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Woods Hole Oceanographic Institution

NEW ENGLAND SHELF/SLOPE EXPERIMENT
(FEBRUARY TO AUGUST, 1976)
DATA REPORT: THE MOORED ARRAY

by

Hsien Wang Ou
John A. Vermersch
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TECHNICAL REPORT

*Prepared for the National Science Foundation
under Grants OCE 76-01813, OCE 78-19513,
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Approved for Distribution

Valentine Worthington, Chairman
Department of Physical Oceanography

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January 1980

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ABSTRACT

The New England Shelf/Slope Experiment (NESS76) was conducted from February to August in 1976 over the continental margin south of the New England coast. The initial objective of the experiment was to examine the kinematic and dynamic coupling of the low frequency oceanic motions between the outer New England shelf and the deeper slope/rise regions; and in particular, to monitor simultaneously the current, temperature, and bottom pressure fluctuations across the New England continental margin. The field program contained several components: (1) a six-month moored array to monitor current, temperature, and bottom pressure; (2) two hydrographic cruises conducted around the moored array; (3) a collection and synthesis of the synoptic meteorological data; and (4) detailed bathymetric surveys conducted around the deeper moorings.

The two hydrographic cruises were conducted during May 11-21 and August 12-23 of 1976, and the initial results from the cruises have been reported elsewhere by Limeburner, Vermersch, and Beardsley (1978). Only the moored array and the meteorological data will be presented here.

1. Introduction

Recent field experiments (summarized in Appendix A, Beardsley, Boicourt and Hansen (1976)) show that the low-frequency (subtidal) currents over the shallower, nearshore zone of the Middle Atlantic Bight are essentially wind-driven, especially during wintertime. A few limited current measurements made by Flagg, Vermersch and Beardsley (1976) over the deeper, middle and outer New England shelf region suggest that the energetic low-frequency current variability observed there may be generated by transmission (or leakage) of energy from the continental rise region across the slope rather than by local or regional meteorological forcing. There have been theoretical studies related to this hypothesis. For example, Niiler and Kroll(1976) have developed an analytical model for the transmission of topographic Rossby wave energy across a continental margin in a homogeneous ocean. Also Suarez (1971) has examined the effect of small bottom slope changes on the propagation of topographic Rossby waves in a baroclinic ocean.

In order to assess more critically the applicability of the above models and to provide a data base for the later efforts of developing a more accurate model, this New England Shelf/Slope Experiment (NESS76) was conducted in 1976 to monitor simultaneously the oceanic motions across the continental margin south of the New England coast. The New England continental margin was chosen as the experimental site

since the theoretical model of Niiler and Kroll (1976) is directly applicable there and some of the important features of the low frequency motion over the rise region are relatively well known (e.g. Schmitz, 1974; Thompson, 1971). The field program contained several components: (1) a six-month moored array to monitor current, temperature, and bottom pressure; (2) two hydrographic cruises conducted around the mooring array; (3) a collection and synthesis of the synoptic meteorological data; and (4) detailed bathymetric surveys conducted around the slope and rise moorings.

The first hydrographic survey was conducted during May 11-21, 1976 on cruise 2B76 of the R/V Eastward, and the second survey during August 12-23, 1976 on cruise 13-3 of the R/V Oceanus. In general, alternate CTD and XBT stations were made approximately every 5 nautical miles along a cruise track which zigzagged on and off the continental shelf and Georges Bank. The initial results from the cruises have been reported elsewhere by Limeburner, Vermersch, and Beardsley (1978). Only the moored array and the meteorological data will be presented here.

Some of the data presented here have been discussed by Ou (1979), and Ou and Beardsley (1980). A more detailed analysis of the data is currently under preparation.

