

Mid-Ocean Dynamics  
Experiment  
AC 42 Box | Folder 107

Jan 1973, renewal proposal for shiptime on R/V Eastward June-July 1973  
Co-Investigators: H. M. Stommel, D. W. Moore



RENEWAL RESEARCH PROPOSAL

Submitted To

THE COOPERATIVE OCEANOGRAPHIC PROGRAM OF DUKE UNIVERSITY

Requesting

Ship-time on R/V EASTWARD  
during the period June - July 1973

Submitted By

Henry M. Stommel, Principal Investigator  
Massachusetts Institute of Technology  
Cambridge, Massachusetts 02139

Dennis W. Moore, Co-investigator  
Massachusetts Institute of Technology  
Cambridge, Massachusetts 02139

from the Department of Meteorology, MIT

in behalf of themselves and

D. J. Baker, Harvard University

T. Pochapsky, Columbia University

NO FUNDING REQUESTED

*Henry M. Stommel* 15 I 1973

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Norman A. Phillips, Head, Department of Meteorology, MIT

January 1973



- a. Name and address of the principal investigator and co-investigator and institutions:

Henry Stommel, Professor of Oceanography, and  
Dennis Moore, MODE Executive Officer  
Massachusetts Institute of Technology  
Cambridge, Massachusetts 02139

- b. Title of proposed research:

Intercomparison of velocity profiling techniques and pressure gauges.

- c. Abstract of proposed research:

During March through July, 1973, a cooperative experiment to study mesoscale motions in the deep ocean in an area centered at 28°N, 69°40' W, will be carried out by scientists from a number of different institutions under the name MODE-I (Mid-Ocean Dynamics Experiment - I). A general description of this experiment is given in the attached yellow book. A detailed scientific plan for the field experiment was finalized at the MODE Scientific Council meeting at Harvard on October 13, 1972. A copy of this document is attached. A total of six ships will be involved in the MODE-I field program. We would like to arrange two EASTWARD cruises.

On the first cruise, T. Pochapsky, of Columbia University, would make vertical profiles of horizontal velocity using an acoustic profiling technique. He worked from the EASTWARD during August 1972. During MODE-I his profiling will be done at the same time and in the same place that T. Sanford of WHOI is doing velocity profiling using an electromagnetic profiling system from the R/V CHAIN. This will allow an intercomparison of the two profiling techniques.

On the second cruise, James Baker of Harvard will recover bottom pressure gauges set earlier from R/V HUNT. The data from these gauges will be compared with data from pressure gauges of other types to be used during MODE-I. Also, comparison with current meter records obtained from near bottom current meters located between the pressure gauges will allow us to estimate how nearly geostrophic are the bottom current fluctuations.

- d. Description of proposed research and objectives:

Two cruises are planned.

1. Horizontal Velocity Profiles using an acoustic profiler will be conducted near 28°N, 69°40' W by T. Pochapsky of Columbia University for approximately two weeks.
2. Deep Sea Pressure gauges set by James Baker of Harvard from the R/V Hunt in March 1973 will be recovered.



- e. Equipment needed from the Program:
  - 1. Loran-C navigation equipment
  - 2. Precision depth recorder
  - 3. Deck crane capable of handling 1500 pounds
- f. Equipment provided by principal investigator:
  - 1. Acoustic Velocity Profiling System
  - 2. Bottom pressure gauges
- g. Time required to carry out proposed research:

The total time required for the research, including time to get from port to the MODE area, is 32 days. This would involve two cruises, one of 17 days duration and the other of 15 days duration. The first cruise would leave Beaufort, N.C. on June 3, 1973. T. Pochapsky would do his acoustic profiling on this cruise. The second cruise would leave Bermuda on June 24, 1973 and arrive at Beaufort, N.C. on July 8, 1973. D. James Baker would recover his pressure gauges on this cruise.

- h. Background and qualifications of principal investigator, co-investigator, and other personnel: Curricula vitae are attached.
- i. Summary of research accomplished to date.

The first of two MODE cruises aboard the R/V EASTWARD took place from 18-30 August. Groups from Harvard and Columbia were aboard; they reported successful results and calm weather, having pulled into port just before a tropical storm.

