climatic and ecological controls on extreme wildfire years in the northwestern United States, as discussed in [43].
- **Developing runoff reconstruction**. A paleo-reconstruction for Columbia Basin runoff and drought since 1750 was developed and presented in [44].
- **Investigating clam growth rings**. It has been demonstrated that growth rings in long-lived geoducks clams can provide a new and very promising tool for paleoclimate reconstructions for coastal ocean temperatures in the extratropical North Pacific. Individual geoducks clams can live at least 150 years. An abundant supply of preserved clamshells and cross-dating techniques can be used to extend growth series for at least several centuries into the past, and geoducks clams are distributed in coastal waters from San Francisco, CA, north to Alaska, and southwestward to Japan. The details of the analysis are reported in [115].

Goal 2: To assess the sensitivity of Pacific Northwest resources to greenhouse warming.

Accomplishments

- **Estimating regional climate sensitivity.** The impacts of year-to-year and decade-to-decade climatic variations on some of the Pacific Northwest's key resources are used as a basis for estimating the sensitivity of regional climate changes that are to occur in association with expected human-induced global warming. These sensitivities are then linked to scenarios of future climate produced by IPCC model simulations to yield climate change impacts scenarios for the Pacific Northwest. Details are reported in [96].

Goal 3: To make weather and climate forecast information more readily available to resource managers in the Pacific Northwest.

Accomplishments

- **Developing a website.** A website has been developed that allows users to extend NOAA/NCEP 7-14 day lead time ensemble forecasts for the indices of prominent circulation patterns into experimental (7-14 day lead time) extreme weather event risk assessment forecasts. The forecasts are based on observed relationships between the probability of certain extreme weather events in the US and variations in the Pacific North American (PNA) and Northern Annual Mode (NAM) patterns. The url for the

JISAO/CIG experimental risk-assessment page is:
http://www.cses.washington.edu/cig/fpt/extreme.shtml

- **Examining river runoff**. The variability and potential predictability in North American river runoff was assessed and results are reported in [84].

Capacity Building in Coastal Communities in Southern Africa

(Vlad Kaczynski, PI**)**

Goal: To help coastal communities in the Republic of South Africa, Namibia and Mozambique to adapt to changing climate and marine environmental conditions.

Accomplishments:

- Designed and organized the **Regional Capacity Building and Coastal Adaptation Seminar** at the University of Port Elizabeth, Republic of South Africa in July 2004. This 6-working day seminar and round table discussion contributed to a greater capacity in adaptation processes of coastal communities of South Africa, Namibia and Mozambique to the ocean and coastal life conditions and to the use of natural resources that are potentially available but threatened by unsustainable exploitation. Over 40 foreign and Southern African specialists delivered presentations on marine environmental and sea/coastal resource management, coastal development planning, policy aspects, enabling environment for improved social and economic responses to the ocean climate change, roles of non-governmental organizations, and opportunities for business including small and micro enterprises for the coastal poor. The Seminar attracted over 140 participants.

- Designed and organized the **Public Education Expo**: "Marine Resources in Service of Coastal Communities", University of Port Elizabeth, July 2004. This event was organized at the same time as the Regional Capacity Building Seminar and was based on the mobile exhibition package delivered and organized by NOAA - Office of Global Programs. The Expo explained key ocean climate, physical, chemical, and biological changes in the marine and coastal environments and delivered timely warning of the impacts of natural phenomena like El Niño Southern Oscillation and other climatic changes (including those caused by humans) might have on the well being of coastal populations and their economies. There were over 2,000 visitors who received verbal presentations, guidance, brochures and other written materials.

Environmental Chemistry

The Carbon Cycle

(Task II: R. Feely, C. Sabine, **C. Cosca, F. Menzia**) (Carbon Cycle References: 30, 31, 34, 35, 36, 104, 107, 108, 109, 110, 117)

The PMEL/JISAO Global Carbon Cycle Program (GCCP) conducts research on the sources and sinks of carbon dioxide in the oceans. Atmospheric and oceanic carbon dioxide data are collected on cruises onboard NOAA vessels and from the TAO moorings. Modeling studies employing

these data enhance our understanding of the ocean's role in the global carbon cycle and the important feedback mechanisms that will affect future climate changes. The following summarizes several of the GCCP's successes, including promising developments in new research.

Goal 1: To contribute to our scientific understanding of carbon sources and sinks in the oceans.

Accomplishments:

- **Determining anthropogenic CO_2 in the world oceans.** The GCCP provided an estimate of the amount of anthropogenic CO_2 in the World Oceans based on observations from the WOCE/JGOFS/OACES Global CO_2 survey. The integrated amount of anthropogenic CO_2 that has accumulated in the oceans between 1800 and 1994 is estimated to be 118 ± 19 Pg C, which is approximately 48 % of the total amount of fossil fuel and cement manufacturing CO_2 emissions during this period. These results suggest that the terrestrial biosphere was a net CO_2 source to the atmosphere of 39 ± 28 Pg C over this timeframe. The highest inventories are associated with the Subtropical Convergence zones. Low inventories are observed in the equatorial and high latitude Southern Ocean regions. [34]

- **Estimating the carbonate dissolution in the world oceans.** The GCCP used total alkalinity together with ^{14}C and CFC data to estimate $CaCO_3$ dissolution rates in the World Oceans. These rates are important for predicting how fast the oceans can neutralize the anthropogenic CO_2. The integrated rate of dissolution for the global ocean is approximately 0.5 Pg C yr^{-1}. The penetration of anthropogenic CO_2 into the ocean interior has caused an upward migration of the calcite and aragonite saturation horizons by about 40 - 200 m over large regions of the Pacific and Indian Oceans. Over time, these changes in the aragonite saturation state will have profound impacts on the health of our coral reefs and other $CaCO_3$ shell-forming organisms. [109]

- **Determining the effects of the Pacific Decadal Oscillation on seawater pCO_2 in the equatorial Pacific.** The equatorial Pacific Ocean is one of the most important yet highly variable oceanic source areas for atmospheric carbon dioxide (CO_2). We used the partial pressure of CO_2 (PCO_2), measured in surface waters from 1979 through early 2001, to examine the effect of the Pacific Decadal Oscillation phase shift, which occurred around 1988 to 1992, on the equatorial Pacific CO_2 chemistry. In the decade before the shift, the surface water PCO_2 (corrected for temperature changes and atmospheric CO_2 uptake) in the central and western equatorial Pacific decreased at a mean rate of about 2 µatm per year. After the shift, surface water PCO_2 increased at about 1.5 µatm per year. These changes altered the CO_2 fluxes of the equatorial Pacific significantly. [117]

Goal 2: To foster the use of chemical and hydrographic data information for modeling efforts

Accomplishments:

- **Distributing ocean carbon data to the oceanographic community.** The GCCP group has developed a WWW-based access for hydrographic and carbon data. This resource has been used by the modeling community to verify their carbon system biogeochemical process models for the oceans. The WWW site is supported by a live access server that provides both data access and graphical outputs. All the data and graphics can be found at the following WWW site: *http://www.pmel.noaa.gov/co2/co2-home.html*

- **Integrating historical PMEL carbon data with other data sets.** The GCCP group has formed a partnership with CDIAC to provide data products from the Repeat Hydrography CO_2/Tracer Program and the WOCE/JGOFS/OACES Global CO_2 Survey**.** These products can be found at: *http://cdiac.ornl.gov/oceans/glodap/Glodap_home.htm*

Goal 3: To contribute to graduate education at the University of Washington.

Accomplishment:

- **Hosting North Pacific Climate Variability Workshop.** The GCCP Group hosted a workshop on the variability of the North Pacific carbon system in June. The focus of the workshop was on an overall picture of North Pacific variability that draws together all of these individual lines of evidence and looks for coherent patterns that may help us understand the regional significance of this variability and the possible mechanisms controlling the observed spatial and temporal patterns. The workshop was designed to bring together relevant data sets for re-analysis with a view toward the larger picture. This data synthesis will be further enhanced by a simultaneous examination of North Pacific variability in a variety of climate model runs. The workshop was a component of the University of Washington Program on Climate Change so that both students and faculty members directly contributed to and benefited from the workshop.

Chlorofluorocarbon Tracer Program

(Task II: J. Bullister, **R. Sonnerup, F. Menzia)**

Goal 1: To monitor the uptake of anthropogenic chlorofluorocarbons (CFCs) into the ocean on decadal timescales and to use this information to estimate the rates and pathways of ocean ventilation processes.

Accomplishments:

- Participated in several CLIVAR Repeat Hydrographic/CO_2/Tracer expeditions in the Atlantic and Pacific oceans, repeating sections occupied a decade earlier. The goal of this program is a systematic and global re-occupation of select hydrographic sections to quantify changes in storage and transport of heat, fresh water, CO_2, CFCs and related parameters. Changes in observed CFC fields are being used to estimate water mass formation rates and to evaluate the importance of physical vs. biological processes in observed subsurface dissolved oxygen changes.

- Developed analytical methods for ultra-trace level measurements of sulfur hexafluoride in seawater. This anthropogenic compound is rapidly increasing in the atmosphere and

has the potential to provide valuable information on the rate of uptake of gases in the ocean and for estimating water mass ventilation rates.

Goal 2: To use observed CFC tracer fields to help evaluate global ocean model simulations and to estimate the oceanic uptake of other tracer gases, including carbon dioxide.

Accomplishments:

- Completed estimate of the global uptake of CFCs in the ocean through the 1990's. This inventory will be of value for testing global models of oceanic uptake of trace gases.

- Worked with carbon investigators to utilize CFCs to estimate the global oceanic uptake of anthropogenic carbon dioxide.

Carbon Isotope Constraints on Ocean GCM Simulations of Anthropogenic CO_2 uptake

(Task III: P. Quay, PI, **R. Sonnerup**)

Goal: To use observed data on the isotope ^{13}C as a basis for optimizing the mixing scheme in the GFDL Modular Ocean Model.

Accomplishments:

- A $^{13}CO_2$ gas exchange and biological cycling module for the GFDL Modular Ocean Model was implemented and used to simulate the steady state pre-industrial concentration of $DI^{13}C$, using several representations of mixing in the model.

- The same variants of the model were used to estimate the oceanic response to the observed anthropogenic CO_2 and $^{13}CO_2$ perturbations.

- CO_2 and $^{13}CO_2$ changes in the Indian Ocean derived from the different variants of the model were compared with the observed changes. The variant of the model that compares most favorably with the observations arguably possesses the most realistic representation of the mixing.

Aerosols and Trace Gases

(Task II: Bates P. Quinn, D. Covert, **D. Coffman, *S.* Doherty, D. Hamilton, J. Johnson, T. Miller, K. Schulz)**

The PMEL/JISAO Atmospheric Chemistry - Aerosol Program is designed to quantify the spatial and temporal distribution of natural and anthropogenic atmospheric aerosol particles and to determine the physical, meteorological and biogeochemical processes controlling their formation, evolution and properties. Recent efforts are grouped under three goals:

Goal 1 – To assess the regional climate and air quality impacts of atmospheric aerosol particles through measurements of their chemical and radiative properties

Accomplishments:

- **Carrying out field measurements.** Aerosols directly affect climate and air quality through the scattering and absorption of incoming solar radiation. Measurements of aerosol properties during integrated field campaigns provided data for the validation of regional models that are used to estimate aerosol direct radiative forcing and the validation of algorithms used to retrieve aerosol optical depth from satellite observations. In addition, the measurement of regional aerosol plumes allowed for the linking of aerosol sources to climate and air quality impacts. The overall payoff is a reduction in the uncertainty associated with estimates of aerosol direct radiative forcing (climate) and aerosol haze plumes (air quality).

- **Synthesizing measurements from different field campaigns.** Means and variability of aerosol chemical composition and optical properties were compared during the past year [106] for the first and second Aerosol Characterization Experiments (ACE 1 and ACE 2), a cruise across the Atlantic (Aerosols99), the Indian Ocean Experiment (INDOEX), the Asian Aerosol Characterization Experiment (ACE Asia), the Tropospheric Aerosol Radiative Forcing Observational Experiment (TARFOX), and the New England Air Quality Study (NEAQS). The data have allowed us to draw several conclusions about the chemical and optical properties of aerosols in the marine boundary layer as well as to identify some of the gaps in our understanding.

- **Analyzing measurements over New England.** A more thorough analysis of the data from NEAQS 2002 revealed that on average, 75 ± 8% of the dry aerosol mass sampled 18 m above the sea surface was in the < 1 μm fraction (size cut at 55% relative humidity). The major sub-micron aerosol components were ammonium sulfate and particulate organic matter comprising more that 89% of the total mass. Under northwesterly flow, Particulate Organic Matter was the dominant component (67%) followed by $(NH_4)_xH_ySO_4$ (23%), dust (7%), and EC (3%). Under southwesterly, $(NH_4)_xH_ySO_4$ was the dominant component (55%) followed by particulate organic matter (40%), dust (3%) and EC (2%). Multiple linear regressions of submicron non-refractory (NR) particulate organic matter and NR $(NH_4)_xH_ySO_4$ versus submicron light scattering (σsp) at 500nm wavelength suggest that particulate organic matter was the dominant chemical component contributing to aerosol light scattering (haze) during NEAQS 2002, contributing 69% and 58% to σsp (measured at 55% relative humidity) in the northwesterly and southwesterly trajectories, respectively. These data are similar to that found off the mid-Atlantic states during TARFOX but contrary to the current understanding that the New England haze is primarily a result of sulfate aerosol.

Goal 2: To quantify the oceanic source of atmospheric sulfur, dimethylsulfide.

Dimethylsulfide (DMS) is biologically produced in the surface ocean and is the major natural source of sulfur to the atmosphere. In the atmosphere, DMS is transformed into sulfate aerosol particles which scatter solar radiation back to space and alter the properties and lifetimes of clouds. The concentration of DMS in surface seawater and thus its flux to the atmosphere vary

spatially and temporally as a result of the physical, biological and chemical properties of seawater.

Accomplishments:

- **Establishing a database.** PMEL-JISAO scientists are developing and maintaining a web-based interactive database containing over 30,000 measurements of surface seawater DMS concentrations that have been collected since the early 1980s. The database (*http://saga.pmel.noaa.gov/dms/*) now contains over 30,000 seawater DMS measurements.

- **Collecting additional data.** Additional measurements of surface seawater DMS concentrations are needed to assess the temporal and spatial variability, particularly in higher latitudes. The automated PMEL underway-DMS system operated onboard the NOAA R/V Ronald H. Brown data can be viewed in near real-time at *http://saga.pmel.noaa.gov/underwaydms/*. Users can plot the DMS and auxiliary data collected during various time periods in 2002 and 2003.

Goal 3: To improve our capability to observe, understand, predict, and protect air quality through national and international partnerships.

Accomplishment:

- **Hosting IGAC**. PMEL/JISAO hosts the International Global Atmospheric Chemistry (IGAC) Core Project Office with funding from NOAA, NSF and NASA. The goal of IGAC is to promote and facilitate international atmospheric chemistry research that will lead to a better understanding of the Earth System. Dr. Sarah Doherty, JISAO Research Scientist, is the Executive Officer of the Seattle Project Office (*http://www.igac.noaa.gov/*). Dr. Tim Bates, PMEL Research Chemist, is a co-chair of the IGAC Scientific Steering Committee. During the past year IGAC has organized 3 international specialty workshops and has initiated 4 new international Research projects.

