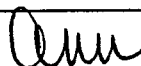


OMB Number 3145-0058

**NATIONAL SCIENCE FOUNDATION**  
**4201 Wilson Blvd.**  
**Arlington, VA 22230**

## PI/PD Name and Address

Livingston, Hugh D



Woods Hole, MA 02543  
 United States

JUL 1 1996

# NATIONAL SCIENCE FOUNDATION

## FINAL PROJECT REPORT

PART I - PROJECT IDENTIFICATION INFORMATION	
1. Program Official/Org.	Woods Hole Oceanographic Institution
2. Program Name	CHEMICAL OCEANOGRAPHY
3. Award Dates	From: 05/01/92 To: 04/30/96
4. Institution and Address	Woods Hole Oceanographic Institution Woods Hole Ocean Inst Woods Hole, MA 02543
5. Award Number	9208261
6. Project Title	Planning and Implementation for the U.S. Joint Global Ocean Flux Study

DOE Patent Clearance Granted

Sept 5, 2003  
Date

Mark P. Dvorscak

(630) 252-2393

E-mail: mark.dvorscak@ch.doe.gov

Office of Intellectual Property Law

DOE Chicago Operations Office

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## **DISCLAIMER**

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**NSF Grant Conditions (Article 17, GC-1, and Article 9, FDP-11) require submission of a Final Project Report (NSF Form 98A) to the NSF program officer no later than 90 days after the expiration of the award. Final Project Reports for expired awards must be received before new awards can be made (NSF Grants Policy Manual Section 677).**

Below, or on a separate page attached to this form, provide a summary of the completed projects and technical information. Be sure to include your name and award number on each separate page. See below for more instructions.

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## **PART II - SUMMARY OF COMPLETED PROJECT (for public use)**

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The summary (about 200 words) must be self-contained and intelligible to a scientifically or technically literate reader. Without restating the project title, it should begin with a topic sentence stating the project's major thesis. The summary should include, if pertinent to the project being described, the following items:

- The primary objectives and scope of the project
- The techniques or approaches used only to the degree necessary for comprehension
- The findings and implications stated as concisely and informatively as possible

*(See enclosed SUMMARY OF COMPLETED PROJECT)*

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## **PART III - TECHNICAL INFORMATION (for program management use)**

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List references to publications resulting from this award and briefly describe primary data, samples, physical collections, inventions, software, etc. created or gathered in the course of the research and, if appropriate, how they are being made available to the research community. Provide the NSF Invention Disclosure number for any invention.

*(See enclosed TECHNICAL INFORMATION)*

I certify to the best of my knowledge (1) the statements herein (excluding scientific hypotheses and scientific opinion) are true and complete, and (2) the text and graphics in this report as well as any accompanying publications or other documents, unless otherwise indicated, are the original work of the signatories or of individuals working under their supervision. I understand that willfully making a false statement or concealing a material fact in this report or any other communication submitted to NSF is a criminal offense (U.S. Code, Title 18, Section 1001).

<b>Submitted via FastLane</b>	<b>06/26/96</b>
Principal Investigator/Project Director Signature	Date

### **IMPORTANT: MAILING INSTRUCTIONS**

**Return this *entire* packet plus all attachments in the envelope attached to the back of this form. Please copy the information from Part I, Block I to the *Attention block* on the envelope.**

## **PART II - SUMMARY OF COMPLETED PROJECT**

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### **U.S. JGOFS Progress as of June 1996**

#### **Program elements**

##### **Large scale surveys**

The large scale survey of oceanic CO<sub>2</sub> parameters conducted as part of the WOCE Hydrographic Program (WHP) cruises is a major component of the survey mode program element. U.S. scientist's contributions to this effort have included so far several WOCE lines in both the

##### **Indian**

Pacific and Atlantic oceans. The U.S. contribution to the WHP global survey is presently to be completed by 1997.

The other major large scale effort is the new ocean color sensor Sea-Viewing Wide Field Sensor (SeaWiFS). Continuing delays have delayed

the launch date. It is still hoped that the planned studies in the Southern Ocean

will be the first to benefit directly from this new tool.