The Harvard group (James Baker, Winfield Hill, Dick Wearn and Jack Calman) deployed two fused-quartz pressure gauges and recovered one. The first gauge was deployed in 5330 m of water at 29°33'N, 69°47'W (50 km north of a deep current meter in Array-3) on 20 August and was recovered on 28 August. A full week of pressure and temperature data was obtained. The temperature record appears to be good, showing a total tidal signal of peak-to-peak magnitude 14 mb with high water occurring about 0.5 hours after lunar transit at Greenwich (a phase roughly midway between those observed for  $M_2$  at Bermuda and the Bahamas). However, there was an initial drift in the signal of about 80 mb. This appears to be too large to be attributed to the gauge sinking into the sediments and is not yet understood.

The second gauge was deployed in 5390 m of water at 28°24'N 69°39'W, midway between two deep current meters. This gauge will be left in the area until November, when it will be recovered by the EASTWARD.

The Columbia group (Ted Pochapsky and Frank Malone) carried out the following work. Three disposable transponders were bottom-



i. Continued

anchored in a triangular array on a relatively flat bottom, 5250 m deep, located a few miles to the west of the ridge reported at 28° N 69°30' W. A sinking or rising float was dropped near two of the transponders and supplied data during five profiles. In all but one profile, "oscillation" apparently took place between the master and the transponders; therefore, the master clock did not control the sampling rate. This complicates the procedure for determining profiles, but it should not reduce the accuracy. Drops were made away from the third transponder to avoid signal confusion attending the lack of master keying. Pings from the ship served to locate the vessel relative to the array. Bottom surveys were made during transits. A preliminary survey showed the terrain of the ridge to be very rough; thus, an array was not placed on the ridge as originally intended.

The transponders withstood prolonged exposure to the bottom pressures at 5250 m, although there was initial question as to their mechanical adequacy at such depths. On the other hand, two transponders were "lost" at mid-depth for unknown electronic or mechanical reasons.

The second MODE cruise aboard R/V EASTWARD took place from 20 November to 3 December. The primary aim was recovery of the three-month pressure gauge mooring (2) set in August, and deployment and recovery of three more (4,5, and 6). Dick Wearn and Wolfgang Pape of Harvard and Winfield Hill of Sea Data Corporation participated. Jean Driscoll of WHOI was aboard to take bottom photographs in the MODE area for a study of biological variation in the Abyssal Plain. Ten bottom camera stations were obtained by Driscoll.

The trip was a qualified success. Mooring 2 was recovered and a three-month record of pressure and temperature obtained. Mooring 6 was deployed and recovered without incident; a six-day record was obtained. There is no evidence of drift on this pressure record. Since the reference chamber on Mooring 6 was filled with dry argon, it confirms our suspicion that the drift observed earlier was due to water vapor in the reference chamber. Unfortunately, the plexiglas window on a deep-sea camera on mooring 4 imploded after 14 hours on the bottom (in spite of having survived a pressure test to greater than this depth), and the camera was demolished. No information on sinking, an unlikely candidate for pressure gauge drift anyway, was obtained. The pressure sensor did not survive the explosion, and no pressure record was obtained from mooring 4.

We were not able to release mooring 5. Although we could enable the transpond, transpond with the release, and disable the transpond, the release signal did not get through. A variety of techniques were tried, including varying the pulse rate frequency, but nothing worked. Since the transpond is operative, we have some (small) hope that the mooring might be released later.

We attempted to raise the two U.R.I. moorings but apparently could make no contact.



j. Capacity of projects to carry other investigators:

It seems likely that there would be room for 3-4 students who would be welcome to come along for training purposes. The experimenters would obviously be in physical oceanography measurement techniques.

k. Preferred Dates:

Leave Beaufort June 3, 1973 - Arrive Bermuda June 20, 1973.  
Leave Bermuda June 24, 1973 - Arrive Beaufort July 8, 1973

This proposed schedule is closely tied to the schedule of the R/V CHAIN from WHOI. It is crucial that Pochapsky and Sanford be able to use their respective profiling technique at the same time at the same place. For this reason we are requesting these specific dates.

l. Outside Support

<u>Investigator</u>	<u>Institution</u>	<u>Grant No.</u>
Henry Stommel Dennis Moore (MODE Executive Officer)	MIT	NSF GX-29051
D. James Baker, Jr.	Harvard	NSF GX-28846
T. Pochapsky	Columbia	

m. Institutional approval of the proposal: On cover page.

