#245
4/23/80

LB. 1083

**DATA REPORT,
OCEANOGRAPHIC DATA FROM
MOORED INSTRUMENTATION:**

MASTER

**VELOCITY, TEMPERATURE, AND SALINITY OFF
SHINNECOCK, LONG ISLAND, IN MAY 1977**

**T.S. HOPKINS, J.T. SCOTT, R.D. PILLSBURY,
E.G. DIVIS, AND J. LOFSTRAND**

July 1979

**OCEANOGRAPHIC SCIENCES DIVISION
DEPARTMENT OF ENERGY AND ENVIRONMENT**

**BROOKHAVEN NATIONAL LABORATORY
ASSOCIATED UNIVERSITIES, INC.**

UNDER CONTRACT NO. EY-76-C-02-0016 WITH THE

UNITED STATES DEPARTMENT OF ENERGY

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

DATA REPORT
OCEANOGRAPHIC DATA FROM
MOORED INSTRUMENTATION

VELOCITY, TEMPERATURE, AND SALINITY
OFF SHINNECOCK, LONG ISLAND, IN MAY 1977

T.S. HOPKINS, J.T. SCOTT, R.D. PILLSBURY,
E.G. DIVIS, AND J. LOFSTRAND

July 1979

DISCLAIMER

This book was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

OCEANOGRAPHIC SCIENCES DIVISION
DEPARTMENT OF ENERGY AND ENVIRONMENT

BROOKHAVEN NATIONAL LABORATORY
UPTON, NEW YORK 11973

DISCLAIMER

This book was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

Printed in the United States of America
Available from
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161
Price: Printed Copy ~~\$8.00~~; Microfiche ~~\$2.00~~

A08

A01

ABSTRACT

Four instrumented moorings were deployed in the near-shore region off Shinnecock, Long Island, in May 1977. Each mooring had four sensor packages at distributed depths recording velocity, conductivity, and temperature over hourly intervals. The information was radioed to Brookhaven National Laboratory.

Three moorings performed satisfactorily. Buoy 1 data suffered frequent gaps due to weak transmissions. The average period of operation was 25 days. The data are shown here through statistics, real-time plots, progressive vector diagrams, and stick figures of daily mean currents.

ACKNOWLEDGMENTS

The funds for the program came from the Department of Energy under contract No. EY-76-C-02-0016. Many thanks are given to Mr. V. Pfeiffer and Mr. D. Carlson for their calibration and preparation of the instruments. Appreciation is also extended to C. Benkovitz and her staff for their assistance in the data processing. Special thanks also are given to W. Jahnig and A. Tuthill for their assistance during sea operations and to J. Kennedy and crew of the LCU 1647, Naval Underwater Sound Center, New London, CT. Many others of the BNL staff helped with the program. The cooperation of Dr. G. Csanady and his assistants also promoted the success of the program.

CONTENTS

Acknowledgments.....	iii
Abstract.....	iii
I. Introduction.....	1
II. Description of the Data Collection System.....	2
III. Errors of the Current Meter Sensors.....	5
A. Sensor Output and Calibration Errors.....	5
B. Errors Due to Sensor Mounting.....	6
C. Data Processing and Telemetry Errors.....	6
D. Field Comparisons.....	7
E. General Statement on Accuracy.....	7
IV. Description of the Processed Data.....	8
A. Data Acquisition.....	8
B. Data Reduction.....	9
V. References.....	11
VI. May Data Figures.....	13
A. Sensor Statistics.....	15
B. Time Series.....	19
Buoy 1.....	19
Buoy 2.....	41
Buoy 3.....	63
Buoy 4.....	85

CONTENTS (Continued)

C. Stick Diagrams.....	107
Buoy 1.....	107
Buoy 2.....	113
Buoy 3.....	119
Buoy 4.....	125
D. Progressive Vector Diagrams.....	131
Buoy 1.....	131
Buoy 2.....	137
Buoy 3.....	143
Buoy 4.....	149

I. INTRODUCTION

During April-May 1977 the Brookhaven National Laboratory (BNL) Oceanographic Sciences Division deployed four Spar Buoy Oceanographic Telemetry Systems (SBOTS) in the region near Shinnecock Inlet off the south coast of Long Island (Figure 1). The SBOTS is designed to measure, in real time, the variables of water velocity, temperature, and conductivity by a semirigid spar buoy equipped with a line-of-sight telemetry system.