##### **Major process studies**

Following the initial JGOFS process study of the spring bloom in the North Atlantic in 1989, the U.S. carried out a major process study in the Equatorial Pacific in 1991-92. The study had a principal focus on the N/S line at 140 degrees W and included both survey and time-series

components. But a sub-set of the cruises were organized to collect larger scale data on several N/S sections both east and west of 140 W.

In addition, area overflights by a NASA P-3 aircraft provided further larger spatial scale observations of surface ocean properties around the area surveyed by the surface vessels. A major benthic cruise was conducted in November 1992. Moored traps were deployed in November 1991 and recovered in January 1993. The first post-cruise workshop was

held in July 1993 in Seattle. Further discussions of the scientific results from this study were held at the AGU/ASLO Ocean Science meeting in San Diego in February 1994 and at the Oceanography Society meeting in Honolulu in July of 1994. The latter followed a major synthesis and data evaluation workshop held in Scottsdale, Arizona in June 1994. The first of two special issues of Deep Sea Research dedicated

to the Equatorial Pacific study was published during the Summer of 1995.

The second will appear in mid-1996. A NATO advanced research

## **PART II - SUMMARY OF COMPLETED PROJECT**

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**(Page 2 of SUMMARY )**

workshop was held in June 1995 in Noumea, New Caledonia.

U.S. JGOFS has now completed a major process study in the Arabian Sea for about sixteen months which began in late 1994. These cruises provided seasonal coverage of the annual monsoon and inter-monsoon cycles in the area south east of Oman - from where the cruises were staged. This study was made in the wider context of international JGOFS plans for this region and in collaboration with WOCE cruises scheduled for this region.

The Southern Ocean is the next U.S. JGOFS area of concentrated field work. The U.S. JGOFS Southern Ocean Process Study will begin field

work in late 1996 and continue through April of 1998. The cruises will be staged

from the port of Christchurch, New Zealand. The logistics for the Southern

Ocean are being coordinated by Antarctic Support Associates (ASA), who

operate one of the two ships to be utilized during the nearly two-year long field

work, the R/V Nathaniel B. Palmer, and maintain its cruise schedule.

### **Time-series sites**

U.S. JGOFS maintains two long term time-series stations located near Hawaii and Bermuda. Data collected at these sites on regular ship visits and permanent moorings allow assessment of oligotrophic ocean variability of parameters affecting the ocean carbon system on a range

of time-scales. A suite of JGOFS core measurements have been made at these sites since their inception in 1988. These data have provided new insights on the seasonal and interannual variability of ocean carbon system parameters there. A special issue of Deep Sea Research published in early 1996 presents some of the scientific results from these efforts.

### **Modeling studies**

Modeling efforts supported directly through the U.S. JGOFS program have been rather limited. Since the Bloom experiment, North Atlantic modeling has involved some biological simulations in eddy resolving and general circulation models. The Princeton/GFDL ecosystem model of the Equatorial Pacific was used extensively in planning the Process Study there in 1991-2. Some U.S. modelers have provided modeling

## PART II - SUMMARY OF COMPLETED PROJECT

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(Page 3 of SUMMARY)

input

into Arabian Sea Process Study planning, but there is at present no U.S. modeling effort in support of Southern Ocean planning. Three U.S.

groups have been working with models using data from the Bermuda and Hawaii time-series stations. Some of these biological/physical models

were discussed at a workshop organized by J. Steele and C. Davis in June, 1993.

### Synthesis and Modeling

The U.S. JGOFS Synthesis and Modeling Project (SMP) will be launched this

summer at a workshop on the role of oceanic processes in the global carbon cycle.

To be held Aug. 13-19 in Durham, New Hampshire, the workshop will bring together

empiricists and modelers for a week of intense discussion on how to achieve the

central JGOFS goals of characterizing the processes controlling oceanic carbon fluxes

on a global scale and predicting the responses of oceanic biogeochemical processes to anthropogenic perturbation.

The main legacy of this component of U.S. JGOFS will be the synthesis of knowledge

gained from field and modeling studies into a set of models that reflect our current

understanding of how oceanic processes affect the global carbon cycle.

