Mid-Ocean Dynamics
Experiment
AC 42 Box 1 Folder 77

n.d. "The Production of Mesoscale Oceanic Motions by Atmospheric Forcing over Strong Topographic Features"
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INFORMAL VERSION

A PROPOSAL TO

THE NATIONAL SCIENCE FOUNDATION

INTERNATIONAL DECADE OF OCEAN EXPLORATION

THE PRODUCTION OF MESOSCALE OCEANIC MOTIONS BY ATMOSPHERIC FORCING OVER STRONG TOPOGRAPHIC FEATURES

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THE PRODUCTION OF MESOSCALE OCEANIC MOTIONS BY ATMOSPHERIC FORCING OVER STRONG TOPOGRAPHIC FEATURES.

The MODE-I area is bounded on the west and south by regions of strong topography. The Blake Escarpment and the Bahama Escarpment have slopes as large as .1 - .2, and appear on the topographic charts as virtual cliffs. Figure 1 is taken from the Bathymetric Atlas of the Atlantic, Caribbean, and Gulf of Mexico compiled by Elazar Uchupi at W.H.O.I. (unpublished manuscript). We know that these charts are very inaccurate for the detailed topography of the MODE-I area itself, but they should be sufficiently accurate to assess the horizontal scales and slopes of the major topographic features. The broad Blake-Bahama Outer Ridge has bottom slopes one or two orders of magnitude less than the escarpments, and the large scale slope of the Hatteras Abyssal Plain is smaller by another order of magnitude. The parameter $s = f|\nabla H|/\beta H$, where H is the depth below the main thermocline, $|\nabla H|$ the bottom slope, and f/β= earth's radius/cotangent(latitude) , is a measure of the relative importance of slope to β effects. (Dynamics and the Design of MODE-I, p.13.) For the MODE-I area s=O(1), for the Blake-Bahama Outer Ridge s=O(10), and for the Blake Escarpment s=O(100) or greater.

The wind systems acting on this portion of the ocean are very seasonal. In the summer not much is going on. In the winter the main storm track over North America moves south, and the weather on the S.E. coast of the U.S. is characterized by the passage of a series of high and low pressure areas, with horizontal wave lengths on the order of 4000 kilometers. The highs are more intense than the lows, and are asymmetric. The leading edge of the high pressure area is characterized by intense winds from the north. The width of these strong northerly wind regions is comparable to the width of the Outer Ridge. The southerly winds accompanying the lows are not as strong. Typical periods for the passage of such systems are from four days (Prof. Saunders' estimate) to seven or ten days (Estimate of Prof. Niiler, long time Florida resident). Of course not all the "northers" are equally strong, so the effective forcing may consist of a few days of strong wind from the north once or twice a month. If this proposal is accepted the first undertaking of one of us (D. Moore) will be to study the weather map file at M.I.T. to get some accurate estimates concerning the time and space scales as well as amplitudes of the real winds acting in the area. (The description of the wind systems as given in this paragraph is a personal communication from Prof. F. Saunders of M.I.T. to D. Moore)