Atmospheric chemistry and biogeochemistry of methane, and molecular hydrogen

(Task I: **A. Rice**)

Goal 1: To evaluate the seasonal cycle of the concentration and isotopic composition of atmospheric methane To use isotopic constraints to interpret temporal seasonal variations in sources and sinks.

Accomplishments

- **Analyzing measurements.** Measurements of CH_4 concentration and carbon isotopic composition ($\delta^{13}C$) have been ongoing at Niwot Ridge, CO since 1994 and at Montana de Oro, CA since 1996. Measurements of the hydrogen isotopic composition (δD) at these sites were begun in 1998 and 2000 respectively. These long-term datasets were detrended for annual changes in the growth rate, $\delta^{13}C$, and δD over the period and mean values

were subtracted. Residuals were fit with Fourier series to provide a model of the annual average seasonal cycle.

Goal 2: To use isotopic constraints to interpret temporal seasonal variations in sources and sinks.

Accomplishments:

- Applying a simple model. A "sink only", OH-driven CH_4 seasonal cycle was evaluated with the use of a simple "0-dimensional" time dependent model based on chemical kinetics, kinetic isotope effects, and variations in OH fields output from the OSLO 3D CTM. Model output was compared with fits to measured data. Results indicate a strong bias in the seasonal cycle of CH_4, $\delta^{13}C$, and δD, from seasonal sources in the northern hemisphere. Results indicate the presence of a large CH_4 source in early fall providing a peak in CH_4 concentration at that time coincident with unusually depleted $\delta^{13}C$ and δD isotope ratios. The observations suggest the existence of a strong seasonal northern hemispheric biogenic CH_4 source during the early fall, perhaps as a result of rice agriculture or from a "drying-out" of the high-latitude wetlands. The isotopic data also suggests that it is unlikely that this signal is from either fossil CH_4 or from seasonal biomass burning.

Goal 3: To develop and implement a small volume analytical method for measuring the isotopic composition of atmospheric molecular hydrogen.

Accomplishments

- **Streamlining isotopic hydrogen measurements.** Prior work by Quay and Gerst at the University of Washington provided the first high-precision atmospheric isotopic molecular hydrogen (H_2) dataset. However, the method utilized tremendous sample sizes (>1000L) of ambient air and required lengthy analyses. A new method has been developed to streamline these analyses. The new technique uses low temperatures (40K) to isolate atmospheric H_2 and continuous-flow IRMS techniques to measure δD-H_2 in 500ml samples of ambient air. Analysis time has been significantly reduced to roughly one hour per sample. This recently implemented method provides the isotope laboratory with a method to increase sample throughput and dramatically improve the flexibility of air sample collection.

- **Testing the new method.** A comparison of samples (n=30) analyzed using this new method and the more conventional method shows no systematic bias and a level of precision (±3‰) comparable or better than was previously achieved .

- **Analyzing past measurements from Cheeka Peak**. Measurements of δD-H_2 in nearly two dozen catalogued "clean air" samples collected at Cheeka Peak, WA since early 2002 averaged 120±14‰ relative to VSMOW. Average H_2 concentration in these samples was found to be 523±21ppbv. No significant seasonal cycle in either concentration or isotope ratio was apparent. However, more data will be needed to evaluate whether there is significant seasonality in δD.

- **Analyzing global measurements.** Samples collected on board Coast Guard cruises between Seattle and Antarctica during November-December, 2002 and December-March, 2004 were analyzed for δD-H_2. Results indicate a minimum in δD in the equatorial region near 80‰ (vs. VSMOW) corresponding to a maximum in H_2 concentration of ~600ppbv. δD increases poleward to 150‰ in the high latitude southern hemisphere and to 125‰ in the mid-latitude northern hemisphere, mirroring an observed meridional trend in H_2 concentration.

Goal 3: To develop a method for measuring the concentration and isotopic composition of atmospheric formaldehyde.

Measurements of formaldehyde (HCHO) in the atmosphere are revealing gaps in our understanding of the atmospheric chemistry of HCHO and its sources. Studying the isotopic composition of HCHO can improve our understanding of processes which control its concentration, but to date studies are few and limited to the carbon isotopic composition. HCHO also represents 60% of the H_2 total source, but is the only source to remain isotopically uncharacterized.

Accomplishments

- **Developing a new measurement technique.** An innovative method has been developed that has the potential to measure the concentration and both the carbon and hydrogen isotopic composition of HCHO. The analytical technique couples new gas chromatographic methods with recent advances in continuous-flow isotope ratio mass spectrometry. Levels of precision for measurement of concentration and δD-HCHO are approximately ±15% and ±50‰ respectively. Currently, measurements can be made on sample sizes ranging from 19-70 L of air.

- **Analyzing preliminary measurements in urban air.** Measurements of HCHO concentration and δD in samples collected in Seattle, WA during Spring 2004 show considerable variability in concentration (0.44 to 2.9ppbv) and δD (-230 to 210‰ versus VSMOW). These data likely point to a mixture of HCHO sources in this urban environment. There is a clear inverse relationship between concentration and isotope ratio which likely results from a mixture of two dominant HCHO source categories. The most enriched δD values found at low HCHO concentrations are likely dominated by secondary photochemical sources of HCHO, in particular the oxidation of volatile organic compounds. The most depleted δD values found at high HCHO concentrations are likely dominated by primary (direct) sources of HCHO associated with fossil fuel combustion.

- **Extending measurements to clean air sites.** The current focus of this research is to measure δD-HCHO in air samples collected at "clean air" sites, beginning with Cheeka Peak. In remote settings, sources of HCHO should be secondary in nature and dominated by CH_4 oxidation. The characterization of δD-HCHO will provide us with the last source isotope signature in the global H_2 budget.

Marine Ecosystems

Quantitative Analysis of the North Pacific Marine Ecosystem

(Task II: P. Stabeno, J. Overland**,** S. Hickley**,** B**.** Megrey, **N. Bond**, **A. Hermann**, **Y. Lee**, **C. Mordy**, **F. Mueter**, **C. Parada**,**)**

Goal 1: To improve modeling of the North Pacific marine ecosystem.

Accomplishments

- **Developing nested models.** Development continued on a suite of nested physical and biological models designed to serve GLOBEC, Steller Sea Lion Initiative, FOCI, and other programs. Each of the nested physical models is based on the Regional Ocean Modeling System (ROMS), a primitive equation circulation model with highly efficient mixing and advection schemes. These models have been implemented on a distributed memory, massively parallel computing platform at the Forecast Systems Laboratory of NOAA, with generous assistance from their staff. The implementation of parallel code has made it possible to run the model at much finer resolution, and for much longer time periods than was previously possible. Developments toward a multi-scale nested modeling system in the past year included major upgrades of ROMS-based primitive equation models of: the North Pacific at 40 km resolution (NPAC), the NE Pacific (from Baja California through the Bering Sea) at 10 km resolution (NEP), and the Gulf of Alaska at 2.5 km resolution (GOA-2, in collaboration with researchers at the University of Alaska Fairbanks). NEP model hindcasts of years 1997-2001 have been compared with satellite and moored data from the Gulf of Alaska. Models of California at 2.5 km resolution, and the eastern equatorial Pacific at 10 km resolution, have been developed by colleagues, using the output from NEP and NPAC models as boundary conditions. Improvements to the modeling approach in the past year include refinements of bulk formulae for atmospheric forcing, improved methods for lateral input of buoyancy representing river runoff, and corrections to local bathymetry.

- **Incorporating biological processes.** A lower trophic level (NPZ) model with emphasis on juvenile salmon prey items has been fully implemented in three-dimensional form, and driven with nested circulation model output. Prey fields generated from the NPZ model will be used in bioenergetic-based models of salmon, developed with other researchers within GLOBEC. The NPZ model spans the coastal and deep basin areas, and now explicitly includes iron as a limiting nutrient (to better resolve the different dynamics observed in coastal vs. open ocean regions). Output is being used to analyze nutrient flux pathways in the Coastal Gulf of Alaska.

- **Coupling atmosphere and ocean models.** The continuing MEAD program entails coupling an atmospheric model (WRF) with an ocean model (ROMS) across nodes of the Teragrid. A related program, funded by HPCC, entails coupling these models across platforms within NOAA.

- **Modeling walleve Pollock.** Relationships between physical and biological factors that determine the transport and survival of early stages of Pollock in the Gulf of Alaska (up

to age-0 juveniles) to the nursery area (Shumagin Islands) have been investigated using an individual based model coupled to an hydrodynamic (provides current and salinity field) and an ecological (provides the food field for walleye Pollock) model. The setting, optimization, coupling of the models and running of preliminary experiments were the major aim for this period. The individual base model for Pollock and the ecological model (Nitrogen Phytoplankton Zooplankton model) were implemented in a Dec-compac machine. A series of experiments was performed to test the consistency of the code featuring previous runs such as 1994. Also a preliminary sensitivity analysis testing different parameters and the shape of the functions for grazing and predation of the one-dimensional ecological model was performed. In addition, the individual base model was run for a series of 13 years to assess transport of juveniles in the nursery area in the Gulf of Alaska. A Matlab toolbox for visualization of the outputs of both models was developed. Spatial and temporal data of Pseudocalanus (naupliar and copepodites) in Line 8 and of eggs and larvae of walleye Pollock were gathered for validation purposes.

Goal 2: To develop and use quantitative methods to characterize the status of the North Pacific ecosystem and detecting climate change signals.

Accomplishments:

- **Analyzing trends.** A statistical approach was developed to analyze and detect trends in population-based metrics, such as survey catch per unit effort or average individual weight, across large numbers of species. This approach was applied to groundfish communities in the Bering Sea and Gulf of Alaska. It revealed significant trends in catch per unit effort and frequency of occurrence of both commercial and non-commercial fish and invertebrate species in the Eastern Bering Sea.

- **Analyzing covariability in recruitment and survival among Northeast Pacific groundfish stocks.** Combined indices of recruitment and survival rate were developed across major commercial stocks. The combined indices help detect periods of high and low productivity in the groundfish community and appear to be related to large-scale climate patterns. Work on refining measures of uncertainty for the combined indices and on exploring relationships between the indices and environmental variability that could help predict low- and high-productivity periods is ongoing.

- **Analyzing production dynamics.** Surplus production dynamics of the groundfish complexes in the Eastern Bering Sea and Gulf of Alaska were analyzed. Aggregate estimates of biomass from stock assessments and catch data summed across major commercial stocks were used to compute total annual surplus production as an index of overall productivity. Simple statistical models were fit to the total surplus production – total biomass relationship to obtain estimates of maximum sustainable yield for the groundfish complex as a whole.

Goal 3: To assess the performance of the statistical tools currently used to forecast walleye Pollock.

Accomplishment:

- **Comparing the performance of statistical prediction models.** A number of different statistical tools that are commonly used to analyze stock-recruitment data with environmental indices, were applied to simulated data with known properties and apply the analytical tools to the simulated data. The examined statistical tools include traditional linear regression, non-linear regression, generalized additive models, and artificial neural networks. The results indicated that the higher accuracy of the predictive power of non-parametric methods over parametric methods for future recruitment prediction.

Salmon Recruitment and Survival

(Task III: E. Miles, PI, ***V. Agostini,*** R. Francis**, N. Mantua, P. Mote, E. Salathe, A. Snover, L. Whitely-Binder)**

Goal 1: To improve methodology for predicting salmon recruitment.

Accomplishment:

- **Model development.** A relatively simple empirical model has been developed that links three different measures of coastal ocean habitat (sea surface temperature, the date of the spring transition, and coastal sea level) to observed year-to-year variations in coho salmon marine survival. Each year, salmon management agencies predict the expected number of adult coho salmon there are in the ocean before they develop harvest policies, yet pre-season run-size forecasts are notorious for their large errors. Analysis of the model behavior yields a new conceptual model for understanding how highly unpredictable environmental processes influence the ocean survival of coho salmon, and its real-time output from the model offers a relatively simple bases for salmon management personnel to adjust pre-season run-size forecasts using easy to measure environmental data. The details of this study are reported in [77] and a further discussion of the management implications of this work are presented in [79]. A model has also been developed for linking climate to stream impacts on Oregon coho salmon [72].

Goal 2: To assess the risk of extinction of Pacific salmon.

Accomplishments:

- See [39]

Goal 3: To relate decadal variations in salmon recruitment to regime shifts in the marine ecosystem.

Accomplishment:

- Methods for detecting regime shifts in large marine ecosystems have been reviewed [80], and evidence of the occurrence of past regime shifts has been discussed [29].

Air-Sea Interactions on the Bering Sea Shelf

(Task II: **K. Bahl, N. Bond, N. Kachel, C. Ladd, D. Righi, S. Rodionov, M. Spillane,** B. Megrey, J. Napp, J. Overland, P. Stabeno)

Goal – To determine how variations and trends in climate impact the ocean, and ultimately influence the marine ecosystem.

Accomplishments:

- **Analyzing atmospheric forcing of Bering Sea shelf.** Extreme, episodic weather events have been shown to be crucial to changes in populations of a variety of marine species.

- **Maintaining a Bering Sea web site.** Increasing effort has been devoted to providing real-time information on the physical state of the Bering Sea (and to the extent they are available in a timely manner, chemical and biological properties) for use by scientists and fishery managers.

Exploring for Cold-Adapted Microorganisms

(Task III: J. Deming, PI)

Goal: To bring into culture microbes from Arctic settings (especially deep water and around ice) that have previously undiscovered genes and enzymes.

Accomplishments:

- Obtained several specimens on a cruise to the Chukchi Sea in August 2003 aboard the R/V Chinair and performed phylogenetic analysis on them. This work is being carried out in collaboration with Chinese microbiologist Chen Bo.

Ecosystem Indicators for the North Pacific

(Task III, B. Miller, J. Overland and **S. Rodionov**, co-PI's; P. Livingston, S**.** Bartkiw)

The purpose of this project is to add to the suite of ecosystem indicators being provided to the North Pacific Fishery Management Council in the Ecosystem Considerations section of the stock assessment and fishery evaluation document.

Goal 1: Derive ecosystem level indicators for the eastern Bering Sea: K-dominance curves and size diversity spectrum analysis.

Goal 2: Provide a suite of environmental indicators and analysis tools for the Bering Sea.

Accomplishments:

- **Ecosystem indicators:** A size diversity analysis for Bering Sea fish and invertebrates was developed and k-dominance curves were produced.

- **Results presented:** The diversity analysis was presented in the Ecosystem Considerations Section for 2004, which is provided to the North Pacific Fishery Management Council.

Marine Biological Interactions in the North Pacific – Fish Interactions

(Task III: B. Miller, PI; P. Livingston, J. Boldt, K. Dodd, R. Hibpshman, **J. Jurado-Molina**, I. Ortiz, A. Whitehouse)

This research project focuses on improving ecosystem based fishery management through increased understanding of predator/prey relationships, improved predator/prey models, and development of ecosystem indicators.