2. The Moored Current Meter Array Program

The principal component of the field experiment is a moored current meter array located on the outer continental shelf, slope and rise region south of New England. The location of the moored array is shown in Fig. 1; the individual moorings have been designated as "NEq" where the integer q increases with increasing depth. The array consisted of a linear five-element subarray oriented across the shelf, slope and rise and three additional elements oriented along the 500-m and 85-m isobaths. The principal subarray, moorings NE2 through NE5, was designed to (a) measure the low-frequency current variability and kinetic energy distribution from the rise to the shelf, and (b) study the horizontal and vertical structure of the current field over the outer shelf and upper slope at moorings NE2 and NE3. The two subarrays, moorings NE3E, NE3, and NE3W, and moorings NE2 and NE2W, were intended to measure the along-isobath structure of the low frequency current over the outer shelf and upper slope.

A total of 12 VACM's were deployed, seven supplied by the W.H.O.I. Buoy Group, and five from Nova University. The placement of the current meters within the array is shown schematically in Fig. 2. The nominal measurement depths chosen were 40, 75, 150, 300 and 2000 meters. All current meters were set using subsurface floatation and either chain (NE2, NE2W) or wire rope. The shallower moorings (NE1, NE2, and NE2W) were

deployed without an acoustic release, using instead a ground line retrieval scheme. Two large surface markers were set straddling the subsurface scientific mooring. The deeper moorings were deployed with acoustic releases using the standard W.H.O.I. Buoy Group deep-water mooring techniques. For several reasons (including both source of current meters and relative security of the moorings), two separate instrument moorings were actually deployed at NE3: a deep mooring NE3A containing two VACM's at 300 m and 150 m and a shallower mooring NE3B containing two VACM's at 75 m and 40 m. This latter mooring (NE3B) was set with two acoustic releases in parallel and though still in place during the mid-April topographic survey cruise, could not be found during the recovery cruise in August. This loss, coupled with the instrumental failure at NE3E and the partial failure at NE3A, has severely reduced our ability to describe both the vertical and along-isobath current variability over the upper slope region. The actual mooring locations, instrument depths and identification numbers, dates of deployment and recovery, data return and other relevant information of the experiment are summarized in Table 1. The duration of the experiment and the data with good quality are shown schematically in Fig. 3.

3. The Bottom Pressure Array Program

The bottom pressure array consisted of a shelf instrument (PICKET), two upper slope instruments (KELVIN and KIWI), and a single deep instrument (REIKO). The two gauges at KELVIN and KIWI were designed to measure the along-isobath pressure gradient over the continental slope just beyond the shelf break, and the three gauges PICKET, KELVIN, and REIKO were designed to (a) explore the relationship between the low frequency pressure fluctuations observed on the shelf and over the New England continental slope; (b) estimate the cross-isobath pressure gradients; and (c) study the relationship between the pressure field observed over the New England continental margin and the subsurface pressure (SSP) fluctuations observed at Bermuda. The last question has been raised by the results from the Mid-Ocean Dynamics Experiment (Brown, Munk, Snoggrass, Mofjeld, and Zetler, 1975). W. Brown was responsible for the three shallow instruments and M. Wimbush (Nova University) furnished the deep sea gauge. The locations of these instruments are also shown in Figs. 1 and 2. With the exception of REIKO, which used a Hewlett-Packard quartz pressure gauge, all instruments used the Paroscientific Digiquartz pressure sensor. PICKET, KELVIN, and KIWI were deployed in March, serviced in May, and then redeployed. REIKO was deployed in May. Due to malfunction of the tape recorders, there were short records from PICKET and KIWI, and no data from REIKO. Relevant information pertaining to the bottom pressure measurements is also included in Table 1 and Fig. 3.

4. The Meteorological Program

A sequence of six-hourly synoptic surface pressure charts for the Northern hemisphere has been obtained from the Boston Marine Forecast Center at Logan Airport for the duration of the experiment. These charts have been analyzed by J. Chase and R. Limburner to give a time series of surface wind speed (to the nearest 5 knots) and direction (to the nearest 10) at the designated location shown by the triangle in Fig. 1. The wind stress time series was then calculated from this estimated surface wind data using a quadratic drag law with a drag coefficient of 1.22×10^{-3} .

