

Mid-Ocean Dynamics
Experiment
AC 42 Box + Folder 106

Dec. 1971 Proposal to Cooperative Oceanographic Program of Duke
Univ. requesting ship-time on the R/V Eastward 1972-1973
Co-Investigators: H.M. Stommel, D.W. Moore

RESEARCH PROPOSAL

Submitted To

THE COOPERATIVE OCEANOGRAPHIC PROGRAM OF DUKE UNIVERSITY

Requesting

Ship-time on R/V Eastward
during the period 1972-73

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

C. S. Cox, Scripps Institution of Oceanography

W. S. Richardson, Nova University

H. T. Rossby, Yale University

A. D. Voorhis, Woods Hole Oceanographic Institution

C. I. Wunsch, Massachusetts Institute of Technology

NO FUNDING REQUESTED

Henry M. Stommel

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Dennis W. Moore, Co-investigator, MODE Executive Officer
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Norman A. Phillips

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

December 1971

- 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 measuring techniques and devices.

- c. Abstract of proposed research:

During March through June 1973, a cooperative experiment to map out mesoscales of motion at 29°N, 70°W will be carried out by scientists from different institutions under the name MODE-I (Mid-Ocean Dynamics Experiment-I). A description of this experiment is given in the attached yellow book. As the time for this experiment approaches, several principals (from institutions which do not have ships of their own) find themselves in need of opportunities to test and evaluate new instruments and techniques in the MODE area. Originally it had been thought that the Woods Hole Buoy Group could accommodate these field trials on their regularly scheduled buoy cruises, but this now appears to be impossible. We think that some preliminary trials in the MODE area of our equipment are essential before the full scale experiment in early 1973.

- d. Description of proposed research and objectives:

Several different field trials are planned:

1. Launching and recovery of large SOFAR floats (Rossby of Yale, Voorhis of Woods Hole), testing the new Grand Turk listening station.
2. Dispersion experiment using cluster of small Swallow floats (Rossby of Yale) and vertical velocity profiler with STD's and Nansen bottles (Wunsch, MIT).
3. Comparison of vertically integrated velocity by Cox (Scripps) bottom-mounted electric field recorder and Richardson (Nova) air-expendable probes.
4. Comparison by Baker (Harvard) bottom-mounted pressure gauge, Rossby (Yale) inverted echo sounder, serial STD measurements, and Wunsch (MIT) moored temperature recorder.
5. All of these experiments to be done in the neighborhood of a long-term instrumental mooring that is maintained by the WHOI buoy group (independently

of this proposal).

e. Equipment needed from the Program:

1. All the equipment required for deep hydrographic stations to determine salinity and temperature to 5500 meters*.
2. Provision of winch on which our acoustic wire can be wound for STD work.
3. Precision depth recorder.
4. Deck crane capable of handling 1500 pounds.

f. Equipment provided by principal investigator:

1. Large SOFAR float.
2. Bottom pressure gauge.
3. Bottom electric field recorder.
4. Hydrophones and remote AMF command equipment.
5. Conducting cable and STD.
6. Small Swallow floats.
7. Inverted echo sounder.
8. Omega navigation set.

g. Time required to carry out proposed research:

We require two cruises of two weeks duration each, one in August, 1972 and the other in November, 1972. If no time is available in August, early September would be a suitable alternative. We estimate that it will take 3 or 4 days to get to and from the MODE-I area from Beaufort, so that each cruise will give us about 10 working days in the area.

h. Background and qualifications of principal investigator, co-investigator, and other personnel: Curricula vitae are attached.

*We will be able to supply some of this equipment ourselves if the Program does not possess it.

i. Preferred dates: Two weeks in August, 1972 and two weeks in November, 1972

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 experiments would obviously be in physical oceanography measurement techniques.

k. Outside Support:

<u>Investigator</u>	<u>Institution</u>	<u>Grant No.</u>
Henry Stommel Dennis Moore (MODE Executive Officer)	MIT	NSF GX-29051
James D. Baker, Jr.	Harvard	NSF GX-28846
Charles S. Cox	Scripps Inst. of Oceanography	NSF GA-31342
William S. Richardson	Nova University	NSF GX-29055
H. T. Rossby	Yale University	NSF GX-30416
Arthur Voorhis	Woods Hole Oceanographic Institution	NSF GX-30220
Carl Wunsch	MIT	NSF GX-29034

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

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

NOVA UNIVERSITY
FORT LAUDERDALE, FLORIDA

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. Journal of Fluid Mechanics, <u>233</u> , 2, pp. 241-259.
1970	The Mass Transport Velocity Induced by Free Oscillations at a Single Frequency, Geophysical Fluid Dynamics, <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).

VITA

Dr. Charles S. Cox

Dr. Cox received his B.A. degree in Physics from the California Institute of Technology in 1944, and his Ph.D. in Oceanography at Scripps Institution of Oceanography in 1954. From 1950 to 1954 he was appointed Assistant Research Oceanographer and promoted to Associate Professor in 1960, and has been serving as Full Professor since July of 1966. He holds memberships in the following societies: Sigma Xi, Royal Astronomical Society, American Geophysical Union, and Tau Beta Pi.