Henry M. Stommel

Date of Birth: September 27, 1920

Place of Birth: Wilmington, Delaware

Education: B.S., Yale University, 1942  
M.A. (Hon), Harvard, 1961  
Ph.D. (Hon), Gothenberg, 1964

Experience: Instructor in mathematics and  
Astronomy, Yale, 1942-1944

Research Associate, Woods Hole  
Oceanographic Institution, 1944-1960

Professor of Oceanography, Massachusetts  
Institute of Technology, 1963-present

Honors: Phi Beta Kappa, Sigma Xi

Member, National Academy of Sciences,  
1961

Sverdrup Medalist, American  
Meteorological Society, 1964

Albatross Award, 1966

Social Security No: 076-10-3675



Number	Author(s)	Year	Title of Article or Chapter	Title of Periodical or Book (and publisher, when a book)	Vol.	Pages	WHOI Contr.
95	Henry Stommel K. N. Fedorov	1966	Small-scale structure in temperature and salinity near Timor and Mindanao	Tellus	19	306-325	
96	E. H. Schroeder Henry Stommel	1966	How representative is the series of Panulirus stations of monthly mean conditions off Bermuda?	Symposium on Variability of the Sea, SCOR-UNESCO Consiglio Ricerca Nazionale Rome. Progress in Oceanography			
97	G. MacDonald, et al. (H. Stommel on Panel)	1966	Effective Use of the Sea	Report of the Panel on Oceanography, President's Science Advisory Committee. Pub.: The White House, Washington, D.C.			
98	A. B. Arons Henry Stommel	1967	On the abyssal circulation of the world ocean. Part III An advective-lateral mixing model of the distribution of a tracer property in an ocean basin	Deep-Sea Research	14	441-457	188
99	Henry Stommel Claes Rooth	1968	Circulation produced by applied stress and heating	Deep-Sea Research	15	165-170	203
00	Thomas Winterfeld Henry Stommel	1971	Distribution of stations and properties at standard depths in the Kuroshio Area	Chapter 5 in: A Treatise on The Kuroshio. Tokyo University Press		in press	
01	Henry Stommel Robert Frazel	1968	Hidaka's Onions (Tamanegi)	Records of Oceanographical Work in Japan	9	279-281	
02	John Cooper Henry Stommel	1968	Regular Steps in the Main Thermocline near Bermuda	Journal of Geophysical Res.	73	5849-5854	21



Number	Author(s)	Year	Title of Article or Chapter	Title of Periodical or Book (and publisher, when a book)	Vol.	Pages	WHOI Contr.
03	Joseph Reid, Jr. Henry Stommel E. Dixon Stroup Bruce A. Warren	1968	Detection of a deep boundary current in the South Pacific	Nature	217	937	
04	Henry Stommel	1968	Kinematic Waves in the Gulf Stream	Proc. Nat. Acad. Sci.	60	747-749	
05	Henry Stommel Roberto Frassetto	1968	The time of appearance of cold water off Somalia	Proc. Nat. Acad. Sci.	60	750-751	
06	Henry Stommel	1968	Horizontal variations in the mixed layer of the South Pacific Ocean	Okeanologia	9	97-102	
07	Joseph Reid, Jr. Henry Stommel E. Dixon Stroup Bruce A. Warren	1968	Physical Oceanography in the South Pacific 1967	Antarctic J.	3	168-169	
08	Henry Stommel Kim Saunders William Simmons John Cooper	1969	Observations of the diurnal thermocline	Deep-sea Research Supplement (Fuglister Volume)	16	269-284	226
09	John Bowen Henry Stommel	1970	On the steadiness of the Antarctic Circumpolar Current	Proceedings of AAAS meeting in Dallas		in press	
10	MEDOC Group (includes H. Stommel)	1970	Observation of formation of deep water in the Mediter- ranean Sea	Nature	227	1037-1040	