Goal 1: To investigate the feeding ecology of North Pacific fishes.

Accomplishment:

- **Feeding ecology of North Pacific fishes.** A total of 15,412 groundfish stomachs were analyzed. Personnel contributed to an update of the stomach content analysis procedures manual. Diet summaries and maps were produced for over 105 species/cruise combinations. A tracking system for tracking sample buckets through the system was fully implemented to better track hazardous chemicals and locate particular specimens.

Goal 2: To collect stomach, plankton or benthic samples in the field.

Accomplishment:

- **Assisted with the collection of stomach, plankton or benthic samples.** Collection of groundfish stomachs during the time period totaled 10,264 stomachs. Four cruise legs were covered by JISAO personnel.

Goal 3: To estimate and test parameters of single-species, multi-species and ecosystem models.

Accomplishment:

- **Parameter estimation of ecosystem models,** Modeling activities focused in the updating of the multispecies virtual population (MSVPA) and the multispecies forecasting model (MSFOR). A new quarterly version of the MSFOR was developed. Activities also focused on the development of the multispecies statistical model. The first version of the MSM is finished.

Goal 4: To develop ecosystem indicators.

Accomplishments:

- **Aleutian Islands ecosystem model.** Finished and balanced the food web model for the Aleutian Islands. Compared results between the three Alaskan ecosystem models: Eastern Bering Sea, Gulf of Alaska and Aleutian Islands. Evaluated fishing effort data in the Aleutian Islands.

- **Ecosystem indicators:** Several sections of an Ecosystem Indicators (EI) report were produced as a result of the annual Ecological Indicators meeting at the Alaska Fishery Science Center in Seattle, September 22-23, 2003.

Fish-Marine Mammal Interactions

(Task III: B. Miller, PI; L. Logerwell, D. Gunderson)

Goal: To develop a tag release-recovery model for Pacific cod. The model will be used to understand local-scale and seasonal movements as well as estimating natural mortality rates.

Accomplishments:

- **Literature review:** Literature review on cod (Pacific and Atlantic) biology and mark-recapture methodology. A cod tagging database has been developed which includes current AFSC tagging data (mostly winter) in eastern Bering Sea, previous AFSC tagging data (mostly spring and summer) in eastern Bering Sea, and ADFG tagging data in the Gulf of Alaska.

- **Field data collected:** Assessed pot performance during tidal cycles as a sampling gear for cod abundance estimation. Tagged and released a batch of Pacific cod prior to the beginning of winter fishing season for Pacific cod.

Spatio-temporal Distribution Patterns of Walleye Pollock

(Task III: J. Horne, PI: J. Burgos)

This research is a component of a multi-disciplinary project initiated to examine the effect of varying prey abundance and distribution on Steller sea lion foraging behavior and bioenergetics

Goal 1: To quantitatively describe walleye pollock spatial and temporal distribution patterns.

Accomplishments:

- **Data processing:** Data from 5 NOAA acoustic surveys have been converted to Echoview format and categorized by fish species.

- **Database creation:** Designed and created database of walleye pollock density distributions and aggregation characteristics by transect.

- **School detection sensitivity analysis:** Completed sensitivity analysis of Echoview school detection variables.

Goal 2: To develop a three-dimensional dynamic simulation of walleye pollock abundance patterns.

Accomplishment:

- **Computer simulations:** Initial formulation of computer simulation model was completed. Walleye pollock distributions were created to provide test data for Steller Sea Lion individual based model.

Fisheries Acoustics Research

(Task III: J. Horne, PI)

This project supports an Associate Research Faculty position at the University of Washington, School of Aquatic and Fishery Sciences (SAFS). Research activities examine acoustic backscatter properties of northwest Pacific fish species. Service activities include participation on Midwater Assessment and Conservation Engineering (MACE) survey cruises, liaison between SAFS and the Alaska Fisheries Science Center, organizing and administering the SAFS-AFSC summer internship program, supervision and mentoring of graduate students, acoustic training of students and government scientists, and participation in academic committees at the School of Aquatic and Fishery Sciences.

Goal 1: To examine acoustic backscatter properties of fish.

Goal 2: To increase collaboration between the Alaska Fisheries Science Center and the UW School of Aquatic and Fishery Sciences.

Accomplishments:

- **Courses taught**: Marine BioAcoustics was taught during summer at Friday Harbor Laboratories. Bioacoustical Oceanography was taught during Fall quarter at UW. A module on Fisheries Acoustics was taught for the Techniques in Fisheries class.

- **Papers published:** A total of 10 papers and one book chapter were published. A second book chapter was submitted.

- **Papers presented:** A total of 5 seminars were presented at national and international meetings.

- **Graduate students/Postdocs supervised:** Five graduate students were directly mentored, three postdocs conducted research in association with the laboratory, and the PI participated in an additional 3 student committees.

- **Internship program:** Four undergraduate students participated in the summer internship program. All students had an at-sea experience.

- **Cruise participation:** Acoustic data was collected on a cruise in Japan and over the mid-Atlantic Ridge during the reporting period.

Trends in Fish Abundance and Productivity

(Task III: D. Gunderson, PI; A. Cooper, Gregg, D.Kimura, D. Anderl)

The overall goal of this project is to improve methodology for studying the response of marine ecosystems to the direct and indirect impacts of fishing activities and fluctuations in climate.

Goal: To determine reproductive potential and natural mortality of thornyheads (two species) and Greenland turbot.

Accomplishments:

- Collected ovarian tissue over the year to document the reproductive biology for these species.

- Time of spawning, size at maturity, effective fecundity, annual reproductive effort, and natural mortality were all determined for these species.

- A new method of staining Greenland turbot otoliths for age determination was developed.

Atka Mackerel Ecology

(Task III: D. Gunderson, PI; A. Cooper, S. McDermott)

The goal of this project was to develop a method of estimating local population sizes with respect to Steller Sea lion trawl exclusion zones. A tagging program for estimating population sizes and movement rates for Atka mackerel was developed in previous years, and we continued to participate in the NMFS tagging cruises for this species.

Goal 1: To participate in NMFS atka mackerel tagging cruises

Accomplishment:

- Participated in NMFS Atka mackerel tagging cruises.

Goal 2: To develop a method for using egg production to estimate population size, with further collection and processing of ovarian samples.

Accomplishment:

- Collected and processed ovarian samples for population size estimate based on egg production.

Biology of Skates

(Task III: D. Gunderson, PI: M. Matta)

Goal: To describe the reproductive biology, size at maturity, and fecundity of deepwater skates (Bathyraja parmifera) and develop a technique for age determination.

Accomplishments:

- Collected reproductive tissues, vertebrae, and other structures.

- Began initial analyses on age determination.

Assessment of Fine-Scaled Interactions Between Steller Sea Lion Abundance and Trends of Local Fisheries

(Task III: J. Skalski)

The overall goal of this study was to assess the fine geographic scale interactions between Steller sea lion abundance trends and the abundance of local fisheries and commercial fishing efforts.

Goal 1: Estimate localized rates of population change for Steller sea lions.

Accomplishments:

- Census counts of Steller sea lions at 54 different trend sites and rookeries over the period 1976 to 2002 were analyzed. These 54 locations were ultimately combined to form 34 different populations with spatially distinct population trends.

Goal 2: Assemble fish stock databases.

Accomplishments:

- Fish databases were assembled.

- The triennial bottom-trawl surveys, 1983-2002, were used to estimate the local abundance of walleye pollock, Pacific cod, Atka mackerel, and arrowtooth flounder within a 40 nmi radius of each haulout or rookery cluster [Alaska Fisheries Science Center's Resource Assessment and Conservation Engineering Division (RACE)] database.

- For the years 1990-2002, fishery effort data were obtained from the North Pacific Groundfish Observer Program (NPGOP) database. Fishing effort within 40 nmi of haulout or rookery clusters were summarized for both longline and trawl fisheries for boats >60 ft. Effort was expressed in terms of boat days.

- Herring abundance was characterized by spawning indices, 1973-2002, obtained from the Alaska Department of Fish and Game. The herring abundance was expressed in terms of spawn mile-days and was considered a reliable index of annual abundance.

Goal 3: Conduct relational statistical analyses.

Accomplishments

- Multiple regression analysis using log-linear models or general estimating equations (GEE) were used to investigate the relationships between the instantaneous rates of population change of Steller sea lions within sites over time and across rookeries and haulout areas with localized fish abundance and fishing effort. Based on this analysis, it appears the longline fishery is more likely to more negatively impact Steller sea lion population trends than the trawl fishery is. The factors investigated in this study have a

relatively small incremental effect on Steller sea lion trends. In most cases, these effects are much smaller than the rates of decline seen in the 1970s and 1980s.

Hydrothermal Vents

(Task II: **D. Butterfield, J. Resing**, K. Roe, G. Lebon)

Mid-ocean ridge hydrothermal systems have been studied intensively since the late 1970s, but there are still many geologic environments on the seafloor that have not been investigated, and recent discoveries remind us that there is still much that we have not seen on the seafloor. At present, the classic mid-ocean ridge (or divergent plate margin) environment is relatively well documented, but volcanic arcs (convergent plate margin) and off-axis environments are not. Hence,

Goal 1: To characterize the chemistry of hydrothermal fluids from volcanic arcs, back arcs, and off-axis sites.

Accomplishments.

- In the past 2 years, fluids from two environments that are very different from the classic mid-ocean ridge have been sampled and analyzed. Under NSF support, in 2003 samples were obtained from the off-axis hot spring site near the Mid-Atlantic Ridge, the Lost City hydrothermal field (Butterfield, Roe). The Hydrothermal Fluid and Particle Sampler was used on the submersible Alvin to recover A large number of samples from a range of vents in this new class of hydrothermal field. Unlike volcanic systems directly on the mid-ocean ridge axis, a large portion of the heat coming from this system may result from exothermic chemical reactions between seawater and mantle rocks (peridotites).

- Another major project, funded by NOAA Office of Ocean Exploration, has sponsored two field expeditions in an area of the ocean that was nearly unknown to science, the undersea portion of the Marianas Volcanic Arc between Guam and Iwo Jima. The first expedition (March 2003) generated high-resolution bathymetric maps and water-column surveys of hydrothermal signals (Resing and Lebon). The second expedition (March/April 2004) used the mapping work to locate, sample, and explore seafloor volcanic and hydrothermal features on six submarine volcanoes (Butterefield, Roe, Lebon) . Some remarkable discoveries were made along the way, including the first direct observation of volcanic activity in the deep sea, overlapping hydrothermal and photosynthetic ecosystems, and venting of liquid carbon dioxide (see http://oceanexplorer.noaa.gov/explorations/04fire/). Water samples from this expedition, collected with the PMEL Hydrothermal Fluid and Particle Sampler, are still being analyzed. This is the first major expedition to sample multiple sites on a submarine volcanic arc and adds significantly to the global database for arc volcanoes. The results confirm that arc volcanoes release fluids with extremely high gas content and extreme variation in vent fluid chemistry.

- In April/May 2004 exploratory research (Resing, Lebon) was also conducted in the relatively unexplored Lau Back Arc Basin along the East Lau Spreading Center (ELSC).

This research was funded by NSF's Ridge 2000 program as part of an effort to develop an Integrated Study Site on the ELSC. The ELSC has the most striking and pronounced gradients in fundamental geophysical properties of any similar length of spreading axis on the globe. This makes the ELSC a particularly exciting place to study the interplay between magmatic and hydrothermal processes. During this cruise, we documented the extent and nature of hydrothermal activity along the ELSC. We found that hydrothermal plume incidence vs. spreading rate on the ELSC exceeds that on MORs and increases with spreading rate (mantle heat input) and faulting intensity indicating that these parameters have a greater effect on hydrothermal activity than the rate of magmatic input.

Goal 2: To understand how submarine hydrothermal systems evolve over time and how they respond to local and regional tectonic or volcanic events.

Very little is known about how hydrothermal systems change when they are perturbed by geological events, and the prospect of recording data and collecting samples immediately after an event promises to yield new insight into the workings of hydrothermal systems. Volcanic events have been seen to give rise to microbial blooms, but the chemical conditions that lead to increased biomass in vent fluids have not been measured.

Accomplishments

- JISAO scientists (Butterfield, Roe) are working with a large cast of investigators from the University of Washington and several other institutions on experiments to link seismic activity and hydrothermal processes (especially chemical and microbiological processes) along the Endeavour segment of the Juan de Fuca ridge and the Nootka fault zone adjacent to Vancouver island. This work, which is supported for 5 years (2001-2006) by the W. M. Keck Foundation, involves instrument development and experiments in the field. Three time-series samplers for chemistry and microbiology were deployed for a year and recovered during an Alvin submersible expedition in June of 2004. Many different instruments are deployed at the same time in an inter-disciplinary approach to understand the links between physical, chemical, and biological processes in hydrothermal systems.

- JISAO scientists have pioneered the use of acoustic/satellite systems to enable two-way data transmission between the seafloor and shore-based laboratories. The NeMO satellite/acoustic link observatory at Axial Volcano was successfully installed again, with one interactive water sampler and a bottom pressure recorder. The NeMO-Net project is the first to return data via acoustic modem and satellite from a deep-sea site. This system has been working since 1999, and data are displayed in near real-time on the internet (*http://www.pmel.noaa.gov/vents/nemo/realtime/index.html*). Two-way communication allows direct modification of a seafloor sensing and sampling instrument, so that the sampling rate can be changed, special routines initiated, or immediate return of sensor data requested. Sensors include temperature and pH, with the addition this year of a redox (Eh) sensor. Recovered filters and water samples allow extensive chemical analysis to detect changes related to volcanic activity or long-term evolution. Progress continues in

the development of this new and intricate technology for monitoring the composition of hydrothermal vents in an active volcano.

- Water samples were collected again at Axial Volcano using the hydrothermal fluid and particle sampler. Hydrothermal plumes samples were collected from above the Volcano for the sixth consecutive year. In addition moored instruments within the plumes were recovered. This work is funded by the NOAA Vents program, with additional funding from NOAA West Coast and Polar Regions Undersea Research Center.

Hydrothermal vents represent outcrops on the seafloor of different portions of the thermal and chemical gradients that exist in the sub-seafloor hydrothermal system and therefore provide a window into sub-seafloor chemical and biological processes. It is hypothesized that chemosynthetic organisms living in submarine hydrothermal systems depend directly on the geochemical environment for energy, and that in turn microbial activity may modify the chemical composition of the hydrothermal system. However, very little data exists to verify this hypothesis, and the details of how microbial communities vary with the geochemical environment are unknown. Hence,

Goal 3: to understand the link between the chemical environment and microbial communities in hydrothermal vents.

Accomplishments

- A unique sampling tool has been developed (Butterfield, Roe) that can take clean water samples and concentrate microbes on filters from the same location, while recording the temperature of the vent fluid in order to control sample quality. This sampler has been used extensively since 1998 to collect an unprecedented suite of samples that are being analyzed for their chemical and microbial content. A significant innovation includes the addition of an in-situ preservative for the extremely short-lived rna molecule to reveal the true in-situ activity of hydrothermal microbes. Research activities to support this goal have been sponsored by the PMEL Vents Program, Washington Sea Grant, NOAA West Coast and Polar Regions Undersea Research Center, the W.M. Keck Foundation, and the National Science Foundation. Research in support of this goal has taken place at a wide variety of sites, and has involved the efforts of several graduate students in the U.W. School of Oceanography.