Attaining

this goal will be neither simple nor straightforward, requiring as it must the synthesis

and modeling of knowledge gained from the global survey of carbon dioxide (CO<sub>2</sub>)

in the ocean, the time-series programs at Hawaii and Bermuda, the U.S. process

studies in the North Atlantic, equatorial Pacific, Arabian Sea and Southern Ocean,

and JGOFS studies conducted by our international partners.

### Data Management

## **PART II - SUMMARY OF COMPLETED PROJECT**

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**(Page 4 of SUMMARY )**

**U.S. JGOFS has made significant progress since June of 1994, when Christine Hammond joined our staff. A Data Management Office in Woods Hole has been established and funded. Chris's technical skill has successfully teamed up with the data management experience of George Heimerdinger, the NOAA/NODC Northeast Liaison Officer whose services have been generously loaned to U.S. JGOFS by NODC. In July of 1995, they were joined half-time by data and information technician Kathryn Elder.**

**The adoption of the World Wide Web's httpd as the server utilized by Glenn Flierl's object-oriented distributed data system marked the beginning of increased acceptance of the U.S. JGOFS approach. We see this as a flexible and increasingly useful system which will meet the demands of Principal Investigators for easy access to JGOFS data, and will adequately handle the huge volume of data currently and soon to be generated. The current status of data being served can be viewed at this site  
at <http://www1.whoi.edu/jgofs.html>**



## **PART III - TECHNICAL INFORMATION**

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### **U.S. JGOFS Reports 1992-6**

**U.S. JGOFS Arabian Sea Process Study Implementation Plan (1992).**

**Sharon Smith, 26 pp.**

**U.S. JGOFS Planning Report Number 14 (1992).**

**Report of the U.S. JGOFS Workshop on Modeling and Data Assimilation ,  
Mark R. Abbott (Chairman), 28 pp.**

**U.S. JGOFS Planning Report Number 15 (1992).**

**Design for a Mesoscale Iron Enrichment Experiment , John Martin,  
Penny  
Chisholm, et al., 26 pp.**

**U.S. JGOFS Planning Report Number 16 (1992).**

**U.S. JGOFS: Southern Ocean Process Study Planning Workshop Report ,  
Robert F. Anderson (Chairman), 114 pp.**

**U.S. JGOFS Planning Report Number 17 (1993).**

**U.S. JGOFS: Southern Ocean Process Study Science Plan , Robert F.  
Anderson, 67 pp.**

**U.S. JGOFS Planning Report Number 18 (1993).**

**Bio-optics in U.S. JGOFS, Tommy D. Dickey and David A. Siegel  
(Co-editors), 180 pp.**

**U.S. JGOFS Planning Report Number 19 (1995).**

**BBOP Data Processing and Sampling Procedures, David A. Siegel, et al.,  
80 pp.**

**U.S. JGOFS Southern Ocean Process Study Implementation Plan,**

**Robert F. Anderson and Walker O. Smith, Jr., 20 pp.**

**U.S. JGOFS EqPac Data and Science Workshop No. 1, Proceedings Report  
(1993).**

**Jim Murray et al., 408 pp.**

**Hawaii Ocean Time-Series Data Report 4, 1992 (1993).**

**Luis Tupas, Fernando Santiago-Mandujano, et al. (University of  
Hawaii,  
Honolulu) SOEST Technical Report 93-14, 248 pp + 3 1/2 inch diskette  
containing data set.**

**Hawaii Ocean Time-Series Data Report 5, 1993 (1994).**

**Luis Tupas, Fernando Santiago-Mandujano, et al. (University of  
Hawaii,**

### **PART III - TECHNICAL INFORMATION**

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**(Page 2 of TECHNICAL INFORMATION)**

**Honolulu) SOEST Technical Report 94-5, 156 pp + 3 1/2 inch diskette containing data set.**

**U.S. JGOFS BATS Data Report B-2 (1992).**

**Bermuda Atlantic Time-Series Study: Data Report for BATS 13 24, October 1989 September 1990, Anthony H. Knap, Anthony F. Michaels et al., 345 pp.**