Number	Author(s)	Year	Title of Article or Chapter	Title of Periodical or Book (and publisher, when a book)	Vol.	Pages	WHOI Contr.
11	David Anati Henry Stommel	1970	The initial phase of deep-water formation in the North-west Mediterranean during MEDOC '69 on the basis of observations made by Atlantis II January 25, 1969 to February 12, 1969	Cahiers Oceanographique	22	343-352	
12	Henry Stommel	1970	Future prospects for Physical Oceanography	Science	168	1531-1537	
13	Henry Stommel	1970	Deep Winter-time convection in the Mediterranean Sea	Wüst Jubilee Book		in press	
14	Henry Stommel Edward Goldberg	1969	Oceanography: An International Laboratory (letter)	Science	165	751	
15	Henry Stommel	1969	Review: Ocean currents, by G. Neumann, Elsevier 1968	Marine Geology	8	109-110	
16	Henry Stommel Arnold Arons	1971	On the abyssal circulation of the world ocean. Part V: Dynamics of deep western boundary currents	in preparation			



DENNIS WILSON MOORE  
Associate Professor, Theoretical Oceanography (on leave)

NOVA UNIVERSITY  
FORT LAUDERDALE, FLORIDA

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Born: May 12, 1939, Toledo, Ohio

Married: July 25, 1964, Carolyn Gail Greenough

Education:

1945-53	Durham, N. H. Public School, Grades 1-8.
1953-57	Phillips Exeter Academy, Exeter, N. H. Graduated Cum Laude, June, 1957.
1956-Summer	Pre-Collegiate Summer Studies Program. Roscoe B. Jackson Memorial Laboratory, Bar Harbor, Maine. Research in Tissue Culture.
1957	Admitted to Harvard College, Cambridge, Mass. Sophomore standing.
1957-58, 59-61	Harvard College, A.B. in Mathematics (Cum Laude in General Studies).
1961	Harvard University, Graduate School of Arts and Sciences. Committee on Applied Mathematics. M.A. (Applied Mathematics), February, 1963. Ph.D. (Applied Mathematics), June, 1968. Thesis: "Planetary Gravity Waves in an Equatorial Ocean," February, 1968.

Positions Held:

1959-Summer	Scientific Assistant aboard the U.S.N.S. Chain, from Athens, Greece to Woods Hole, Mass. Sound Velocity Measurements at Sea. W.H.O.I.
1960-Summer	Woods Hole Oceanographic Institution Summer Fellow. Research with Dr. Claes Rooth on the physics of the bursting of air bubbles at an air-sea interface. Informal Auditor in the W.H.O.I. Geophysical Fluid Dynamics Summer Course.



DENNIS WILSON MOORE

Positions Held (cont.)

1961-64	Proctor and Member of the Board of Freshman Advisors, Harvard College.
1963-68	Research Assistant to Prof. A.R. Robinson. Half-time during school year, full time in summer. Thesis research: "Free Planetary Waves in an Equatorial Ocean."
1968	Assistant Research Geophysicist, Institute of Geophysics and Planetary Physics, U.C.S.D., La Jolla, California.
1968-71	Assistant Professor, Nova University
1971-Present	Associate Professor, Nova University (on leave)

Publications:

1968	Is the Cromwell Current Driven by Equatorial Rossby Waves? By Walter Munk and Dennis Moore. <i>Journal of Fluid Mechanics</i> , <u>233</u> , 2, pp. 241-259.
1970	The Mass Transport Velocity Induced by Free Oscillations at a Single Frequency, <i>Geophysical Fluid Dynamics</i> , <u>1</u> , pp. 237-247.



Resume

D. James Baker, Jr.

Pierce Hall, Harvard University  
Cambridge, Massachusetts 02138

Personal Data

Address: 44B Sacramento St., Cambridge, Massachusetts 02138  
Telephone: (617) 495-2899  
Birthdate: March 23, 1937  
Birthplace: Long Beach, California  
Marital Status: Married  
Nationality: U.S.A.

Education

B.S. (Physics) Stanford University 1958. Honors Scholarship 1957-1958.  
Ph.D. Cornell University 1962. Major: Experimental Physics.  
Minors: Theoretical Physics and Mathematics. Honors Teaching  
Assistant, 1962. Thesis Title: "The Photoelectric K-absorption  
Cross Section of Helium and Lithium."