5. Data Processing

The current meter data was transcribed and decoded from digital cassettes for processing. The time series was examined for obviously erroneous values, and bad points were replaced with linearly interpolated values. The resultant hour-averaged data were further low passed by the PL33 digital filter (Flagg, et al. 1976) to remove tidal and other high frequency fluctuations. Except for the auto-spectra shown in Fig. 6 through 9, and the statistics shown in Table 2 and 3, the low-passed data are used throughout this report.

6. Data Presentation

All the times used in this report refer to Greenwich Mean Time.

Detailed Bathymetric surveys have been conducted around the slope and rise moorings during the experiment, shown by the rectangles in Fig. 1. Close-ups of the topography are shown in Fig. 4. The arrows indicate the estimated trend of local topography at the mooring site. At other mooring locations, the topographic trend was estimated from the larger scale bathymetric chart of Uchupi (1965). The estimated topographic trend are shown by the dashed arrows in Fig. 1. The longshore and onshore directions used in Table 4 are referred to these arrows.

The data are presented in a fairly standard format. Readers are referred to the List of Tables and Figure Captions for the more detailed descriptions.

The deeper moorings correspond to the following W.H.O.I. Buoy Group mooring numbers:

NE3A.....587,

NE4.....588,

NE5.....589,

NE3W.....590.

7. Acknowledgements

This experiment was made possible by the support and assistance of many individuals and groups. The W.H.O.I. Buoy Group and P. Bedard of Nova University supplied the VACM's. M. Wimbush of Nova University supplied the deep sea pressure gauge. Mooring deployments and recoveries were carried out with the help of the W.H.O.I. Buoy Group and the U. S. Geological Survey on the following vessels: NOAA ship George B. Kelez, M/V Whitefoot, R/V Subsig II, R/V Oceanus, and R/V Eastward. Hydrographic cruises were conducted in collaboration with B. Butman of the U.S.G.S. on the R/V Oceanus and R/V Eastward using the U.S.G.S. CTD profiling equipment. We gratefully acknowledge the assistance given us by the officers and crews of these vessels. The meteorological data was collected by F. Faller of M.I.T., and was compiled and analyzed by J. Chase and R. Limeburner of W.H.O.I.

This work has been supported at Woods Hole Oceanographic Institution by the National Science Foundation under grant numbers OCE 76-01813 and OCE 78-19513. The bottom pressure program was directed by W. Brown, who was supported by the National Science Foundation under grant numbers OCE 76-2590 and OCE 76-02190.

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MOORING I.D.	LAT. (N)	LONG. (W)	WATER DEPTH (m)	DATE OF DEPLOY.	DATE OF RECOV.	INST. I.D.	INST. DEPTH (m)	INST. TYPE	CONDITION OF DATA
NE1	40°43.2'	71°18.6'	60	23 MAR.	28 APR.	PICKET/A	69.3	T-P	O.K.
	40°43.1'	71°19.2'		13 MAY	10 JUN.	PICKET/B	69.6		short, tape recorder malfunction
NE2	40°21.7'	71°12.0'	83	17 FEB.	23 AUG.	NE21	38	VACM	short record, rotor fouling
						NE22	73	VACM	short record, rotor fouling
NE2W	39°58.9'	71°57.4'	83	17 FEB.	9 AUG.	NE2W1	38	VACM	O.K.
NE3A	39°56.1'	71°02.9'	496	9 FEB.	7 AUG.	NE31	146	VACM	O.K.
						NE32	296	VACM	no speed, rotor lost shortly after deployment
						KELVIN/A	516.7	T-P	O.K.
NE3B	39°56.8'	71°01.9'	501	9 FEB.	8 AUG.	KELVIN/B	522.1		
						NE3B1	41	VACM	no data, mooring lost
NE3W	39°42.5'	71°47.0'	504	10 FEB.	9 AUG.	NE3B2	76	VACM	
						NE3W1	304	VACM	O.K.
NE3E	39°54.7'	69°23.4'	500	5 MAR.		NE3E1	300	VACM	no data, mooring lost
						KIWI/A	511.1	T-P	O.K.
						KIWI/B	499.5		short, tape recorder malfunction
NE4	39°36.8'	70°56.5'	2300	10 FEB.	6 AUG.	NE41	300	VACM	O.K.
						NE42	2000	VACM	O.K.
NE5	39°16.7'	70°48.9'	2650	10 FEB.	6 AUG.	NE51	2000	VACM	O.K.
						REIKO	2650	T-P	no data, tape recorder malfunction

Table 1.