In a project funded by NSF (Butterfield, Roe), microbial community structure and hydrothermal fluid composition have been linked at two sites on the Juan de Fuca ridge (NeMO Axial Volcano observatory and the Main Endeavour Field) and two sites on the eastern flank of the Juan de Fuca ridge (Baby Bare seamount and Ocean Drilling Project Hole 1026B). The field work for this project included the use of a new breakaway coring instrument to penetrate 1.5 to 3 meters below the seafloor at Baby Bare seamount and collect fluids from the stainless steel spikes. Fluids were also recovered from Ocean Drilling Program Hole 1026B, Endeavour Main Field, and Axial SE caldera. The second of two cruises took place in July, 2003 as part of this project to understand sub-seafloor microbial communities in varied environments, including active, volcanically driven hydrothermal systems on the Juan de Fuca ridge axis, and older hydrothermal systems operating at lower temperatures on the east flank of the Juan de Fuca ridge.

Coastal Oceanography

Tsunami Research Program (TRP)

(Task II: Gonzalez, **Arcas,** Bernard, Eble, Mofjeld**, Newman, Titov, Venturato)**

The Tsunami Research Program (TRP) conducts research to improve our understanding of tsunami dynamics and develop applications that will reduce the loss of life and property. An important motivation and focus of this research is NOAA's national responsibility to address issues of public safety and economic cost associated with extreme weather and ocean hazards, including tsunamis. Consequently, NOAA organized and leads the U.S. National Tsunami Hazard Mitigation Program (NTHMP), a Federal/State collaborative partnership of NOAA, USGS, FEMA, NSF and the Emergency Management and Geotechnical agencies of the five Pacific states – Alaska, California, Hawaii, Oregon and Washington. The complementary *NOAA Research Strategic Plan for FY 2003 – FY 2008 and Beyond* identifies four important strategies to achieve Mission Goal 3: *"Monitor and Observe," "Understand and Describe,"* and *"Assess and Predict"* the physical phenomena of interest, and *"Engage, Advise, and Inform"* current and potential users. Each of these NOAA Research Strategies are employed by and are implicit in the specific goals and accomplishments of TRP Research and development, summarized below.

Goal 1: To improve tsunami detection and measurement.

Accomplishment

- **Supporting ongoing tsunami measurement programs**. Accurate and reliable deep-ocean and coastal tsunami measurement networks are crucial to the success and continuing development of tsunami forecasting capabilities. The Tsunami Research Program continues to provide scientific support for Project DART (Deep-ocean Assessment and Reporting of Tsunamis) which has developed a tsunameter measurement system and established a deep-ocean network that provides tsunami data in real-time. Operational responsibility for the tsunameter network is being transferred to the NOAA National Data Buoy Center, and the Tsunami Research Program will continue to support NDBC efforts to improve the quality and reliability of the network. The Tsunami Research Program also provides scientific support for NTHMP efforts to improve the tsunami measurement and reporting capabilities of the Pacific-wide coastal tide gage

network maintained by Pacific Rim countries and, in the U.S., by the NOAA National Ocean Service.

Goal 2: To improve tsunami hazard assessment.

Accomplishments

- **Developing community-specific inundation maps**. Research is conducted by the Tsunami Research Program to improve our understanding of tsunami dynamics, to exploit this understanding for improvements in tsunami numerical modeling technology, and to apply this technology to the development of community-specific inundation maps that describe the potential hazard. These maps are essential tools for State Emergency Management and Geotechnical officials responsible for hazard mitigation, education, and disaster planning and response. The NOAA Center for Tsunami Inundation Mapping Efforts (TIME) was established to support such modeling and mapping efforts in the NTHMP partner States.

- **Assisting the state of Washington in assessing tsunami hazards.** The TIME Center has completed two tsunami modeling studies for the State of Washington. A report on the Seattle tsunami modeling study has been completed, and both hard copy and electronic versions of the inundation model output have been delivered to Washington State Emergency Management and Geotechnical officials. Subsequently, State officials have used the model output to develop and, after review by the TIME Center, publish the official Washington State tsunami inundation map. Similarly, a report on the Straits of Juan de Fuca tsunami modeling study is complete, and the inundation model output have been transferred to State officials. Two official Washington State tsunami inundation maps have been drafted and are in review by the TIME Center.

- **Assisting other states.** The TIME Center also assists tsunami inundation modeling and mapping efforts in Alaska, California, Hawaii, and Oregon, including the acquisition, quality control and distribution of bathymetric and topographic data and computational grids and the development of methodologies for grid construction. The TIME Center continues to improve tsunami modeling techniques, and the latest version of the MOST model for tsunami propagation and inundation has been tested against new benchmark cases. An updated tsunami inundation model has been provided to California.

Goal 3: To improve tsunami warnings.

Accomplishment:

- **Developing forecasting tools**. The Tsunami Research Program is now developing tsunami forecasting tools for NOAA Tsunami Warning Centers (TWC) based on methodologies developed at PMEL. This effort integrates two technologies – tsunami modeling and the real-time tsunameter network -- to provide real-time tsunami forecasts for warning guidance. The objective for this first year has been achieved – a quasi-

operational, web-based version of the tsunami forecasting tools has been completed and is currently under review and testing by the NOAA TWCs.

Goal 4: Improve state's outreach efforts.

Accomplishment

- **Educating the public.** Tsunami Research Program mapping and modeling products are designed and developed with state outreach efforts in mind. Model output includes animations, GIS files and derived products that facilitate state educational and mitigation programs. In addition, team members provide scientific and technical input to state committees and are frequently engaged as contributors to and active participants in state-sponsored public workshops, presentations and other educational and outreach activities.

Information Technology

The PMEL/JISAO information technology (IT) groups are instrumental in providing support to and developing critical infrastructure for research efforts related to all four Themes.

IT Support for NOAA Research

(Task II: **D. Denbo, W. Zhu, M. Spillane, E. Burger, Nazila Merati)**

Goal 1: To provide information technology support for NOAA research.

Accomplishments:

- **Designing IT management system.** Designed an end-to-end system for the management of all information related to the testing, deploying, and real-time data from Argo floats deployed by PMEL. Presently the Web software is under development. The laboratory software currently uses a MySQL database to keep track of float metadata and produce a metadata product used by the Argo community.
- **Providing IT tools.** Continue to provide tools, like ncBrowse, that PMEL researchers are using to improve their exploration of data stored in netCDF files. (Over 5300 unique sites world-wide have downloaded ncBrowse since its March 20, 2000 release.)

- **Developing scripts and software**. Support has included the development of scripts and software for the display and analysis of observational data.

Goal 2: To develop critical infrastructure for the dissemination, visualization, and analysis of observational and model data.

Accomplishments:

- **Developing OceanShare**. OceanShare, a collaborative tool for the interactive exploration of ocean data by teams of researchers, updated and expanded.

Accomplishments involve expanding and enhancing the collaborative and scientific features of OceanShare. The collaboration aspects of the tool have been greatly expanded to create an easier-to-use and manage system. Session and user list archival enable sessions to be logged and backed up, greatly improving reliability. Security has been greatly improved. Encrypted session keys are now stored on the server simplifying secure session management. Session logs in conjunction with date/time and identity saved in each action makes tracing the history of a session much easier. Data can now be loaded into the collaborative tool from a number of local and remote sites. Gridded, profile, time series, and track data are all available. The graphics have been expanded to support the comparison of station data and gridded model results.

- **Developing/distributing Scientific Graphics Toolkit (SGT)**. Developed and distributed the Scientific Graphics Toolkit (SGT) version 3.0. A Java package that is used in many of the projects described here. SGT has recently been extended to enable novice users access to Java scientific graphics through the SGT Beans interface. (Another popular Java package, SGT has had over 22,000 downloads from over 7400 unique sites world-wide since March 2000.) The SGT class library and source code are available from the web.

- **Developing OPeNDAP server.** Developed an in-situ data OPeNDAP (formally DODS) compatible server. The "Dapper" server provides access to oceanographic observational data using the Climate Data Portal backend and the EPIC profile/time-series databases. Several programs can directly access the Dapper server, including, Java Ocean Atlas (JOA), ncBrowse, and OceanShare.

- **Enhancing Live Access Server.** Enhanced the Live Access Server (LAS) was further enhanced to use in-situ data from the Dapper server. Extended LAS functionality by increasing the flexibility for configuration and adding new features for data visualization and analysis.

- **Utilizing virtual reality technology**. Used virtual reality hardware to display physical and biological model output from GLOBEC and other programs at conferences, workshops and schools.

Goal 3: To advance lowest video conferencing among oceanographers.

Accomplishment:

- **Developing video conferencing capabilities.** Implemented Personal Access Grid hardware and software on local PC's at PMEL.

Thermal Modeling and Prediction (TMAP)

(Task II: S. Hankin, **J. Callahan, K. O'Brien, J. McLean**)

Goal 1: To provide software solutions that integrate and disseminate data and data products over the Internet.

Accomplishments:

- **The Live Access Server (LAS).** The Live Access Server is currently installed at approximately 50 institutes worldwide and provides access to terabytes of ocean, atmosphere and climate data. In the last year LAS was enhanced year to provide access to non-gridded data and associated data products. Enhancement of LAS features and products is ongoing.

- **The Ferret Data Server (FDS).** The Ferret visualization package has been enhanced to function as an OPeNDAP data server. This unique package provides the full data analysis capabilities of Ferret as a web service available to other software packages. Data comparison of remote data sources will be provided by the unique regridding capabilities available through FDS.

- **Observing System Monitoring Center (OSMC)** at NOAA Office of Global Programs. A custom interface is being designed for the OSMC that connects to the Live Access Server to provide data visualizations and products. This interface provides an instantaneous overview of the state of the global ocean monitoring system.

- **Support for Hybrid Coordinate Ocean Model (HYCOM).** Enhancements have been made to the Ferret visualization package and the Live Access Server to accommodate curvilinear coordinate models such as those used by HYCOM. It is now possible to regrid curvilinear model data to a rectilinear grid for comparison with other models.

Goal 2: To provide support for sites utilizing LAS for data access.

Accomplishments:

- **Argo Global Ocean Data Assimilation Experiment (GODAE) server in Monterey.** The Live Access Server was installed at the Navy's Fleet Numerical Metereology and Oceanography Center and is currently being used to provide access to data and data products. The GODAE server in Monterey is designated as an official US GODAE server for real time data products.

- **IPRC server in Honolulu.** The Live Access Server was installed at the Asia Pacific Data Research Center (APDRC) at the University of Hawaii. The APDRC server is designated as an official US GODAE server for archive data and data products.

Goal 3: To develop data management solutions that make large volumes of oceanographic data accessible to users on demand in real-time.

Accomplishment:

- **Carbon Data Management.** TMAP is working with the Carbon Dioxide Information Analysis Center at Oak Ridge National Lab to design a data management system that will provide real-time access to a unique collection of ocean carbon measurements including 'underway' data, profiles and time series. The initial data base schema has been implemented and hooked up to LAS to provide an end-to-end data management and visualization system for these types of data.

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Selected Honors and Awards

- Senior Fellows Richard A. Feely and Christopher L. Sabine were lead author and co-author (with T. Takahashi and R. Wannikov) on the paper "Uptake and storage of carbon dioxide in the oceans" (Oceanography, 14(4), 18-32 (2001) which won the NOAA OAR 2002 Outstanding Paper Award.

- Senior Fellow Michael McPhaden received the Grace Hopper Government Technology Award ("Gracie Award") on behalf of the TAO Project for leadership in the innovative application of information technology (December 2003). McPhaden was also named one of the University of Colorado's Destinguished Lecturers. He will present his lecture in November 2004.

- Senior Fellow Ed Miles, Director of the JISAO Climate Impacts Group, was elected a member of the National Academy of Sciences.

- Yvonne Ortiz, a collaborator on JISAO Task III projects, received an award for the best poster at the International Symposium for Quantiaitive Ecosystem Indicators in Paris, France, March 31 - April 3, 2004.

- The American Geophysical Union has instituted the James R. Holton Award for outstanding young scientists. Holton was a JISAO Senior Fellow who died in March 2004.

Appendices

Appendix 1

JISAO Senior Fellows

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Appendix 2

Task I Program Workshops and Special Events 2003-04

July 2003

7-11: PALEO Workshop to discuss aspects of abrupt climate change in the past, including observations and physical mechanisms, and to assess the likelihood that abrupt climate changes may happen in the future, especially in relation to increasing greenhouse gas concentrations. All of the participants will be making presentations (formal and informal) during the course of the workshop.

1. David Battisti, "Understanding Dansgaard/Oeschger Events: Recent developments and remaining issues."
2. John Chiang, "Midlatitude influence on the tropical marine climate: lessons from the tropical Atlantic".
3. Sang-Ik Shin, "North Atlantic thermohaline circulation changes at the LGM from the results of NCAR's coupled climate system model."
4. Jeffrey Yin, "Thoughts on tropical control of midlatitude storm track/mean flow variability."
5. Eric Steig, "Phase relationships between Antarctic and Greenland climate records".
6. Gerard Roe, "Characterization of millennial-scale climate variability".

Joe Barsugli, Eric DeWeaver, Gerard Roe, and Richard Seager attended.

October 2003

13: *Kunihiko Kodera*, Meteorological Research Institute, Tsukuba, Ibaraki, Japan. "AO/NAO/ENSO, and their relationship with solar activity."

16: *Kevin E. Trenberth*, Senior Scientist at NCAR Climate & Global Dynamics Division. "Seamless Poleward Energy Transports and Implications for the Hadley Circulation."

17: *Kevin E. Trenberth,* Senior Scientist at NCAR Climate & Global Dynamics Division. "Problems with Climate Observations and the Need for an Earth Information System."

30: *Hans van Storch*, Professor, Institute for Coastal Research, Germany. "Climate model simulates global cold climate during late Maunder minimum (1675-1710)."

November 2003

03: *Sandy Tudhope*, Edinburgh University, Department of Geology & GeophysicsSen. "Variability in ENSO and Tropical Pacific climate: evidence from living and fossil coral."

26: *Nathan Gillett,* University of Victoria, BC. "Simulating the effect of ozone depletion on Southern hemisphere climate."

December 2003

23: *Paul Schopf,* Professor of Oceanography, Institute for Computational Sciences and Informatics, George Mason University. "Self-regulation of ENSO."

Task I Program (Continued)

January 2004

21: *Rene D. Garreaud,* Professor Assistant of Physical and Mathematical Sciences, University of Chile. "The Diurnal Cycle in Circulation and Cloudiness over the Subtropical Southeast Pacific."

May 2004

27: *Takamitsu Ito,* Post doctorate candidate. "Southern ocean biogeochemistry and the residual mean circulation."