Experience

1958: Participated in expedition to Chatham Straits,  
Alaska with Applied Physics Laboratory,  
University of Washington (Summer).  
1959: Participated in "Dorado" expedition to North  
Equatorial Pacific with Scripps Institution of  
Oceanography (Summer).  
1962-63: Post-doctoral Fellow at University of Rhode  
Island and member of International Indian  
Ocean Expedition.  
1963-64: National Institutes of Health Fellow at  
University of California, Berkeley.



## Experience (Cont'd)

- 1964-66: Research Fellow in Geophysical Fluid Dynamics, Harvard University
- 1966-1970: Assistant Professor of Oceanography, Harvard University
- 1968-1969: Guest Investigator, Woods Hole Oceanographic Institution.
- Summer, 1970: Visiting Scholar, Woods Hole Oceanographic Institution.
- July 1, 1970 - Associate Professor of Physical Oceanography, Associate of the Center for Earth and Planetary Physics, Harvard University
- 1971: Joint chief investigator in "Aries" Expedition to Equatorial Pacific, member of "MODE" Scientific Council.

## Member Board of Editors of Geophysical Fluid Dynamics

## Grants and Awards

1. From Harvard Committee on Science Research Support: \$1400 for development of laboratory oceanography demonstrations.
2. From Charles H. Tozier Fund: \$330 for Deep-Sea Oceanography Film.
3. From National Science Foundation: \$180,300 for Deep-Sea Pressure Measurements in the MODE experiment of the International Decade of Ocean Exploration

## Societies

- Member of: American Geophysical Union  
American Association for the Advancement of Science  
American Association of University Professors

## Publications

1. "Continuous Photoelectric Absorption Cross Section of Helium," Physical Review 124 1471-1476 (1961) (With D. E. Bedo and D. H. Tombouliau).
2. "Photoelectric K-absorption Cross Section of Lithium," Physical Review 128 677-680 (1962) (with D. H. Tombouliau).
3. "Resource Letter PB-1 on Physics and Biology," American Journal of Physics 34 1-10 (1966).



Publications' (Cont'd)

4. "Time-dependence of Fluorescent Lamp Emission - A Simple Demonstration," American Journal of Physics 34 627-628 (1966).
5. "Demonstrations of Fluid Flow in a Rotating System," American Journal of Physics 34 647-652 (1966).
6. "A Technique for the Precise Measurement of Small Fluid Velocities," Journal of Fluid Mechanics 26 573-575 (1966).
7. "Shear Layers in a Rotating Fluid," Journal of Fluid Mechanics 29 165-175 (1967).
8. "A Demonstration of Magnification of Dynamic Topography at the Thermocline," Journal of Marine Research 26 283-285 (1968).
9. "Concerning the Existence of Taylor Columns in Atmospheres," Quarterly Journal of the Royal Meteorological Society 94 576-580 (1968). (with P. H. Stone).
10. "Demonstrations of Fluid Flow in a Rotating System II: The 'Spin-up' Problem," American Journal of Physics 36 980-986 (1968).
11. "The Use of Moire Fringes in Laboratory Oceanography," Journal of Marine Research 26 361-366 (1969).
12. "A Laboratory Model for the General Ocean Circulation," Philosophical Transactions of the Royal Society (London) A265 533-566 (1969) (with A. R. Robinson).
13. "Discussion of a Paper by D. L. Boyer," Trans ASME: J. Basic Eng. 92 Series D, 435 (1970).
14. "A Source-sink Laboratory Model of the Ocean Circulation," Geophysical Fluid Dynamics 2 17-30 (1971).
15. "Small Scale Mixing in the Ocean," to appear in Proceedings of the Symposium on Indian Ocean and Adjacent Seas, Cochin, India, 1971.
16. "Density Gradients in a Rotating Stratified Fluid: Experimental Evidence for a New Instability," Science 172 1029-1031 (1971).

Technical Reports

1. "An Attempt to Measure Light-Induced Dielectric Constant Changes in Biological Systems," Bio-Organic Chemistry Group Quarterly Report, Lawrence Radiation Laboratory, University of California, September, 1964.