KIWI A

KELVIN A

PICKET A

```

*****
VARIABLE * TEMPERATURE
UNITS * DEGREES C
*****
MEAN * 5.476
STD. ERR. * .107E-1
VARIANCE * .110
STD. DEV. * .331
KURTOSIS * 2.445
SKEWNESS * .225
MINIMUM * 4.653
MAXIMUM * 6.528
*****
VARIABLE * PRESSURE
UNITS * DB
*****
MEAN * 519.038
STD. ERR. * .972E-2
VARIANCE * .110
STD. DEV. * .331
KURTOSIS * 1.829
SKEWNESS * .791E-1
MINIMUM * 518.314
MAXIMUM * 519.870
*****

```

```

*****
* SAMPLE SIZE = 125 POINTS
* SPANNING RANGE
* FROM 76- 11-25 16:00:00
* TO 76- V-11 21:00:00
* DURATION 50-21 DAYS
*****

```

```

*****
* SAMPLE SIZE = 1146 POINTS
* SPANNING RANGE
* FROM 76- 11-24 15:00:00
* TO 76- V-12 27:00:00
* DURATION 48-54 DAYS
*****

```

```

*****
* SAMPLE SIZE = 975 POINTS
* SPANNING RANGE
* FROM 76- 11-23 16:00:00
* TO 76- IV-28 16:00:00
* DURATION 30-00 DAYS
*****

```

KIWI B

KELVIN B

PICKET B

```

*****
VARIABLE * TEMPERATURE
UNITS * DEGREES C
*****
MEAN * 5.500
STD. ERR. * .197E-2
VARIANCE * .163E-1
STD. DEV. * .403
KURTOSIS * 1.228
SKEWNESS * .179E
MINIMUM * 4.953
MAXIMUM * 6.443
*****
VARIABLE * PRESSURE
UNITS * DB
*****
MEAN * 524.391
STD. ERR. * .115
VARIANCE * .345
STD. DEV. * 1.895
KURTOSIS * 523.108
SKEWNESS * 523.180
MINIMUM * 522.180
MAXIMUM * 525.180
*****

```

```

*****
* SAMPLE SIZE = 649 POINTS
* SPANNING RANGE
* FROM 76- V-15 03:00:00
* TO 76- VI-12 05:00:00
* DURATION 27-83 DAYS
*****

```

```

*****
* SAMPLE SIZE = 21-2 POINTS
* SPANNING RANGE
* FROM 76- V-13 06:00:00
* TO 76- VII-08 17:00:00
* DURATION 87-54 DAYS
*****

```

```

*****
* SAMPLE SIZE = 487 POINTS
* SPANNING RANGE
* FROM 76- V-13 20:00:00
* TO 76- VI-10 19:00:00
* DURATION 28-58 DAYS
*****

```

Table 3.