June 2004

07: *Meredith Hastings*, Post doctorate candidate. "Using isotopes to discern sources, transport and chemistry of atmospheric nitrate at Bermuda."

11: *Jessica Lundquist,* Post doctorate candidate. "Spring onset in the Sierra Nevada: When is snowmelt independent of elevation?"

Thomas Peter, Professor, Institute for Atmospheric and Climate Science, Department of Environmental Sciences, ETH Swiss Federal Institute of Technology - Zurich. Professor Peter is a visiting scientist through June and July.

24: *Thomas Peter,* Swiss Federal Institute of Technology-Zurich. "The origin of high ice crystal number densities in cirrus clouds."

29: *Thomas Peter,* Swiss Federal Institute of Technology-Zurich. "Ultra thin tropical tropopause clouds: a measure of mesoscale upwelling."

July 2004

01: *Thomas Peter,* Swiss Federal Institute of Technology-Zurich. "Tracing troposphere-to-stratosphere transport above a mid-latitude deep convective system."

Appendix 3

JISAO Employees Supported by Task II Projects

Name	Title
A'Hearn, Patrick	Research Consultant
Alvarez-Flores, Carlos M.	Research Associate
Bahl, Kimberly	Research Consultant
Boeing, Wiebke	Research Associate
Boldt, Jennifer	Research Associate
Bond, Nick	Meteorologist
Burger, Eugene	Research consultant
Butterfield, Dave	Oceanographer
Callahan, Jon	Research Consultant
Cheng, Wei	Research Scientist
Cianelli, Lorenzo	Research Associate
Coffman, Derek	Research Scientist
Cooper, Dan	Research Scientist
Cosca, Cathy	Research Scientist
Denbo, Donald	Research Scientist
Dobbins, Elizabeth	Research Scientist
Doherty, Sarah	Research Scientist
Dougherty, Daniel	Research Consultant
Doyle, Miriam	Research Scientist
Fey, Curran	Research Consultant
Flosadottir, Agusta	Research Engineer
Hamilton, Drew	Oceanographer
Hermann, Albert	Oceanographer
Jenkins, Antonio	Research Scientist
Johnson, Jim	Oceanographer
Jurado-Molina, Jesus	Research Associate
Kachel, Nancy	Oceanographer
Ladd, Carol	Research Scientist
Lebon, Geoff	Research Scientist
Lee, Yong Woo	Research Associate
Martin, Bill	Research Scientist
Mazur, Michael	Research Associate
McCarty, Marguerite	Research Scientist
McClurg, Dai	Research Scientist
McHugh, Kevin	Research Scientist
McLean, Joseph	Research Consultant
Menzia, Fred	Research Scientist
Merati, Nazila	Research Scientist
Miller, Theresa	Research Scientist
Moore, Christopher	Research Scientist
Mordy, Calvin	Oceanographer
Mueter, Franz	Research Associate

JISAO Employees Supported by Task II Projects

Newman, Jean	Research Scientist
Noor, Sonya	Research Consultant
O'Brien, Kevin	Research Scientist
Parada-Veliz, Carolina	Research Associate
Proctor, Peter	Research Scientist
Resing, Joseph	Research Scientist
Rice, Andrew	Research Associate
Righi, Dylan	Research Scientist
Rodionov, Sergei	Research Scientist
Roe, Kevin	Research Scientist
Sawatzky, Trisha	Research consultant
Sonnerup, Rolf	Research Scientist
Spillane, Mick	Research Scientist
Steele, T	Tech Writer
Stratton, Linda	Research Scientist
Sullivan, Margaret	Research Scientist
Titov, Vasily	Research Scientist
Venturato, Angie	Research scientist
Wang, Muyin	Meteorologist
Wood, Kevin	Research Scientist
Zhang, Dongxiao	Research Scientist
Zhu, Willa	Research Scientist
Zimmerman, David	Research Engineer

Appendix 4

List of JISAO Task III Principal Investigators and Projects:

APPENDIX 4, List of Task III Principal Investigators and Projects

PI NAME	ACADEMIC UNIT	TITLE OF PROPOSAL	FUNDING
BATTISTI, D.	Atmospheric Sciences	Observing System Research Studies	$60,000
BRETHERTON, C.	Atmospheric Sciences	Climate Process Team Collaborative Research on Low-Latitude Cloud Feedbacks on Climate Sensitivity	$178,812
COVERT, DAVID	Atmospheric Sciences	Multiwavelength Measurement of Aerosal Absorption Coefficient	$88,400
DEMING, JODY	Oceanography	Exploring for Novel Cold-Adapted Microorganisms/Vxusiong Actic Expedition 2003	$25,200
GUNDERSON, D.	Aquatic & Fishery Sciences	(Trands in Fish Abundance and Productivity) Greenland Turbot Age Determination	$101,997
GUNDERSON, D.	Aquatic & Fishery Sciences	Biology of Skates	$77,917
HILBORN, R.	Aquatic & Fishery Sciences	Graduate Student Stipend for Stock Assessment Training and Improvement	$72,340
HORNE, J.	Aquatic & Fishery Sciences	Fisheries Acoustics Research	$133,431
HOUZE, R.	Atmospheric Sciences	Further Analysis of the Tepps Data: Relation to ITCZ Convection to Large-Scale Cross-Equatorial Flow	$100,000
KACZYNSKI, V.	Marine Affairs	Capacity Building and Adaptation to the Climate and Environmental Change in Coastal Zones of the Republic of South Africa	$50,000
LETTENMAIER, D.	Civil & Environmental Eng.	Development of Hydrologic Newcasts and Forecast Products using Land Data Assimilation	$55,000
LINDSAY, R.	Applied Physics Lab	Monitoring of Ice Thickness in the Western Arctic Ocean	$28,500
MASS, C.	Atmospheric Sciences	Regional Weather Analysis and Prediction	$124,942
MILES, E.	Marine Affairs	Impacts of Climate Variability and Change on PNW Coastal Watershed Management	$75,000
MILLER, B.	Aquatic & Fishery Sciences	Marine Biological Interactions in the North Pacific-Fish Interactions	$458,728
NAISH, K.	Aquatic & Fishery Sciences	The Molecular Genetics of Pacific Salmonds	$119,454
NYSTUEN, J.	Applied Physics Lab	Long-Term Acoustical Measurements of Air-Sea Exchange Processes: Rainfall Stratiform Drizzle, Ambient Bubbles and Wind Speeed	$30,200
QUAY, P.	Oceanography	Carbon Isotope Constraints on Ocean GCM Simulations of Anthropogenic COZ Uptate	$98,855
RHINES, P.	Oceanography	Oceanic Observatios of Climate Change in the Arctic-Subpolar Zoned	$365,900
RIGOR, I.	Applied Physics Lab.	Monitoring the Eurasian Basin of the Arctic Ocean	$200,000
RISER, S.	Oceanography	The ARGÖ Project: Global Ocean Observation for Understanding and Prediction of Climate Variability	$1.9M
RISER, S.	Oceanography	Chartering the Research Vessel Pavel Gordienko for ARGO use in the South Pacific	$735,000
SARACHIK, E.	Atmospheric Sciences	The Center for Science in the Earth System	$1.59M
SCHWEIGER, A.	Applied Physics La.	Correction of Systematic Errors in TOVS Radiances	$65,000
SKALSKI, J.	Aquatic & Fishery Sciences	Quantative Assessment of Estimation Based on Data Collected by Observer in the North Pacific Ocean	$40,642

APPENDIX 5

Count of Publications

	JI Lead Author			NOAA Lead Author			Total
	FY 01	**FY 02**	**FY 03**	**FY 01**	**FY 02**	**FY 03**	
Peer-reviewed	27	43	33	21	35	61	220
Non peer-reviewed	23	30	15	16	10	21	115
Totals	**50**	**73**	**48**	**37**	**45**	**82**	**335**

APPENDIX 6

Employee Count (FY 2004)[3]

Visitors (Ph.D.s)	17	
Post Docs	9	
Graduate Students	23*	
	Total	**49**

Professional Staff:

	Unknown	
	No Degree	1
	Associate's	3
	Bachelor's	31
	Master's	16
	Ph.D.	30
	Total	**81**

Hourly/Temporary Staff:

	Unknown	1
	No Degree	1
	Associate's	
	Bachelor's	2
	Master's	
	Ph.D.	1
	Total	**5**

*Preliminary estimates.

[3] There were no subcontract employees paid by JISAO. No JISAO employees were hired by NOAA in FY 2004.

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

David S. Battisti
Principal Investigator for
JISAO PROGRAMS
Director/JISAO

Alvin Kwiram Vice
Vice Provost for Research
Office of the Provost

Director
Grant and Contract Services

**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

Appendix 4
JISAO Projects by Task - 2004

TASK	PI	AWARD $	LONG TITLE
1	**Wallace**	$200,100	Core
1	**Wallace**	$5,000	Second International Conference on Climate Impacts Assessment
1	**Wallace**	$10,000	Special Presidential Award to Research Scientist Nathan Mantua
2	**Wallace**	$10,730	Biophysical Models of Pollack Recruitment Processes in the Western Gulf of Alaska
2	**Wallace**	$20,910	Fisheries-Oceanography Coordinated Investigations (FOCI) Research Support
2	**Wallace**	$1,333,677	Fisheries-Oceanography Coordinated Investigations: Research Support
2	**Wallace**	$43,898	Forage Fishes in the Western Gulf of Alaska: Variation in Productivity
2	**Wallace**	$66,763	Forage Fishes in the Western Gulf of Alaska: Variation in Productivity
2	**Wallace**	$29,024	Gulf of Alaska Spring Ichthyoplanktin Interannual Trends
2	**Wallace**	$65,969	Variability in the Spatial Distribution of Demersal Species Along the West Coast of North America in Response to Climate Changes and Fishing
2	**Wallace**	$304,640	NOAA Fisheries Research Cruise
2	**Wallace**	$379,093	Estuaries Research Program: Research Support
2	**Wallace**	$300,070	Submarine Hydrothermal Venting Program: Research Support
2	**Wallace**	$26,314	Supplemental funding for NOAA Office of Ocean Exploration to the Marianas Volcanic Arc
2	**Wallace**	$5,318	Supplies/Services Support
2	**Wallace**	$75,000	Supplies/Services Support
2	**Wallace**	$75,000	Travel Support
2	**Wallace**	$32,899	Intraseasonal Ocean Response to Atmospheric Forcing Program: Research Support
2	**Wallace**	$14,937	Moored Tropical Rainfall Analysis Program: Research Support
2	**Wallace**	$61,867	Observing Systems Research Studies Program (Graduate Students)
2	**Wallace**	$304,527	Observing Systems Research Studies Program: Research Support
2	**Wallace**	$47,256	Pacific Ocean Circulation Program

2	**Wallace**	$99,073	Tropical Atlantic Ocean Circulation Program: Research Support
2	**Wallace**	$706,367	Tropical Ocean Atmosphere Program; Research Support
2	**Wallace**	$386,832	Atmospheric Chemistry Program: Research Support
2	**Wallace**	$148,845	Chlorofluorocarbon Tracer Program: Research Support
2	**Wallace**	$147,132	Marine Carbon Program: Research Support
2	**Wallace**	$13,608	Supplemental Funding for Kristen Schultz under the Atmospheric Chemistry Research Studies Program
3	**Layton**	$17,079	Estimating the Economic Impact of the Stellar Sea Lion Conservation Area: Developing and Applying New Methods for Evaluating Spatially Complex Area Closures
3	**Essington**	$68,239	Atka Mackerel Food Habit Project
3	**Howe**	$50,000	Analyze Ocean Ambient Sound Data
3	**Horne**	$138,345	Fisheries Acoustic Research
3	**Miller**	$331,499	Marine Biological Interactions in the N Pacific-Fish Interactions
3	**Naish**	$26,413	Molecular Genetics of Pacific Salmon
3	**Naish**	$103,238	Molecular Genetics of Pacific Salmon
3	**Dickhoff**	$44,596	Growth & Development of Salmon
3	**Hilborn**	$47,000	Grad Student Stipend for Stock Assessment Training
3	**Mass**	$124,101	Regional Weather Analysis & Prediction
3	**Riser**	$1,198,319	Charter Research Vessels for Deployment of US ARGO Floats in the S Pacific
3	**Riser**	$2,715,299	The ARGO Project: Global Ocean Observations for Understanding Climate Variability
3	**Sarachik**	$60,000	Simulating ARGO Measurement in an Ocean GCM
3	**Lettenmaier**	$110,000	Development of Hydrologic Nowcast & Forecast Products Using Land Data Assimilation
3	**Bretherton**	$108,180	Climate Process Team on Low-Latitude Cloud Feedbacks on Climate Sensitivity
3	**Quay**	$160,848	Surface Ocean 13C/12C Measurements: A Tracer of Antropogenic CO2 Uptake
3	**Quay**	$102,649	Carbon Isotope Constraints on Ocean GCM Simulations of Anthropogenic CO2 Uptake
3	**Covert**	$151,084	Aerosol Optical Properties: Measurement of Light Scattering & Absorption on the NOAA Research Aircraft and Vessel of Understanding Radiative Transfer
3	**Covert**	$101,588	Aerosol Optical Properties: Measurement of Light Scattering & Absorption on the NOAA Research Aircraft and Vessel of Understanding Radiative Transfer
3	**Percival**	$30,000	Wavelet Analysis of Bering Sea Temperature Time Series
3	**Rigor**	$60,000	Monitoring the Eurasian Basin of the Arctic Ocean

3	**Rhines/Erickson**	$365,600	Oceanic Observations of Climate Change in the Arctic Subpolar Zone
3	**Schweiger**	$65,000	Correction of Systematic Error in the TOVS Radiance
3	**Lindsay**	$63,500	Monitoring Ice Thickness in the Western Arctic Ocean
3	**Miles**	$75,000	Downscaling PNW Climate
3	**Lettenmaier**	$100,000	Experimental Western US Hydrologic Forecasting Systems
3	**Sarachik**	$610,000	Center for Science in the Earth System
3	**Miles**	$885,000	Center for Science in the Earth System

$12,827,426

Appendix 5

JISAO Senior Fellows

Aagaard, Knut (PMEL)	Box 355640	OCE	aagaard@apl.washington.edu
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JISAO Fellow

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Appendix 6

JISAO Post-doctoral Research Associates, 1999-2005, and Their Current Positions

Alvarez-Flores, Carlos, Post-doctoral Research Associate, University of Washington (UW) School of Aquatic and Fishery Sciences, Seattle, WA

Bitz, Cecilia, Physicist, Polar Science Center and Assistant Professor, UW Department of Atmospheric Sciences, Seattle, WA

Boldt, Jennifer, Post-doctoral Research Associate, UW School of Aquatic and Fishery Sciences, Seattle, WA

Codron, Francis F., Assistant Professor, University of Paris, Laboratoire de Meteorologie Dynamique, Paris, France

DeWeaver, Eric T., Assistant Professor, University of Wisconsin-Madison, Department of Atmospheric & Oceanic Sciences, Madison, WI

Duffy-Anderson, Janet, Affiliate Assistant Professor, UW School of Aquatic and Fishery Sciences, Seattle, WA

Hastings, Meredith, Post-doctoral Research Associate, UW Department of Atmospheric Sciences, Seattle, WA

Ito, Takamitsu, Post-doctoral Research Associate, UW School of Oceanography, Seattle, WA

Jurado-Molina, Jesús, Post-doctoral Research Associate, UW School of Aquatic and Fishery Sciences, Seattle, WA

Laimpasuvan, Varavut, Assistant Professor, Coastal Carolina University, Department of Chemistry and Physics, Conway, SC

Larkin, Sim, Research Physical Climatologist, AirFIRE Team, USDA Forest Service Pacific Wildland Fire Sciences Laboratory, Seattle, WA

Lee, Yong Woo, Post-doctoral Research Associate, UW School of Aquatic and Fishery Sciences, Seattle, WA

Mazur, Michael, Post-doctoral Research Associate, UW School of Aquatic and Fishery Sciences, Seattle, WA

Meinen, Christopher, Oceanographer, NOAA/AOML, Miami, FL

Morss, Rebecca, Scientist, National Center for Atmospheric Research (NCAR), Boulder, CO

Mueter, Franz, Post-doctoral Research Associate, UW JISAO, Seattle, WA

Parada-Veliz, Carolina, Post-doctoral Research Associate, UW JISAO, Seattle, WA

Rice, Andrew, Post-doctoral Research Associate, UW JISAO, Seattle, WA

Rodrigues, Regina, Post-doctoral Research Associate, UW JISAO, Seattle, WA

Roe, Gerard, Assistant Professor, UW Earth and Space Sciences, Seattle, WA.