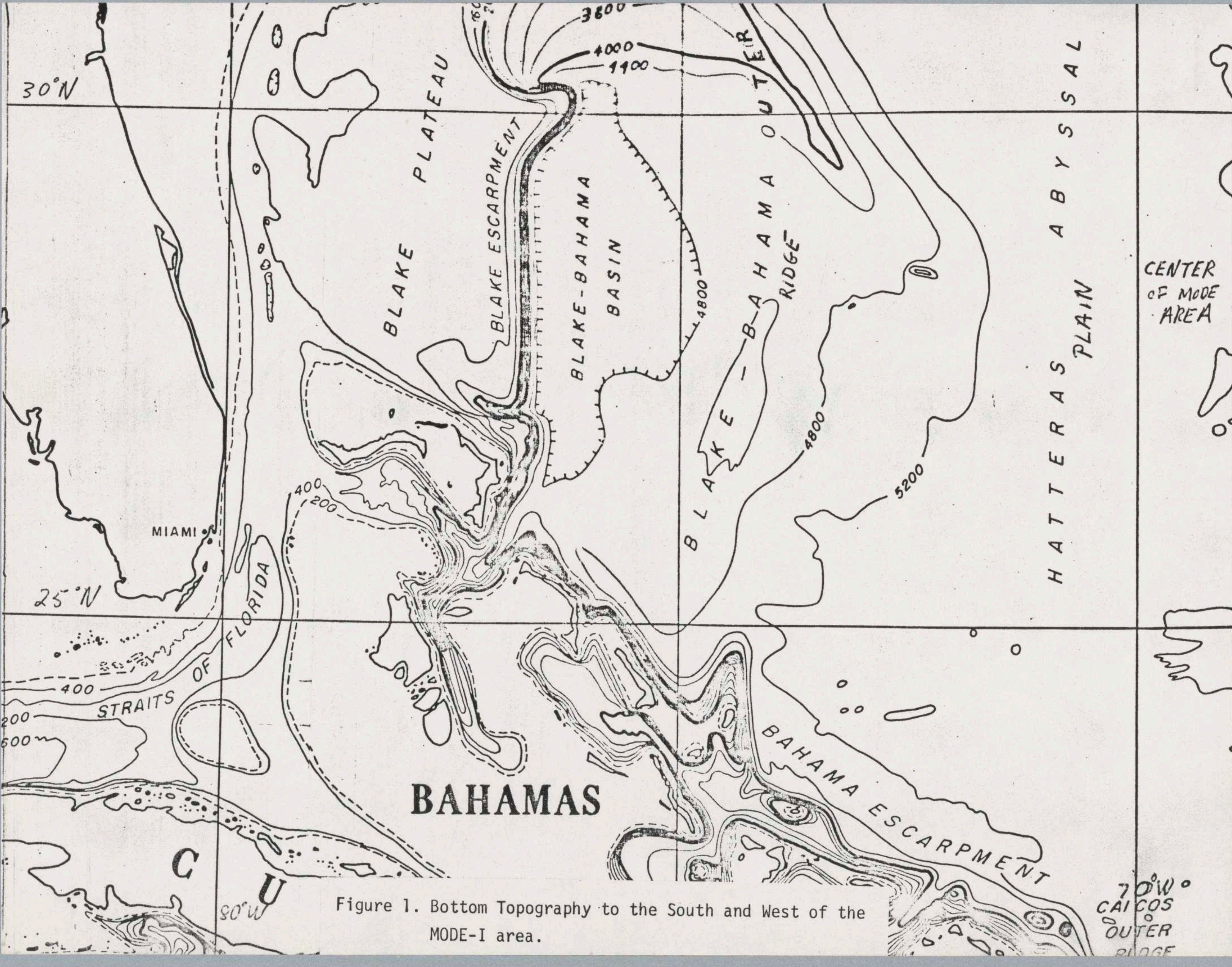

Figure 1. Bottom Topography to the South and West of the MODE-I area.

The problem we wish to investigate is the influence of the strong topographic features described at the beginning of this proposal on the oceanic mesoscale. We wish to assess both the locally forced motions due to the prevailing wind systems and the effect of strong topography in reflecting or scattering incoming topographic Rossby waves. Of particular interest are mechanisms for generating "generalized baroclinic" motions. A hierarchy of models will be used to study a series of forced and free problems. Initially we will use a two layer model in which the wind stress is taken to act as a body force on the top layer. The first generalization of this will be a three layer model (suggested by A.R.Robinson) in which a surface mixed layer of constant density is separated from the deep layer (also of constant density) by a linearly stratified layer to model the main thermocline. In this model the wind will be taken to act as a body force in the surface mixed layer.

A variety of simple bottom topographies will be investigated to assess the influence of the Outer Ridge on motions over the Abyssal Plain, and to assess the influence of the Blake Escarpment on the motions over the Outer Ridge. The situation to the south where the Abyssal Plain is bounded directly by the Bahama Escarpment without an intervening ridge will also be investigated. In each case both locally forced and free reflection problems will be solved.

If the preliminary results are encouraging we will collaborate with Peter Rhines (W.H.O.I.) and use his two layer numerical model with the actual topography of the extended MODE-I region. We will use the best estimates we can make of the actual wind stress, and attempt to relax some of the constraints on the present numerical model. One big numerical problem, already encountered by Myrl Hendershott, has to do with properly inverting the operator $(\Psi_x/H)_x + (\Psi_y/H)_y$ instead of simply inverting $\Psi_{xx}+\Psi_{yy}$. For strong topography the former operator is certainly the one we must use.

The width of the escarpments is somewhat less than the internal Rossby radius of deformation. The Outer Ridge is approximately 500 km. wide, which is O(10) Rossby radii. Somewhere in the region we expect that the topographic features in consort with the broad scale winds will generate significant shears across the main thermocline. These may be trapped near the strong topography unless the forcing frequency is sufficiently low. But in any case the inluence of the real topography on incoming "generalized barotropic" and "generalized baroclinic" topographic Rossby waves must be important for understanding what is going on in the MODE-I area, and the directly forced motions, if not very relevant to MODE-I, must be understood if an experiment on the scale of MODE-II is to be undertaken.

The principal investigators on this project plan to present a preliminary model in detail at the Theoretical Panel meeting on March 15, and discuss a sample calculation. This will be encorporated in the formal proposal.

BUDGET

A. Salaries

Dr. P. P. Niiler	1 summer month	$ 2,400
Dr. D. W. Moore	25% Academic Year	4,300
Dr. M. Spillane	30% Academic Year	4,000
	TOTAL	$ 10,700

B. Fringe Benefits and F.I.C.A.
@ 13% of Salaries — $ 1,391

C. Indirect Costs
@ 74.6% of Salaries — $ 7,982

D. Computing Services (12 hours @ $ 250/hr.) — $ 3,000

E. Travel

2 Computing Trips to NCAR	$ 1,500
4 Meeting and consultation Trips	$ 1,500
GRAND TOTAL	$ 26,073