INST. I.D.	DATA LENGTH (DAYS)	TOPO. ORIENT. (DEG FROM E)	MEAN FLOW ORIENT. (DEG FROM E)	COMPONENT	MEAN (CM/SEC)	STD. DEV. (CM/SEC)	INTEGRAT. TIME SCALE (DAYS)	STD. ERR. (CM/SEC)
NE21	131.79	23.2	-173.62	LONGSHORE	-5.79	6.89	5	1.34
				ONSHORE	1.75	4.05	3	0.61
NE22	67.79	23.2	-159.24	LONGSHORE	-3.99	8.94	5	2.43
				ONSHORE	0.17	3.10	3	0.65
NE2W1	168.58	32.4	-158.65	LONGSHORE	-5.99	8.24	5	1.42
				ONSHORE	1.17	3.20	3	0.43
NE31	176.96	15.9	95.89	LONGSHORE	0.27	10.19	10	2.42
				ONSHORE	1.53	5.13	10	1.22
NE3W1	179.75	43.0	57.77	LONGSHORE	1.29	7.15	10	1.69
				ONSHORE	0.34	2.96	10	0.70
NE41	177.25	20.0	-168.70	LONGSHORE	-3.66	6.35	10	1.51
				ONSHORE	0.56	3.91	5	0.66
NE42	177.25	20.0	-174.77	LONGSHORE	-3.30	4.84	10	1.55
				ONSHORE	0.87	2.00	5	0.34
NE51	176.75	1.0	-176.79	LONGSHORE	-1.81	2.99	10	0.71
				ONSHORE	-0.07	1.77	5	0.30

Table 4.

INST. I.D.	STARTING TIME	ENDING TIME	DATA LGTH. (DAYS)	MEAN (° C)	MIN. TEMP. (° C)	MAX. TEMP. (° C)	STD. DEV. (° C)	STD. ERR. (° C)
NE21	23 FEB.	24 AUG.	185	7.923	5.138	12.051	1.683	0.025
NE22	23 FEB.	24 AUG.	185	9.046	6.787	11.386	1.139	0.017
NE2W1	23 FEB.	10 AUG.	171	8.096	6.064	12.392	1.480	0.023
NE31	11 FEB.	7 AUG.	180	12.669	11.943	13.206	0.233	0.004
NE32	11 FEB.	7 AUG.	180	8.733	7.881	9.692	0.306	0.005
NE3W1	12 FEB.	9 AUG.	181	8.544	7.422	9.445	0.361	0.006
NE41	11 FEB.	7 AUG.	180	9.066	7.644	10.315	0.476	0.007
NE42	11 FEB.	7 AUG.	180	3.462	3.346	3.615	0.054	0.0008
NE51	12 FEB.	6 AUG.	178	3.450	3.378	3.525	0.028	0.0004

Table 5.

Figure 1.

Figure 2.

1976

FEB MAR APR MAY JUN JUL AUG

PICKET

T,P

NE21

V

NE22

V

NE2W1

V

NE31

V

NE32

T

KELVIN

T,P

NE3W1

V

KIWI

T,P

NE41

V

NE42

V

NE51

V

REIKO

T,P

Figure 3.

Figure 4.

NESBWS WIND
76-11-10 TO 76-VI-23
1 PIECES WITH 270 ESTIMATES
PER PIECE. AVERAGED OVER
6 ADJACENT FREQUENCY BANDS

Figure 5.

NE21A1H 38 METERS
76-11-23 TO 76-VI-30
1 PIECES WITH 1536 ESTIMATES
PER PIECE. AVERAGED OVER
6 ADJACENT FREQUENCY BANDS

Figure 6a.

NE22A1H 73 METERS
76-11-23 TO 76-IV-30
1 PIECES WITH 810 ESTIMATES
PER PIECE. AVERAGED OVER
6 ADJACENT FREQUENCY BANDS

Figure 6b.

NE2W1A1H 38 METERS
76-11-22 TO 76-VIII-10
1 PIECES WITH 2048 ESTIMATES
PER PIECE. AVERAGED OVER
6 ADJACENT FREQUENCY BANDS

Figure 6c.

NE31A1H 145 METERS
76-II-10 TO 76-VII-29
1 PIECES WITH 2048 ESTIMATES
PER PIECE AVERAGED OVER
6 ADJACENT FREQUENCY BANDS

Figure 6d.

NE3W181H 302 METERS
76-11-10 TO 76-VIII-08
1 PIECES WITH 2160 ESTIMATES
PER PIECE. AVERAGED OVER
6 ADJACENT FREQUENCY BANDS

Figure 6e.

NE41A1H 305 METERS
76-11-10 TO 76-VIII-08
1 PIECES WITH 2160 ESTIMATES
PER PIECE. AVERAGED OVER
6 ADJACENT FREQUENCY BANDS

Figure 6f.