**U.S. JGOFS BATS Data Report B-3 (1993).**

**Bermuda Atlantic Time-Series Study: Data Report for BATS 25 36, October 1990 September 1991, Anthony H. Knap, Anthony F. Michaels et al., 339 pp.**

**U.S. JGOFS BATS Data Report B-4 (1994).**

**Bermuda Atlantic Time-Series Study: Data Report for BATS 37 48, October 1991 September 1992, Anthony H. Knap, Anthony F. Michaels et al., 263 pp.**

**U.S. JGOFS BATS Method Manual Version 3 (1993).**

**Bermuda Atlantic Time-Series Study March 1993 Anthony H. Knap, Anthony F. Michaels et al., 108 pp.**

**In addition, four issues of U.S. JGOFS NEWS were published each year.**

# **PART IV -- FINAL PROJECT REPORT -- SUMMARY DATA ON PROJECT PERSONNEL**

(To be submitted to cognizant Program Officer upon completion of project)

The data requested below are important for the development of a statistical profile on the personnel supported by Federal grants. The information on this part is solicited in response to Public Law 99-383 and 42 USC 1885C. All information provided will be treated as confidential and will be safeguarded in accordance with the provisions of the Privacy Act of 1974. You should submit a single copy of this part with each final project report. However, submission of the requested information is not mandatory and is not a precondition of future award(s). Check the "Decline to Provide Information" box below if you do not wish to provide the information.

Please enter the numbers of individuals supported under this grant.  
Do not enter information for individuals working less than 40 hours in any calendar year.

	Senior Staff		Post-Doctorals		Graduate Students		Under-Graduates		Other Participants <sup>1</sup>	
	Male	Fem.	Male	Fem.	Male	Fem.	Male	Fem.	Male	Fem.
<b>A. Total, U.S. Citizens</b>	1								1	2
<b>B. Total, Permanent Residents</b>										
U.S. Citizens or Permanent Residents <sup>2</sup> :										
American Indian or Alaskan Native . . . . .										
Asian. . . . .										
Black, Not of Hispanic Origin. . . . .										
Hispanic . . . . .										
Pacific Islander . . . . .										
White, Not of Hispanic Origin . . . . .	1								1	2
<b>C. Total, Other Non-U.S. Citizens</b>										
Specify Country										
1.										
2.										
3.										
<b>D. Total, All participants (A + B + C)</b>	1								1	2
<b>Disabled<sup>3</sup></b>										

☐ Decline to Provide Information: Check box if you do not wish to provide this information (you are still required to return this page along with Parts I-III).

<sup>1</sup> Category includes, for example, college and precollege teachers, conference and workshop participants.

<sup>2</sup> Use the category that best describes the ethnic/racial status for all U.S. Citizens and Non-citizens with Permanent Residency. (If more than one category applies, use the one category that most closely reflects the person's recognition in the community.)

<sup>3</sup> A person having a physical or mental impairment that substantially limits one or more major life activities; who has a record of such impairment; or who is regarded as having such impairment. (Disabled individuals also should be counted under the appropriate ethnic/racial group unless they are classified as "Other Non-U.S. Citizens.")

**AMERICAN INDIAN OR ALASKAN NATIVE:** A person having origins in any of the original peoples of North America and who maintains cultural identification through tribal affiliation or community recognition.

**ASIAN:** A person having origins in any of the original peoples of East Asia, Southeast Asia or the Indian subcontinent. This area includes, for example, China, India, Indonesia, Japan, Korea and Vietnam.

**BLACK, NOT OF HISPANIC ORIGIN:** A person having origins in any of the black racial groups of Africa.

**HISPANIC:** A person of Mexican, Puerto Rican, Cuban, Central or South American or other Spanish culture or origin, regardless of race.

**PACIFIC ISLANDER:** A person having origins in any of the original peoples of Hawaii; the U.S. Pacific territories of Guam, American Samoa, and the Northern Marinas; the U.S. Trust Territory of Palau; the islands of Micronesia and Melanesia; or the Philippines.

**WHITE, NOT OF HISPANIC ORIGIN:** A person having origins in any of the original peoples of Europe, North Africa, or the Middle East.