Russell, Joellen L., Post-doctoral Research Associate, Princeton University, Princeton, NJ

Shi, Yunbing, Research Scientist, UW School of Aquatic and Fishery Sciences, Seattle, WA

Snover, Amy, Research Scientist, UW JISAO/Climate Impacts Group, Seattle, WA

Sonnerup, Rolf, Research Scientist, UW JISAO, Seattle, WA

Thompson, Christopher, Physical Oceanographer, NOAA/AOML, Miami, FL

Vecchi, Gabriel, Visiting Scientist, NOAA/GPDL, Princeton, NJ

Wang, Weimin, No longer in field

Wong, Annie, Research Scientist, NOAA/PMEL, Seattle, WA

Wu, Zhaohua, Research Scientist, Center for Ocean-Land-Atmosphere Studies, Calverton, MD

Yu, Bin, Research Scientist, Meteorological Service Canada, Climate Research Branch, Downsview, Ontario, Canada

Yu, Cheng-Ku. Assistant Professor, Chinese Culture University, Department of Atmospheric Sciences, Taipei, Taiwan

Zhang, Dongxiao, Research Scientist, UW JISAO, Seattle, WA

Appendix 7
JISAO Graduate Students 1999 - 2005

GRAD STUDENT NAME	ACADEMIC DEPARTMENT	DEGREE	PHD SUPERVISOR
AGOSTINI, VERA	School of Aquatic & Fisheries Sci	Ph.D.	Robert Francis
A'MAR, Z TERESA	Quant Ecol Res Mangmnt	Ph.D.	Andre Punt
ANDERSEN, MELISSA S.	School of Marine Affairs	M.S.	Ed Miles
BALL, JOSEPH ANDRE	Civil & Environmental Engineering	Ph.D.	Rick Palmer
BIASUTTI, MICHELA	Atmos Sci	Ph.D.	David Battisti/Ed Sarachik
BROWN, CRAIG A.	Atmos Sci	M.S.	David Battisti
BURGOS, JULIAN	School of Aquatic & Fisheries Sci	Ph.D.	John Horne
CARSON, MARK L.	Oceanography	M.S.	Ed Harrison
CHIODI, ANDREW M.	Oceanography	M.S.	Ed Harrison
CHRISTIANSEN, RUTH	School of Marine Affairs	M.M.A.	Tom Leschine
CIANNELLI, LORENZO	School of Aquatic & Fisheries Sci	Ph.D.	Bob Francis
COOPER, DANIEL	School of Aquatic & Fisheries Sci	M.S.	Bruce Miller
CUNY, JEROME	Oceanography	Ph.D.	Peter Rhines
ENGOLTZ, TALI	School of Marine Affairs	M.S.	Ed Miles
GEDALOF, ZE'EV	College of Forest Resources	Ph.D.	David Peterson
GORDON, BRIANA J.	Atmos Sci	M.S.	Cliff Mass
GRIMIT, ERIC	Atmos Sci	Ph.D.	Cliff Mass
GUTHRIE, KATHRYN	School of Aquatic & Fisheries Sci	M.S.	Faye Dong
HAHN, MARGARET	Civil & Environmental Engineering	Ph.D.	Rick Palmer
HAMLET, ALAN	Civil & Environmental Engineering	Ph.D.	Dennis Lettenmaier
HAYNIE, ALAN C.	Economics	Ph.D.	Robert Halvorsen/G. Brown
HAZEN, ELLIOTT L	School of Aquatic & Fisheries Sci	M.S.	John Horne
KIDO, JANINE S.	School of Aquatic & Fisheries Sci	Ph.D.	Bruce Miller
KINZEY, DOUGLAS	School of Aquatic & Fisheries Sci	Ph.D.	Andre Punt
LARSON, BENJAMIN I	Oceanography	Ph.D.	Marv Lilley
LI, CAMILLE	Atmos Sci	Ph.D.	David Battisti
LITTELL, JEREMY	College of Forest Resources	Ph.D.	David Peterson
MATTA, MARY E.	School of Aquatic & Fisheries Sci	M.S.	Don Gunderson
MAURER, EDWIN P	Civil & Environmental Engineering	Ph.D.	Dennis Lettenmaier
MC GUIRE, MARKETA	Civil & Environmental Engineering	M.S.	Dennis Lettenmaier
MILLER, MICHAEL	Civil & Environmental Engineering	Ph.D.	Rick Palmer
MILLER, TIMOTHY	School of Aquatic & Fisheries Sci	Ph.D.	John Skalski
MORIMOTO, GINA	School of Marine Affairs	M.S.	Ed Miles/Dave Fluharty
MORLOCK, SUMMER M.	School of Marine Affairs	M.S.	Ed Miles
NELSON, MARK WILLIAM	School of Aquatic & Fisheries Sci	M.S.	Bruce Miller
ORTIZ, IVONNE	School of Aquatic & Fisheries Sci	Ph.D.	Bob Francis
PARK, HYO SEOK	Civil & Environmental Engineering	M.S.	Stephen Burges
PETRAS, ELIZABETH	School of Marine Affairs	M.S.	Ed Miles
PIERCE, ANDREW	School of Aquatic & Fisheries Sci	Ph.D.	Walt Dickhoff

PROSKUROWSKI, GIORA K	Oceanography	Ph.D.	Marv Lilley
QUADRALLI, ROBERTA	Atmos Sci	Ph.D.	J. Michael Wallace
ROBERTS, WILLIAM H.	Atmos Sci	Ph.D.	David Battisti
SHARP, JUSTIN	Atmos Sci	Ph.D.	Cliff Mass
STEIN, EVE B.	Atmos Sci	M.S.	Robert Houze
STEINBERGER, ANDREA	Oceanography	M.S.	Paul Quay
TAKAHASHI, KEN	Atmos Sci	Ph.D.	David Battisiti
TRASK, RICHARD BLAKE	School of Marine Affairs	M.S.	Ed Miles
TRIBBLE, SHANNON C.	School of Aquatic & Fisheries Sci	M.S.	Bruce Miller
VAN RHEENEN, NATHAN	Civil & Environmental Engineering	Ph.D.	Rick Palmer
VIMONT, DANIEL	Atmos Sci	Ph.D.	David Battisiti/Ed Sarachik
WADE, RACHEL H.	Oceanography	M.S.	unknown
WHITLEY BINDER, LARA	Evans School of Public Affairs	M.S.	Ed Miles/Phil Mote
WOOD, ANDREW W	Civil & Environmental Engineering	Ph.D.	Dennis Lettenmaier
YIN, JEFFREY	Atmos Sci	Ph.D.	David Battisiti
ZAHN, PATRICK H.	Atmos Sci	M.S.	Cliff Mass
ZHANG, XUEBIN	Oceanography	Ph.D.	Mike McPhaden
ZHU, CHUNMEI	Civil & Environmental Engineering	Ph.D.	Dennis Lettenmaier

Appendix 8

JISAO Peer-Reviewed Publications.

1. Aagaard, K., and R.A. Woodgate, 2001: Some thoughts on the freezing and melting of sea ice and their effects on the ocean. *Ocean Modeling,* **3**, 127-135.

2. Adams, J.M., N.A. Bond, and J.E. Overland, 2000: Regional variability of the arctic heat budget in Fall and Winter. *Journal of Climate*, **12**, 1542-1548.

3. Anderson, T.L., D.S. Covert, J.D. Wheeler, J.M. Harris, K.D. Perry, B.E. Trost, and D.J. Jaffe, 1999: Aerosol single scattering albedo: measured values and uncertainties at a coastal station in the Pacific Northwest. *Journal of Geophysical Research*, **104**, 26793-26807.

4. Anderson, T.L., S.J. Masonis, D.S. Covert, R.J. Charlson, and M.J. Rood, 2000: In-situ measurement of the aerosol extinction-to-backscatter ratio at a polluted continental site. *Journal of Geophysical Research*, **105**, 26,907 - 26,915.

5. Anderson, T.L., R.J. Charlson, D.M. Winker, J.A. Ogren, and K. Holmn, 2003: Mesoscale variations of tropospheric aerosols. *American Meteorological Society*, **60**, 119-136.

6. Anderson, T.L., S.J. Masonis, D.S. Covert, N.C. Ahlquist, S.G. Howell, A.D. Clarke, and C.S. McNaughton, 2003: Variability of aerosol optical properties derived from in situ aircraft measurements during ACE-Asia. *Journal of Geophysical Research*, **108**(D23), 8647, doi: 10.1029/2002JD003247, 2003.

7. Bailey, K.M., N.A. Bond, and P.J. Stabeno, 1999: Anomalous transport of walleye pollock larvae linked to ocean and atmospheric patterns in May 1996. *Fisheries Oceanography*, **8**, 264-273.

8. Baker, D.M., B. Davies, W.W. Dickhoff, and P. Swanson, 2000: Insulin-like growth factor I increases FSH content and GnRH-stimulated FSH release from coho salmon pituitary cells in vitro. *Biology of Reproduction*, **63**, 865-871.

9. Baker, D.M., D.A. Larsen, P. Swanson, and W.W. Dickhoff, 2000: Long-term peripheral treatment of immature coho salmon (Oncorhynchus kisutch) with human recombinant leptin has no clear physiologic effect. *General and Comparative Endocrinology*, **118**, 134-138.

10. Baker, E.T., D.A. Tennant, R.A. Feely, G.T. Lebon, and S.L. Walker, 2001: Field and laboratory studies on the effect of particle size and composition on optical backscattering measurements in hydrothermal plumes. *Deep-Sea Research, I*, **48**, 593-604.

11. Bates, T., P.K. Quinn, D.S. Covert, D. Coffman, and Johnson, 2000: Aerosol physical properties and processes in the lower marine boundary layer: a comparison of ACE 1 and ACE 2. *Tellus*, **52B**, 258-272.

12. Bates, T.S., D.J. Coffman, D.S. Covert, and P.K. Quinn, 2002: Regional marine boundary layer aerosol size distributions in the Indian, Atlantic, and Pacific Oceans: a comparison of INDOEX

measurements with ACE-1, ACE-2, and Aerosols99. *Journal of Geophysical Research*, **107**(19), 25-1 – 25-15.

13. Bates, T.S., P.K. Quinn, D.J. Coffman, D.S. Covert, T.L. Miller, J.E. Johnson, G.R. Carmichael, S.A. Guazzotti, D.A. Sodeman, K.A. Prather, M. Rivera, L.M. Russell, and J.T. Merrill, 2004: Marine boundary layer dust and pollutant transport associated with the passage of a frontal system over eastern Asia. *Journal of Geophysical Research*, **109**(D19).

14. Battisti, D.S., E.S. Sarachik, and A.C. Hirst, 1999: A consistent model for large steady atmospheric surface circulation in the tropics. *Journal of Climate*, **12**, 2956-2964.

15. Beckman, B.R., M. Shimizu, B.A. Gadberry, and K.A. Cooper, 2003: Response of the somatotropic axic of juvenile coho salmon to alterations in plane of nutrition with an analysis of the relationships among growth rate and circulating IGF-I and 41 kDA IGFBP. *Journal of Comparative Endocrinology*, doi: 10.1016/j.ygcen.2003.10.013.

16. Beckman, B.R., M. Shimizu, B.A. Gadberry, P.J. Parkins, and K.A. Cooper, 2004: The effect of temperature change on the relations among plasma IGF-I, 41-kDa IGFBP and growth rate in post-smolt coho salmon. *Aquaculture*, **241**, 601-619.

17. Barnett, T.P., Chelliah, M., Hasselmann, K., Hegerl, G.C., Jones, P.D., Rasmussan, E., Ropelewski, C., and Santer, B.D., 1999: Detection and attribution of recent climate change: a status report. *Bulletin of the American Meteorological Society*, **80**, 2631-2659.

18. Bhat, G.S., G.A. Vecchi, and S. Gadgil, 2004: Sea surface temperature of the Bay of Bengal derived from the TRMM microwave imager. *Journal of Atmospheric and Oceanic Technology*, **21**, 1283-1290.

19. Biasutti, M., D.S. Battisti, and E.S. Sarachik, 2003: The annual cycle over the Tropical Atlantic, South America, and Africa. *Journal of Climate*, **16**, 2491-2508.

20. Biasutti, M., D.S. Battisti, and E.S. Sarachik, 2004: Mechanisms controlling the annual cycle of precipitation in the tropical Atlantic sector in an atmospheric GCM. *Journal of Climate*, **17**(24), 4708-4723.

21. Bielli, S., and D.L. Hartmann, 2004: Lagged maximum covariance analysis of the summertime MJO in the Eastern Pacific. *Journal of Climate*, **17**, 4080-4088.

22. Bitz, C.C., and D.S. Battisti, 1999: Interannual to decadal variability in climate and the glacier mass balance in Washington, Western Canada and Alaska. *Journal of Climate*, **12**, 3181-3196.

23. Boeing, W.J., C.E. Williamson, D.M. Leech, S. Cooke, and L. Torres, 2004: Damaging UV radiation and invertebrate predation: conflicting selective pressures for zooplankton vertical distribution in the water column of low DOC lakes. *Oecologia*, **138**, 603-612.

24. Bond, N.A., and J.M. Adams, 2002: Atmospheric forcing of the southeast Bering Sea shelf during 1995-99 in the context of a 40-year historical record. *Deep Sea Research II*, **49**, 5869-5887.

25. Bond, N.A., and J.D. Doyle, 2001: Research aircraft observations and numerical simulation of a warm front approaching Vancouver Island. *Monthly Weather Review*, **129**, 978-998.