WILLIAM S. RICHARDSON

Nova University

Degrees:

ScB Brown University (Chemistry) - 1947.
PhD Harvard University (Chemistry) - 1950.
Thesis: Isotope Effects in Vibrational Spectra.

Positions Held:

Mellon Institute, Junior Fellow 1950-51, Senior Fellow 1951-52.
Polymer Structure.

Woods Hole Oceanographic Institution, 1952-63. Physical Oceanography
and Instrumentation.

University of Miami, Institute of Marine Science, 1963-66. Associate
Professor of Oceanography.

Nova University, 1966-Present. Professor of Oceanography.

Publications:

1950 With E. Bright Wilson, Jr., The Infra-Red Spectrum of ClC^{12}N and
 ClC^{13}N . J. Chem. Phys. 18, 155.

With R. A. Ogg, and M. K. Wilson, Experimental Evidence for the
Quasi-Unimolecular Dissociation of Nitrogen Pentoxide. J. Chem.
Phys. 18, 573.

With E. Bright Wilson, Jr., The Infra-Red Spectrum of $\text{N}^{15}\text{N}^{14}\text{O}$ and
the Force Constants of Nitrous Oxide. J. Chem. Phys. 18, 694.

With J. H. Goldstein. The Infra-Red Spectrum of Chloroacetylene
and Deuteriochloroacetylene. J. Chem. Phys. 18, 1314.

1951 The Infra-red Spectrum of DC^{12}N and DC^{13}N . J. Chem. Phys. 19, 1213.

1953 With A. Sacher, Infrared Examination of Various Polyisoprenes.
J. Polymer Sci. 10, 353.

1954 The Microstructure of Diene Polymers. I. Polyisoprenes and
Polybutadienes Prepared at High Temperatures. J. Polymer Sci. 13,
229.

- 1954 The Microstructure of Diene Polymers. II. Polyisoprenes and Polybutadienes Prepared at High Pressures. J. Polymer Sci. 13, 321.
- The Microstructure of Diene Polymers. III. Polyisoprenes and Polybutadienes Prepared with Cationic Catalysts. J. Polymer Sci. 13, 352.
- With W. S. vonArx, H. Stommel, and D. Parsons. A Radio Aerial Survey of the Gulf Stream with Camera and Radiation Thermometer. Science 117, 639.
- 1955 With W. S. vonArx, and D. F. Bumpus. On the Fine Structure of the Gulf Stream Front. Deep-Sea Research 3, 46.
- 1956 Note on a Temperature-Depth Measurement. Deep-Sea Research 3, 289.
- 1958 With C. H. Wilkins. An Airborne Radiation Thermometer. Deep-Sea Research 5, 62.
- 1960 With Charles J. Hubbard. The Contouring Temperature Recorder. Deep-Sea Research, 6 239-244.
- 1963 With Paul Stimson and Charles Wilkins. Current Measurements from Moored Stations. Deep-Sea Research 10, 369.
- 1965 With William J. Schmitz, Jr. A Technique for the Direct Measurement of Transport with Application to the Straits of Florida. J. Mar. Research 23, 172.
- 1967 With James R. Finlen. The Transport of Northwest Providence Channel. Deep-Sea Research 14, 361-367.
- 1968 With William J. Schmitz, Jr. On the Transport of the Florida Current. Deep-Sea Research 15, 679-693.
- 1969 With A. R. Carr and H. J. White. Description of a Freely Dropped Instrument for Measuring Current Velocity. J. Mar. Research 27 (1), 153-157.
- With William J. Schmitz, Jr. and Pearn P. Niiler. The Velocity Structure of the Florida Current from the Straits of Florida to Cape Fear. Deep-Sea Research, Supplement to Vol. 16, 225-231.
- 1970 With R. O. Plaisted. Current Fine Structure in the Florida Current. J. Mar. Research 28 (3), 359-363.
- 1971 With Frank Chew. A Comparison of Direct and Electrical Current Measurements in the Florida Current. J. Mar. Research (in press).
- With William V. Kielhorn and F. P. Burke, Jr. Bathythermograph Measurements from Fixed Wing Aircraft. Mar. Tech. Soc. J. (in press).