NE42A1H 2005 METERS
76-11-10 TO 76-VII-30
1 PIECES WITH 2048 ESTIMATES
PER PIECE. AVERAGED OVER
6 ADJACENT FREQUENCY BANDS

Figure 6g.

NE51A1H 1995 METERS
76-II-10 TO 76-VII-30
1 PIECES WITH 2048 ESTIMATES
PER PIECE. AVERAGED OVER
6 ADJACENT FREQUENCY BANDS

Figure 6h.

Figure 7a.

Figure 7b.

Figure 8.

Figure 9.

Figure 10a.

Figure 10b.

N

Figure 10c.

Figure 11.

Figure 12a.

Figure 12b.

Figure 12c.

Figure 12d.

Figure 12e.

Figure 12g.

Figure 12h.

Figure 13a.

Figure 13b.

Figure 14a.

Figure 14b.

Figure 15.

Figure 16.

Figure 17.

<p>Woods Hole Oceanographic Institution WHOI-80-3</p> <p>NEW ENGLAND SHELF/SLOPE EXPERIMENT (FEBRUARY TO AUGUST, 1976). DATA REPORT: THE MOORED ARRAY by Hsien Wang Ou, John A. Vermersch, Wendell S. Brown and Robert C. Beardsley. 59 pages. January 1980. Prepared for the National Science Foundation under Grants OCE 76-01813, OCE 78-19513, OCE 76-2590 and OCE 76-02190.</p> <p>The New England Shelf/Slope Experiment (NESS76) was conducted from February to August in 1976 over the continental margin south of the New England coast. The initial objective of the experiment was to examine the kinematic and dynamic coupling of the low frequency oceanic motions between the outer New England shelf and the deeper slope/rise regions; and in particular, to monitor simultaneously the current, temperature, and bottom pressure fluctuations across the New England continental margin. The field program contained several components: (1) a six-month moored array to monitor current, temperature, and bottom pressure; (2) two hydrographic cruises conducted around the moored array; (3) a collection and synthesis of the synoptic meteorological data; and (4) detailed bathymetric surveys conducted around the deeper moorings.</p> <p>The two hydrographic cruises were conducted during May 11-21 and August 12-23 of 1976, and the initial results from the cruises have been reported elsewhere by Limeburner, Vermersch, and Beardsley (1978). Only the moored array and the meteorological data will be presented here.</p> <p>This card is UNCLASSIFIED</p>	<p>Woods Hole Oceanographic Institution WHOI-80-3</p> <p>NEW ENGLAND SHELF/SLOPE EXPERIMENT (FEBRUARY TO AUGUST, 1976). DATA REPORT: THE MOORED ARRAY by Hsien Wang Ou, John A. Vermersch, Wendell S. Brown and Robert C. Beardsley. 59 pages. January 1980. Prepared for the National Science Foundation under Grants OCE 76-01813, OCE 78-19513, OCE 76-2590 and OCE 76-02190.</p> <p>The New England Shelf/Slope Experiment (NESS76) was conducted from February to August in 1976 over the continental margin south of the New England coast. The initial objective of the experiment was to examine the kinematic and dynamic coupling of the low frequency oceanic motions between the outer New England shelf and the deeper slope/rise regions; and in particular, to monitor simultaneously the current, temperature, and bottom pressure fluctuations across the New England continental margin. The field program contained several components: (1) a six-month moored array to monitor current, temperature, and bottom pressure; (2) two hydrographic cruises conducted around the moored array; (3) a collection and synthesis of the synoptic meteorological data; and (4) detailed bathymetric surveys conducted around the deeper moorings.</p> <p>The two hydrographic cruises were conducted during May 11-21 and August 12-23 of 1976, and the initial results from the cruises have been reported elsewhere by Limeburner, Vermersch, and Beardsley (1978). Only the moored array and the meteorological data will be presented here.</p> <p>This card is UNCLASSIFIED</p>
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