26. Bond, N.A., and D.E. Harrison, 2000: The Pacific Decadal Oscillation, air-sea interaction and central north Pacific winter atmospheric regimes. *Geophysical Research Letters*, **27**, 731-734.

27. Bond, N.A., and G.A. Vecchi, 2003: The influence of the Madden-Julian Oscillation (MJO) and precipitation in Oregon and Washington. *Weather and Forecasting*, **18**, 600-613.

28. Bond, N.A., and B.A. Walter, 2002: Research aircraft observations of the mean and turbulent structure of a low-level jet accompanying a strong storm. *Journal of Applied Meteorology,* **41**, 1210 - 1224.

29. Bond, N.A., J.E. Overland, M. Spillane, and P. Stabeno, 2003: Recent shifts in the state of the North Pacific. *Geophysical Research Letters*, **30**, 2183, doi: 10.1029/2003 GL018597.

30. Bretherton, C.S., and D.S. Battisti, 2000: An interpretation of the results from atmospheric general circulation models forced by the time history of the observed sea surface temperature distribution. *Geophysical Research Letters*, **27**, 767-770.

31. Bretherton, C.S., M. Widmann, V.P. Dymnikov, J.M. Wallace, and I. Bladé, 1999: Effective number of degrees of freedom of a spatial field. *Journal of Climate*, **12**(7), 1990-2009.

32. Britt, L.L., E.R. Loew, and W.N. McFarland, 2001: Visual pigments in the early life stages of Pacific Northwest marine fishes. *Journal of Experimental Biology*, **204**, 2581-2587.

33. Bullister, J.L., D.P. Wisegarver, and F.A. Menzia, 2002: The solubility of sulfur hexafluoride in water and seawater. *Deep-Sea Research I*, **49**, 175-187.

34. Butterfield, D.A., B.K. Nelson, C.G. Wheat, M.J. Mottl., and K.K. Roe., 2001: Evidence for basaltic Sr in mid-ocean ridge flank hydrothermal systems and implications for the global oceanic Sr isotope balance. *Geochimica et Cosmochimica Acta*, **65**, 4141-4153.

35. Butterfield, D.A., M.D. Lilley, J. Huber, K.K. Roe, R.W. Embley, and G.J. Massoth, 2004: Mixing, reaction and microbial activity in the sub-seafloor revealed by temporal and spatial variation in diffuse flow vents at axial volcano. *American Geophysical Union*, *Geophysical Monograph Series*, **144**, 269-289.

36. Chang, P., R. Saravanan, L. Ji, and G.C. Hegerl, 2001: The effect of local sea-surface temperatures on atmospheric circulation over the tropical Atlantic sector. *American Meteorological Society*, **13**, 2195-2216.

37. Cherkauer, K.A., and D.P. Lettenmaier, 1999: Hydrologic effects of frozen soils in the upper Mississippi river basin. *Journal of Geophysical Research (Atmospheres)*, **104**(16), 19,599-19,610.

38. Cherkauer, K.A., L.C. Bowling, and D.P. Lettenmaier, 2003: Variable infiltration capacity (VIC) cold land process model updates. *Global and Planetary Change*, **38**, 151-159.

39. Chiang, J.C.H., and A.H. Sobel, 2002: Tropical tropospheric temperature variations caused by ENSO and their influence on the remote tropical climate. *Journal of Climate*, **15**, 2616-2631.

40. Chiang, J., M. Biasutti, and D.S. Battisti, 2003: Sensitivity of the Atlantic ITCZ to last glacial maximum boundary conditions. *Paleoceanography*, **18**, 10.1029/2003PA000916.

41. Chiang, J.C.H., and D.J. Vimont, 2004: Analogous Pacific and Atlantic meridional modes of tropical atmosphere-ocean variability. *Journal of Climate*, **17**, 4143-4158.

42. Christopher, S.A., X. Li, R.M. Welch, J.S. Reid, P.V. Hobbs, T.E. Eck, and B. Holben, 2000: Estimation of surface and top-of-atmospheric shortwave irradiance in biomass burning regions during SCAR-B. *Journal of Applied Meteorology*, **39**, 1742-1753.

43. Clarke, A., Y. Shinozuka, V.N. Kapustin, S. Howell, B. Heubert, S. Doherty, T. Anderson, D. Covert, J. Anderson, X. Hia, K.G. Moore II, C. McNaughton, G. Carmichael, and R. Weber, 2004: Size distributions and mixtures of dust and black carbon aerosol in Asian outflow: physiochemistry and optical properties. *Journal of Geophysical Research*, **109**, D15S09, doi:10.1029/2003JD004378, 2004.

44. Coatanoan, C., C. Goyet, N. Gruber, C.L. Sabine, and M. Warner, 2001: Comparison of two approaches to quantify anthropogenic CO2 in the ocean: Results from the northern Indian Ocean. *Global Biogeochemical Cycles*, **15**, 11-25.

45. Codron, F., and R. Sadourny, 2002: Saturation limiters for water vapor advection schemes: impact on orographic precipitation. *Tellus A*, **54**, 338-349.

46. Cowen, J.P., S.J. Giovanonnoni, F. Kenig, H.P. Johnson, D.A. Butterfield, M.S. Rappé, M. Hutnak, and P. Lam, 2003: Fluids from aging ocean crust that support microbial life. *Science*, **299**, 120-123.

47. Doyle, M.J., K.L. Mier, M.S. Busby, and R.D. Brodeur, 2002: Regional variations in springtime Ichthyoplankton assemblages in the northeast Pacific Ocean. GLOBEC (Northeast Pacific) Special Volume in *Progress in Oceanography*, **53**, 247-281.

48. Doyle, M.J., M.S. Busby, J.T. Duffy-Anderson, S.J. Picquelle, and A.C. Matarese, 2002: Early life history of capelin (Mallotus villosus) in the Northwest Gulf of Alaska: a historical perspective based on larval collections, October 1977-March 1979. *Journal of Marine Science*, **59**, 997-1005.

49. Drobinski, P., and R.C. Foster, 2003: On the origin of near-surface streaks in the neutrally-stratified planetary boundary layer. *Boundary Layer Meteorology*, **108**, 247-256.

50. Duffy-Anderson, J., K.M. Bailey, and L. Ciannelli, 2002: Consequences of a subperabundance of larval walleye pollock, Theragra chalcogramma, in the Gulf of Alaska in 1981. *Marine Ecology Progress Series*, **243**, 179-190.

51. Dusek, U., D.S. Covert, S. Wiedensohler, C. Neususs, D. Weise, and W. Cantrell, 2003: Cloud condensation nuclei spectra derived from size distributions and hygroscopic properties of the aerosol in coastal south-west Portugal during ACE-2. *Tellus B*, **55**, 35-53.

52. Dusek, U., D.S. Covert, S. Wiedensohler, C. Neususs, and D. Weise, 2004: Aerosol number to volume ratios in Southwest Portugal during ACE-2. *Tellus B,* **56**(5), 477-491.

53. Feely, R., E.T. Baker, G.T. Lebon, J.F. Gendron, J.A. Resing, and J.P. Cohen, 1999: Evidence for iron and sulfur enrichment in hydrothermal particles at Axial Volcano following the January-February 1998 eruption. *Geophysical Research Letters*, **26**(24), 3649-3652.

54. Feely, R.A., C.L. Sabine, T. Takahashi, and R. Wanninkhof, 2001: Uptake and storage of carbon dioxides in the oceans: the global CO2 survey. *Oceanography*, **14**, 18-32.

55. Foster, R., R.A. Brown, and A. Enloe, 1999: Baroclinic modification of midlatitude marine surface wind vectors observed by the NASA scatterometer. *Journal of Geophysical Research (Atmospheres)*, **104**(D24), 31,225-31,237.

56. Fruh-Green, G.L., D.S. Kelley, S.M. Bernasconi, J.A. Karson, K.A. Ludwig, D.A. Butterfield, and C. Boschi, 2003: 30,000 years of hydrothermal activity at the Lost City Vent Field. *Science*, **301**, 495-497.

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Appendix 9

Most Cited JISAO Publications

Based on data from the ISI Web of Science. Publications within categories are listed in chronological order. The earliest listings are for the year 1998. All publications listed here have at least 20 citations.

CLIMATE DYNAMICS, GENERAL

Barsugli JJ, Battisti DS**.** The basic effects of atmosphere-ocean thermal coupling on midlatitude variability**,** JOURNAL OF THE ATMOSPHERIC SCIENCES 55 (4): 477-493 FEB 15 1998
Times Cited: 108

Bretherton CS, Widmann M, Dymnikov VP, et al. The effective number of spatial degrees of freedom of a time-varying field. JOURNAL OF CLIMATE 12 (7): 1990-2009 JUL 1999
Times Cited: 27

Lilly JM, Rhines PB, Visbeck M, et al. Observing deep convection in the Labrador sea during winter 1994/95. JOURNAL OF PHYSICAL OCEANOGRAPHY 29 (8): 2065-2098 Part 2 AUG 1999
Times Cited: 40

Bretherton CS, Battisti DS**.** An interpretation of the results from atmospheric general circulation models forced by the time history of the observed sea surface temperature distribution GEOPHYSICAL RESEARCH LETTERS 27 (6): 767-770 MAR 15 2000
Times Cited: 53

DeWeaver E, Nigam S. Zonal-eddy dynamics of the North Atlantic oscillation JOURNAL OF CLIMATE 13 (22): 3893-3914 NOV 15 2000 **Times Cited:** 24

Yin JH, Battisti DS**.** The importance of tropical sea surface temperature patterns in simulations of last glacial maximum climate**.** JOURNAL OF CLIMATE 14 (4): 565-581 2001
Times Cited: 26

ENSO

Wallace JM, Rasmusson EM, Mitchell TP, et al.
The structure and evolution of ENSO-related climate variability in the tropical Pacific: Lessons from TOGA . JOURNAL OF GEOPHYSICAL RESEARCH-OCEANS 103 (C7): 14241-14259 JUN 29 1998
Times Cited: 105

McPhaden MJ. Climate oscillations - Genesis and evolution of the 1997-98 El Nino
SCIENCE 283 (5404): 950-954 FEB 12 1999
Times Cited: 292

Meinen CS, McPhaden MJ. Observations of warm water volume changes in the equatorial Pacific and their relationship to El Nino and La Nina/ JOURNAL OF CLIMATE 13 (20): 3551-3559 OCT 15 2000
Times Cited: 36

Thompson CJ, Battisti DS A linear stochastic dynamical model of ENSO. Part I: Model development**.** JOURNAL OF CLIMATE 13 (15): 2818-2832 AUG 1 2000
Times Cited: 22

Thompson CJ, Battisti DS**.** A linear stochastic dynamical model of ENSO. Part II: Analysis**.** JOURNAL OF CLIMATE 14 (4): 445-466 2001
Times Cited: 21

Overland JE, Bond NA, Adams JM. North Pacific atmospheric and SST anomalies in 1997: Links to ENSO? FISHERIES OCEANOGRAPHY 10 (1): 69-80 MAR 2001
Times Cited: 25

INTERDECADAL CLIMATE VARIAILITY

Mantua NJ, Hare SR, Zhang Y, et al. A Pacific interdecadal climate oscillation with impacts on salmon production. BULLETIN OF THE AMERICAN METEOROLOGICAL SOCIETY 78 (6): 1069-1079 JUN 1997
Times Cited: 657

Overland JE, Adams JM, Bond NA. Decadal variability of the Aleutian low and its relation to high-latitude circulation. JOURNAL OF CLIMATE 12 (5): 1542-1548 Part 2 MAY 1999
Times Cited: 61

Garreaud RD, Battisti DS. Interannual (ENSO) and interdecadal (ENSO-like) variability in the Southern Hemisphere tropospheric circulation**.** JOURNAL OF CLIMATE 12 (7): 2113-2123 JUL 1999
Times Cited: 76

Hare SR, Mantua NJ**.** Empirical evidence for North Pacific regime shifts in 1977 and 1989**.** PROGRESS IN OCEANOGRAPHY 47 (2-4): 103-145 2000
Times Cited: 168

McPhaden MJ, Zhang DX. Slowdown of the meridional overturning circulation in the upper Pacific Ocean**.** NATURE 415 (6872): 603-608 FEB 7 2002
Times Cited: 43

Mantua NJ, Hare SR. The Pacific decadal oscillation JOURNAL OF OCEANOGRAPHY 58 (1): 35-44 FEB 2002
Times Cited: 54

ARCTIC CLIMATE

Rigor IG, Wallace JM, Colony RL Response of sea ice to the Arctic oscillation
JOURNAL OF CLIMATE 15 (18): 2648-2663 SEP 2002
Times Cited: 49

CLIMATE IMPACTS ON MARINE ECOSYSTEMS

Hare SR, Mantua NJ, Francis RC. Inverse production regimes: Alaska and West Coast Pacific salmon.
FISHERIES 24 (1): 6-14 JAN 1999
Times Cited: 75

Stabeno PJ, Bond NA, Kachel NB, et al.
On the temporal variability of the physical environment over the south-eastern Bering Sea. FISHERIES OCEANOGRAPHY 10 (1): 81-98 MAR 2001
Times Cited: 44

CLIMATE IMPACTS ON WATER RESOURCES

Widmann M, Bretherton CS. Validation of mesoscale precipitation in the NCEP reanalysis using a new gridcell dataset for the northwestern United States
JOURNAL OF CLIMATE 13 (11): 1936-1950 JUN 1 2000
Times Cited: 24

Nijssen B, Schnur R, Lettenmaier DP**.** Global retrospective estimation of soil moisture using the variable infiltration capacity land surface model, 1980-93**.** JOURNAL OF CLIMATE 14 (8): 1790-1808 2001
Times Cited: 26

Nijssen B, O'Donnell GM**,** Lettenmaier DP, et al./ Predicting the discharge of global rivers. JOURNAL OF CLIMATE 14 (15): 3307-3323 2001
Times Cited: 31

OCEAN CARBON

Sabine CL, Key RM, Johnson KM, et al. Anthropogenic CO2 inventory of the Indian Ocean. GLOBAL BIOGEOCHEMICAL CYCLES 13 (1): 179-198 MAR 1999
Times Cited: 71

Feely RA, Wanninkhof R, Takahashi T, et al.. Influence of El Nino on the equatorial Pacific contribution to atmospheric CO2 accumulation. NATURE 398 (6728): 597-601 APR 15 1999
Times Cited: 66

Takahashi T, Sutherland SC, Sweeney C... Feely, RA and C. SabineGlobal sea-air CO2 flux based on climatological surface ocean pCO(2), and seasonal biological and temperature effects. DEEP-SEA RESEARCH PART II-TOPICAL STUDIES IN OCEANOGRAPHY 49 (9-10): 1601-1622 2002
Times Cited: 81

Feely RA, Boutin J, Cosca CE, et al.
Seasonal and interannual variability of CO2 in the equatorial Pacific. DEEP-SEA RESEARCH PART II-TOPICAL STUDIES IN OCEANOGRAPHY 49 (13-14): 2443-2469 2002
Times Cited: 22

ATMOSPHERIC AEROSOLS AND TRACE GASES

Bates TS, Kapustin VN, Quinn PK, et al. Processes controlling the distribution of aerosol particles in the lower marine boundary layer during the First Aerosol Characterization Experiment (ACE 1) JOURNAL OF GEOPHYSICAL RESEARCH-ATMOSPHERES 103 (D13): 16369-16383 JUL 20 1998
Times Cited: 56

Anderson TL, Covert DS, Wheeler JD, et al. Aerosol backscatter fraction and single scattering albedo: Measured values and uncertainties at a coastal station in the Pacific Northwest. JOURNAL OF GEOPHYSICAL RESEARCH-ATMOSPHERES 104 (D21): 26793-26807 NOV 20 1999
Times Cited: 40

Quinn PK, Bates TS, Coffman DJ, et al.
A comparison of aerosol chemical and optical properties from the 1st and 2nd Aerosol Characterization Experiments. TELLUS SERIES B-CHEMICAL AND PHYSICAL METEOROLOGY 52 (2): 239-257 APR 2000
Times Cited: 33

Swietlicki E, Zhou JC, Covert DS, et al. Hygroscopic properties of aerosol particles in the northeastern Atlantic during ACE-2 TELLUS SERIES B-CHEMICAL AND PHYSICAL METEOROLOGY 52 (2): 201-227 APR 2000
Times Cited: 46

Anderson TL, Masonis SJ, Covert DS, et al.. Variability of aerosol optical properties derived from in situ aircraft measurements during ACE-Asia . JOURNAL OF GEOPHYSICAL RESEARCH-ATMOSPHERES 108 (D23): Art. No. 8647 AUG 19 2003

Times Cited: 22

Appendix 10
JISAO Awards and Honors 1999-2005

2005

Lettenmaier, Dennis, Senior Fellow, received the Walter Orr Roberts Lecture award at the AMS January Meeting.