HANS THOMAS ROSSBY

CURRICULUM VITAE

Date of Birth: 8 June 1937

Place of Birth: Boston, Massachusetts

1937-1947: Resided in Chicago

1947-1962: Resided in Sweden

Education: Sigtunaskolan, Sigtuna, Sweden (1951-1957)
 Royal Institute of Technology, B.S. Applied Physics, 1962
 Bachelor's thesis at Swedish National Defense Research Institute on the development of an expandable multilevel pulseheight analyzer.
 Massachusetts Institute of Technology, Ph.D. Oceanography, 1966

Languages: Swedish (fluent), French and German

Married: Adrienne Birgitta Ribbing, 28 December 1962

Children: Sten Erling, born 24 May 1964
 Björn Lindorm, born 8 November 1968

Publications: On Thermal Convection-Driven by Non-Uniform Heating from Below: An Experimental Study. Deep-Sea Research, 12, 1965, pp. 9-16
 A Study of Benard Convection with and without Rotation. J. Fluid Mech., 1969, 36, pp. 300-335.
 A Vertical Profile of Currents Near Plantagenet Bank. Deep-Sea Research, 1969, 16, 377-388
 On Monitoring Depth Variations of the Main Thermocline Acoustically. J.G.R., 74, 1968, pp. 5542-5546
 Observing Abyssal Motions by tracking Swallow floats in the Sofar Channel. (With D. Webb) Deep-Sea Research, 17, 1970, pp. 359-365

Ph.D. Thesis: An Experimental Study of Benard Convection with and without Rotation.

Employment: 1961-1962, Research Assistant, The Swedish National Defense Research Institute
 1962-1966, Research Assistant, Massachusetts Institute of Technology
 1966-1968, Research Associate, Massachusetts Institute of Technology
 1968- , Assistant Professor, Yale University

ARTHUR D. VOORHIS
Physical Oceanographer
Associate Scientist
Woods Hole Oceanographic Institution

Birth: March 9, 1925

B.A., Cornell University, 1948

Ph.D., Yale University, 1954

Assistant, 1948-49; Assistant in Research, 1952-53, Yale University

Research Physicist, 1954-57, Westinghouse Electric Corporation

Research Associate, 1957-63; Associate Scientist, 1963 to present, Woods Hole Oceanographic Institution

Research in Physics: Low temperature physics, second sound transmission in liquid He II; neutron diffusion in reactors

Research in Oceanography: Hydrodynamics, internal waves and temperature fluctuations; thermal fronts at the sea surface; Gulf Stream; turbulence; underwater sound

Author or co-author of 15 scientific publications in physical oceanography, underwater sound, and neutron diffusion problems

November, 1971

CARL WUNSCH

CURRICULUM VITAE

Date of Birth: May 5, 1941

Place of Birth: Brooklyn, New York

Education: Staples High School, Westport, Connecticut
Massachusetts Institute of Technology
S.B. in Mathematics, June, 1962
Ph.D. in Geophysics, September, 1966

Experience: Research Assistant, MIT, Project Vela
Uniform, 1962-1963
Lecturer in Oceanography, MIT, 1966-1967
Assistant Professor of Oceanography, MIT
1967-1970
Associate Professor of Oceanography, MIT
1970-present

Honors: Sigma Xi
James B. Macelwane Award, American
Geophysical Union

Professional Groups: American Geophysical Union

CARL WUNSCH

PUBLICATIONS

- (1) The Multiple Spectral Factorization Procedure of Wiener and Masani, in IEEE Transactions on Information Theory, April, 1965, 11, pp. 175-182.
- (2) The Long-Period Tides, Reviews of Geophysics, November, 1967, 5, pp. 447-475.
- (3) On the Propagation of Internal Waves Up A Slope, Deep-Sea Research, April, 1968, 15, pp. 251-258.
- (4) Progressive Internal Waves On Slopes, Journal of Fluid Mechanics, January, 1969, 35, pp. 131-145.
- (5) Fluctuations of the Florida Current Inferred from Sea Level Records, (with D. Hansen and B. Zetler), Deep-Sea Research, August, 1969, Supplement to Vol. 16 (Fuglister Vol.), pp. 447-460.
- (6) Resonant Internal Wave Interactions, Nature, 1969, 224, pp. 1014-1016, (with S. Martin and W. Simmons).
- (7) Array Measurements of Oceanic Internal Waves, 1969, Transactions of the New England Regional Meeting of the Institute of Electrical and Electronics Engineers, Vol. II, pp. 168-169.
- (8) On Oceanic Boundary Mixing, 1970, Deep-Sea Research, 17, pp. 293-301.
- (9) Preliminary Results of Internal Wave Measurements in the Main Thermocline at Bermuda (with J. Dahlen), 1970, Journal of Geophysical Research, 75, 5899-5908.
- (10) Note on some Reynolds stress effects of internal waves on slopes, 1971, Deep-Sea Research, 18, 583-592.
- (11) Internal Waves - Quadrennial Review For XVth General Assembly, IUGG, Moscow, 1971, EOS, 52, 233-235.
- (12) The generation of resonant triads by single internal waves, (with S. Martin and W. F. Simmons), 1971, to be published.

- (13) Temperature Microstructure on the Bermuda slope, with application to the mean flow, to be published.
- (14) Bermuda sea level in relation to tides, weather, and baroclinic fluctuations, 1972, Revs. Geophys. and Space Phys. (in press).
- (15) Experimental study of internal waves on a slope, (with D. Cacchione), 1971, to be published.
- (16) Measurements with a current meter array on the continental slope (with R. Hendry) in preparation.