The overall objective of these experiments is to provide coastal circulation and transport data for applications to studies of the various effects of ongoing or planned energy-related activities on the continental shelf. One of the first scientific goals is to understand circulation in the coastal boundary layer, a zone ~ 10 km from shore which is defined as the region where the large-scale flows of the shelf proper are modified by the presence of the coast. Another goal is the interpretation of SBOTS data for applications to studies of the continental shelf marine ecosystem.

The SBOTS was constructed and tested by BNL from September 1975 through 1976. Some of the results from the first deployments are reported by Scott and Csanady⁶ and by Walsh et al.⁸ A SBOTS mooring during October-November 1976 is reported in a previous data report.⁷ Also, Beardsley et al.¹ reported on a comparison of several types of current meters and moorings including two SBOTS moorings.

Figure 1. Mooring location

II. DESCRIPTION OF THE DATA COLLECTION SYSTEM

The system employs electromagnetic current meters and thermistor, conductivity, tilt and direction sensors mounted on a semirigid mooring with a self-contained power source. Real-time data collection and control are obtained with VHF telemetry and a in situ signal averaging accomplished by a data processor on the mooring. Details of the data processor, shore control capabilities, telemetry links, and onshore data storage are described by Dimmler et al.³ For the data reported herein, the onshore receiving facility was located in a trailer below the 108-m-high BNL meteorological tower, a distance of 35 km from the study area.

The mooring design (Figure 2) contains four SBOTS sensor packages, one compass and tilt sensor package, a data processor, RF telemetry receiver and transmitter, an antenna, and a battery. The battery package also serves as the anchor. The buoy construction including the 6.5-cm PCV pipe and linkages, sensor and batteries, and data processors were provided by Deep Ocean Works, Inc., San Pedro, CA. The sensor cages, constructed of 0.8-cm stainless steel, are 30 cm on a side, as shown schematically in Figure 3. The spar articulates through universal joints in the x-y plane above and below the lower three cages, the processor, and the compass-inclinometer cage. From the second sensor to the antenna, it is one continuous piece without a joint.

The sensor packages and housing were provided by ODEC, Inc., Newport, RI, each containing one electromagnetic current meter, one resistance-type conductivity meter, and two thermistor probes. One thermistor is located next to the conductivity sensor (local temperature), and one is typically located at depths midway between the sensor packages to provide additional temperature structure (remote temperature).

Velocity sensors were either Marsh-McBirney (MMI) model 555 or MMI model 711 electromagnetic current meters. The model 711 has the sensors mounted on a 2.2-cm-diam, 23.0-cm-long cylinder extending above the electronic housing (Figure 3). The orthogonal sensor pairs of the model 555 are mounted on a 2.5-cm-diam sphere connected to the sensor package by a 10-mm-diam, 11.8-cm-long tube which contains the lead wires. Both models have the sensor electrodes protruding 30 mm above the spherical or cylindrical sensor head. The principle of operation and some dynamics properties of the electromagnetic current meters are discussed by Olsen⁵ and Cushing.²

Response time of the velocity sensors is essentially instantaneous, but a low-pass 5-sec filter is used on the signals before they are averaged to prevent clipping of high-speed short-period fluctuations caused by waves or mooring motion. The speed range for each speed axis is $\pm 60 \text{ cm sec}^{-1}$.

Voltages from all sensors are converted to frequency and averaged in the data processor. The voltage range is 0 to 5 V. For the current meters, 2.5 V corresponds to a zero speed. The averaging period for this experiment was 1 hr. Transmission requires about 1 min so that each record contains about 59 min of data.

This deployment consisted of four SBOTS set in a line offshore as indicated in Figure 1. The operation time is limited by the battery life. Typically, the voltage diminishes from 14 V to a 12 V cutoff in a 4-week period. The mooring information is summarized in Table 1.

Figure 2. Schematic of SBOTS mooring. Depth is not to scale, but relative size of the individual components is maintained

Figure 3. Schematic showing sensor package, sensor head, and electrode location in the holding cage

Table 1
Mooring Information, May-June 1977

Buoy	Launch	Location	Water depth, m	Recovery	Wet days	Data days
1	1000 4 May	40° 47.7' N 72° 31.5' W	19.2	1300 14 June	41	24
2	1500 27 April	40° 46.6' N 72° 30.8' W	27.4	1100 14 June	48	27
3	1400 27 April	40° 44.7' N 72° 30.1' W	30.5	1000 14 June	48	32
4	1300 27 April	40° 43.3' N 72° 29.4' W	32.0	0900 1 June	48	18

III. ERRORS OF THE CURRENT METER SENSORS

The electromagnetic sensors are subject to several sources of error:

(1) sensor output and calibration, (2) sensor mounting, and (3) data telemetry and processing. The first two of these produce most of the error, although loss of the telemetry linkage produced data gaps such as that on 10 May.