Rhines, Peter, Senior Fellow, received the Haurwitz Lecturer award at the AMS Meeting.

Rhines, Peter, Senior Fellow, received the Houghton Lecturer award, MIT.

2004

Bates, Timothy, Senior Fellow, received the NOAA Administrator's Award in recognition of leadership in national and international atmospheric chemistry programs.

Battisti, David named the Thompson Lecturer at NCAR.

Emerson, Steve, Senior Fellow, elected Fellow of American Geophysical Union.

Feely, Richard, Senior Fellow, and **Christopher L. Sabine,** Senior Fellow, 2002 Outstanding Paper Award (presented in 2004). Lead author and co-author, respectively, (with T. Takahashi and R. Wannikov) ,"Uptake and storage of carbon dioxide in the oceans". Oceanography 14(4), 18-32;.

Holton, James R. The American Geophysical Union has instituted the **James R. Holton** Award for outstanding young scientists. Holton was a JISAO Senior Fellow who died March 2004.

Johnson, Gregory, Fellow**,** received NOAA/PMEL Outstanding Scientific Papers award.

McPhaden, **Michael,** Senior Fellow, named one of the University of Colorado's Distinguished Lecturers.

McPhaden, **Michael,** Senior Fellow, received the Presidential Rank Award for Meritorious Federal Service.

McPhaden, **Michael,** Senior Fellow, listed in Thomson ISI Highly Cited Researchers in Geosciences

Miles, Edward, Senior Fellow, Director of the JISAO Climate Impacts Group, elected a member of the National Academy of Sciences.

Murray, James, Senior Fellow, acknowledged by ISI as Highly Cited.

O'Brien, Kevin, Research Scientist, received a letter of accommodation from NDBC Lab Director Paul Moersdorf for work done in the lab.

Ortiz, **Yvonne,** a collaborator on JISAO Task III projects, received an award for the best poster at the International Symposium for Quantitative Ecosystem Indicators in Paris, France, March 31-April 3, 2004.

Roe, Kevin, Research Scientist, received a letter of accommodation from the NDBC Lab Director Paul Moersdorf for work done while visiting the lab.

Vecchi, Gabriel, Research Scientist, received the Presidential Early Career Award for Scientists and Engineers for his fundamental contributions concerning the roles of subseasonal variability on the onset and termination of El Niño and on Indian Monsoon rainfall.

Untersteiner, Norbert, Senior Fellow, elected Fellow of the AAAS.

2003

Bahl, Kimberly Nicholas Bond, Donald Denbo, Elizabeth Dobbins, Jason Fabritz, Antonio Jenkins, Drew Hamilton, Albert Hermann, Nazila Merati, Christopher Moore, Sergei Rodionov, Margaret Sullivan, Muyin Wang, and Willa Zhu (Research Scientists and Senior Fellows) Bronze Medal from the US Department of Commerce given to the members of the NOAA's Fisheries Oceanography Coordinated Investigations (FOCI) program.

Baross, John, a collaborator on JISAO project, received a Certificate of Appreciation from the National Research Council for the National Academy of Sciences for outstanding service as a chair of the Space Studies Board Committee on the Origins and Evolution of Life.

Battisti, David, Senior Fellow, Invited Speaker at AGU, Goldschmidt, PAGES, and Geological Society of America.

Deming, Jody, a collaborator on JISAO project, elected to US National Academy of Sciences

Battisti, David, Senior Fellow, named the Gertrud and Job Tamaki Professor of Atmospheric Sciences at the University of Washington.

Hamlet, **Alan,** Huppert, Daniel, **Lettenmaier, Dennis** received Best Practice Oriented Paper for their "Economic value of long-lead streamflow forecasts for the Columbia River Hydropower, J water Res Pl-ASCE, 128; 91-101. This paper explores the potential for operating the Columbia River's hydropower dams differently in different years based on information from ENSO/PDO based streamflow forecasts.

Hartmann, Dennis, Senior Fellow, appointed Fellow to the American Geophysical Union.

Johnson, Gregory, Fellow, received a NOAA Special Act or Service Award. NOAA Excellence in Partnership Award for the Argo Project.

Johnson, Gregory, Wong, Annie, Steffen, Elizabeth, **Denbo, Donald**, and **Zhu, Willa** received the National Oceanographic Partnership Program Excellence in Partnering Award for their work on the Argo Project.

McPhaden, Michael, Senior Fellow, received the Grace Hopper Government Technology Award, "Gracie Award" on behalf of the TAO Project for leadership in the innovative application of information technology (December 2003).

Meinen, C.S. and M. J. McPhaden (2000). "Observations of the warm water volume changes in the equatorial Pacific and their relationship to El Niño and La Niña." J. Climate, 12:3551-3559.

Merati ,**Nazila,** Research Scientist, (PMEL) and Tiffany Vance (NMFS) received the GIS Award at the Global Ocean Observing Systems meet GIS.

Miles, Edward, Senior Fellow, elected to membership in the US National Academy of Sciences: for work in the Human Environmental Sciences.

Moore, Christopher, Research Scientist, received the NOAA Research Team Member of the Month for his outstanding work in advanced visualization technology applications in research.

Moore, Christopher and **Al Hermann,** Research Scientists, (PMEL), Dan Schaffer (FSL) received the NOAA Tech 2004 Grid Computing Award.

Moore, Christopher and **Al Hermann,** Research Scientists, received the 3D Visualization Award for Transition from ImmersaDesk to low-cost Geo Wall.

Noor, Sonya, Research Scientist, awarded a Certificate for contribution to NOAA Science Camp 2003, NOAA's "Bring your child to work day".

2002

Battisti, David, Senior Fellow, invited speaker at AGU and AMQUA.

Battisti, David, Senior Fellow, named Distinguished Visiting Scholar, Woods Hole Oceanographic Institution.

Sirott, Joseph, **Callahan, Jonathan**, and Hankin, Steven received Live Access Server award for Best Technology Transfer to Research. Callahan is a research consultant.

Feely, **Richard,** Senior Fellow, received the NOAA Administrator's Award for outstanding leadership in studying the oceanic carbon cycle and its role in sequestering atmospheric CO2 as part of the NOAA Ocean Atmosphere Carbon Exchange Study (OACES).

Gedalof, Ze'ev received a National Science and Engineering and Research Council of Canada two-year graduate fellowship.

Hamilton, Sonia, Research Consultant, received the Best Electronic Poster of the Year Award for "The Bering Sea and North Pacific Ocean Theme Page: A Web-based ocean information system" (S12-396) at the Science Board Symposium North Pacific Marine Science Organization (PICES), Victoria, BC. October 2001.

Hartmann, Dennis, Senior Fellow, appointed Fellow of the American Geophysical Union.

Holman, Melissa received a Graduate Student Fund for Excellence and Innovation graduate fellowship and Achievement Rewards for College Scientists graduate fellowship.

Houze, Robert, a collaborator on JISAO project, designated "Highly Cited Research" by the Institute of Scientific Information, publisher of the Science Citation Index.

Johnson, Gregory, Fellow, accepted the NOAA Special Act or Service Award.

McPhaden, Michael, Senior Fellow, received the award from AGU for Frontiers of Geophysics Lecturer at the 2002 Western Pacific Geophysics Meeting.

McPhaden, Michael, Senior Fellow, received the Walter Orr Roberts Lecturer award at the Western by the AMS.

Moore, Christopher, Research Scientist received the Best Visualization in Research Project PMEL "OLD SALT" AWARD - Presented annually in recognition of exceptional commitment to Laboratory programs through at sea or field research support
Patrick A'Hearn - 99 Days

Mote, Philip, Research Scientist, appointed Affiliate Assistant Professor in the UW Department of Atmospheric Sciences.

Nakawatase, Jill recipient of a Graduate Opportunity Program Graduate Fellowship.

Overland, **James** Senior Fellow, received the NOAA Administrator's Award for exceptional leadership skills in support of NOAA's Arctic Research Program and development of the interagency Study of Environmental Arctic Change (SEARCH) program.

Prichard, Susan received a Canon National Parks Science Scholars three-year graduate fellowship.

Quadrelli, Roberta, Graduate Student, received the "Peter B. Wanger Memorial Award for Women in Atmospheric Sciences" from the Desert Research Institute, University of Nevada.

2001

Battisti, David, Senior Fellow, invited Speaker at PAGES

Hartmann, Dennis, Senior Fellow, received the NASA Group Achievement Award, Earth Science Research Strategy Development Team.

Johnson, Gregory, Fellow, received the NOAA Special Act or Service Award.

Lettenmaier, Dennis, Senior Fellow, awarded the Hydrology Section Award in recognition of his outstanding contributions to the science of hydrology.

Pierce, **Andrew,** Graduate Student, advisor Walt Dickhoff, received the John N. Cobb Scholarship in Fisheries.

McPhaden, **Michael** Senior Fellow, selected as The Walter Orr Roberts Lecturer in Interdisciplinary Sciences by the American Meteorological Society for significant contributions to the understanding of atmospheric processes through the effective interchange of knowledge.

Soh, Sungkwon, Post-doctoral Student , advisor-Donald Gunderson, received Best Student Paper in 2001: "The potential role of marine reserves in the management of shortraker rockfish and rougheye rockfish in the Gulf of Alaska." Fishery Bulletin 99:168-179, 2001

2000

Feely, Richard, Wanninkhof, R., T. Takahashi, and P. Tans received the OAR Outstanding Scientific Paper Award for "Influences of El Nino on the equatorial Pacific contribution to atmospheric CO2 accumulation." Nature, 398, 597-601.

Johnson, Gregory, Fellow, received the NOAA/PMEL Outstanding Scientific Papers Award.

Lettenmaier, Dennis, Senior Fellow, awarded the Hydrology Section Award. The medal recognizes outstanding contributions to the science of hydrology.

Mantua, Nate, Research Scientist, received NOAA's Presidential Early Career Award for Scientists and Engineers.

McPhaden, Michael, Senior Fellow, received the OAR Outstanding Scientific Paper Award for "Genesis and evolution of the 1997-98 El Niño." Science, 283, 950-954.

Miles, Edward, Snover, Amy, Hamlet, Alan, Callahan, B., Fluharty, D., were recipients of the American Water Resources Association W.R. Boggess Award for the best paper published in the Journal of the American Water Resources Association/ Pacific Northwest Regional Assessment: The impacts of climate variability and climate change on the water resources of the Columbia River Basin, /Journal of the American Water Resources Association/ 36(2): 399-420.

Murray, James, Senior Fellow, accepted as AAAS Fellow.

Stratton, Linda, Research Scientist, received a NOAA award for "Stipend for contributions to completion of revised TAO World Web pages, with new enhanced performance capabilities and updated content."

Wong, Annie, Post-doctoral Student, received the Royal Society of Tasmania 1999 Doctoral Award, March 2000.

1999

Battisti, David, Senior Fellow, named Hougton Lecturer, MIT.

Peng, T.H., Wanninkhof, R., **Bullister, J.L., Feely**, **R.A.** and Takahashi, T. won ERL Outstanding Scientific Paper Award for "Quantification of Decadal Anthorpogenic CO2 Uptake in the Ocean Based on Dissolved Inorganic Carbon Measurements" (1998).

Deming, Jody, a collaborator on JISAO project, elected to the American Academy of Microbiology.

Denbo, Donald, Research Scientist, won HPCC Award for Best Sponsored Research in Advanced NOAA Technology: Live Access Server for Best Collaboration Tool (synchronous) on OceanShare Collaboration Tool.

Hankin, Steve and **Callahan, Jon** won HPCC Award Best Sponsored Research in Advanced NOAA Technology for Best Collaboration Tool (synchronous)

Hartmann, Dennis, Senior Fellow, awarded the Aldo Leopold Leadership Fellow, Ecological Society of America.

McPhaden, Michael, Senior Fellow, received the Seattle Federal Executive Board's "Celebration of the Stars" Public Service Award for his extraordinary contributions to PMEL's mission and to the world community by bringing on-line the Tropical Atmosphere Ocean array. It provides data to improve El Niño forecasting and help mitigate El Niño's negative impact on the economies of the United States and other nations.

McPhaden, Michael, A.J. Busalacchi, R. Cheney, J.-R. Donguy, K.S. Gage, D. Halpern, M. Ji, P. Julian, G. Meyers, G.T. Mitchum, P.P. Niiler, J. Picaut, R.W. Peynolds, N. Smith, and K. Takeuchi (1998). "The Tropical Ocean-Global Atmosphere Observing System, A Decade of Progress." J. Geophys. Res., 103(C7>, 14,169-14,240. This paper won ERL Outstanding Scientific Paper Award.

McPhaden, Michael, Senior Fellow, received the Special Award for Completing and Maintaining the TAO Array from AMS.

Moore, Chris and **Al Herman,** Research Scientists, won Virtual Reality for Best Visualization

Mordy, Calvin, Research Scientist, received the US Antarctic Service Medal.

Rhines, Peter, Senior Fellow, elected Fellow of American Academy of Arts and Sciences for elegant theoretical studies that have initiated new fields of inquiry, and a grasp of physical mechanisms in oceanic dynamics that is unparalleled.

Rhines, Peter, Senior Fellow, received the NOAA/CIRES Distinguished Visiting Lecturer

Rhines, Peter, Senior Fellow**,** earned the Henry Stommel Research Award, American Meteorological Society for amazing physical insight and profound appreciation of observations as a guide to understanding how the ocean works.