Technical Reports (Cont'd)

2. "On the Design of Deep-Sea Pressure Transducers," Reports in Meteorology and Oceanography Number 3, Division of Engineering and Applied Physics, Harvard University, (December, 1968).
3. "On the History of the High Seas Tide Gauge," (a translation) Woods Hole Oceanographic Institution Technical Memorandum PO 5-69 (May, 1969).
4. "The Harvard Deep-Sea Pressure Gauge" Reports in Meteorology and Oceanography Number 4, Division of Engineering and Applied Physics, Harvard University, (November, 1971).

Popular Articles

1. "Laboratory Models of Ocean Circulation," Scientific American (January, 1970).
2. "Unrest in the Deep Sea," an article in the volume Oceanography - The Last Frontier (Basic Books, N.Y., 1971).



## Resume

Theodore E. Pochapsky, 29 Terrace Lane, Blauvelt, N. Y. 10913,  
Phone: 914 359-2187, Born: Sept. 15, 1916, Hazelton, Pa.

### EDUCATION:

B.S. in Engineering Physics, Ohio State University, 1939.  
Ph.D. in Physics, Columbia University, 1951.

### EXPERIENCE:

- Sept. 1968 - Present. Professor of Ocean Engineering, Henry Krumb School of Mines. Courses in engineering projects, design of experiments, physical oceanography. Research in ocean turbulence and internal waves.
- Apr. 1956-Sept. 1968. Associate Director in Oceanography, Hudson Laboratories, Columbia University, Dobbs Ferry, N. Y. Experimental work in physical oceanography with emphasis on the study of turbulence and internal waves in the ocean. Developed instrumented neutrally buoyant floats.
- Apr. 1955 - Apr. 1956, Physicist, De Lackner Helicopter Corp., Mt. Vernon, N. Y. Experimental and theoretical study of bonding of ceramic materials.
- Nov. 1954 - Apr. 1955. Consultant, Independent contract work. Mechanical design and servo work.
- 1953 - 1954. Development Engineer, Electromath Corp., White Plains, N. Y. Responsible for development and pilot production.
- 1951 - 1953. Instructor, Institute of Metals, University of Chicago, Chicago, Ill. Experimental work on general problem of vacancy concentration in metals near their melting points.
- 1939 - 1946. Research Engineer. Battelle Memorial Institute, Columbus, Ohio. Broad technical experience in large industrial research laboratory in fields of ceramics, heat, metallurgy and chemical engineering.

### PRESENT COMMITTEES:

Associate Editor, Journal of Physical Oceanography,  
Mode, IDOE, Scientific Council.

### PUBLICATIONS:

Several dozen publications on currents, internal waves, turbulence, and solid state physics.



Publications During the Last Five Years:

Pochapsky, T.E. and F.D. Malone, 1972: "Spectra Of Deep Vertical Temperature Profiles". J. Phys. Oceanogr., Vol. 2, No.4, Oct., 1972 pp. 470-475.

Pochapsky, T.E. and F.D. Malone, 1972: "A Vertical Profile of Deep Horizontal Current near Cape Lookout, North Carolina". J. Marine Res., Vol. 30, No. 2, May 15, 1972. pp. 163-167.

Pochapsky, T.E., 1971: "Internal Waves and Turbulence in the Deep Ocean". J. Phys. Oceanogr., Vol. 2, No. 1, January 1972, pp. 96-103.

Pochapsky, T.E. and F.D. Malone, 1970: "Changes Of Deep Horizontal Currents in The Ocean". Technical Report No. 1. Col. Univ. - Ocean Engr.

Stone, J. and T.E. Pochapsky, 1969: "Brillouin Scattering By Seawater". Limnology and Oceanography, Vol. 14, No. 5, Sept. 1969, pp. 783-787.

Pochapsky, T.E., 1968: "Currents and Temperature Stability Over the Antarctic Bottom Current at 10 N". Tellus, Vol. 21, pp. 715-723.

Pochapsky, T.E., 1968: "Oceanic Current and Temperature Gradients at 12 N, 27 W<sup>1</sup>". J. Geophys. Res., Vol. 73, No. 4, Feb. 15, 1968, pp. 1221-1237.