The types of errors inherent in the system are generalized in Figure 4, and for convenience these are called Type I, II, and III errors. The potential error in either speed or direction (Type I error) is plotted versus orientation of the fixed axis of the current meter. Type I errors in direction may result from an incorrect determination of the direction of the current meter axes. Type I errors in speed result from a uniformly high or low calibration.

The type II errors result when a shift occurs in the zero-velocity voltage or the gain is adjusted improperly on either or both axes of the current meter or from improper calibration of the V/F converters.

Type III errors are due to the inherently non-uniform horizontal or vertical cosine response in the velocity sensors. The error source is complex and due mostly to the modification of the flow field by the cylindrical or spherical housing upon which the electrodes are mounted and to the protuberance of the electrodes as discussed by Cushing.²

A. Sensor Output and Calibration Errors

Type I errors due to calibration procedures occur when the axes are not aligned perfectly with the tank flow. Other Type I errors occur when the tank flow speed is improperly estimated and from nonlinearity of the sensor output versus speed because only one speed ($\sim 30 \text{ cm sec}^{-1}$) is used. Manufacturers'

Figure 4. Classification of potential errors in speed and direction for the fixed axis orthogonal electromagnetic sensor in their mounting cages

test data attest to the near linearity of the electromagnetic sensors for normal current speeds. Type II errors are reduced by setting the gain and speed voltage before and after deployment, but this simplified calibration procedure does not eliminate Type III errors.

The present calibration procedure does not allow for determination of effects of the housing or the cage upon the flow field. Also, manufacturers' test data clearly show that tilting with respect to the flow field enhances the cosine response error in the cylindrical sensor but reduces this error in the spherical sensor.⁹ Additionally, turbulence in the flow field produces errors of undetermined magnitude, particularly in the spherical sensor, according to tests by Appell and Woodward.⁹

To check the possible effects of the cage and housing mountings, a calibration of one model 711 together with a sensor package inside the cage was undertaken in 1975 at the David Taylor Model Basin in Rockville, MD. The sensor axes and cage corners were aligned properly. First, the effect of the cage was tested for the untilted sensor by rotation about the vertical axis at variety of speeds. The effect of the cage was not discernible above errors due to the sensor noncosine response at speeds $<150 \text{ cm sec}^{-1}$. Tilting of the sensor down-flow produced both positive and negative speed errors when the flow was oriented respectively between the two sensor axes or toward one axis, respectively. The general result of this test was that speed errors no larger than $\pm 5\%$ for given orientations may occur for tilts $<15^\circ$ and that these noncosine errors were not detectably larger than those for the unmounted sensor for speeds $<150 \text{ cm sec}^{-1}$ and tilts $<15^\circ$.

It is estimated that the accumulated maximum errors due to sensor output and calibration inaccuracies are in the range $\pm 10\%$ of speed for a given angle of orientation with respect to instrument "north." Errors in direction will be larger for small speeds, and thus the range of error in direction is not known. In general, the positive and negative errors in speed measurement tend to cancel and are usually much lower than the maximum.

B. Errors Due to Sensor Mounting

The major sensor mounting error is due to improper determination of the sensor orientation on the mooring. Also, deviations in sensor depth occur when the mooring tilts in strong flows. The mooring is designed to be rigid about the vertical axis although it is estimated that a few degrees of play may develop over time after deployment. This play is observed mostly above the processor and has a periodicity $<1 \text{ min}$. A more serious problem is that slight differences in construction at the articulated joints cause the cage orientations to differ by 5° to 10° typically and by as much as 25° from the orientation of the compass cage. For the present data records, the cage orientations were measured by divers using an underwater compass accurate to $\pm 2^\circ$ although uncertainty of the underwater measurement is somewhat larger than this and is estimated to be $\pm 5^\circ$.

C. Data Processing and Telemetry Errors

Tests of the telemetry and storage system with sensors under known conditions in the laboratory, made with source voltages while instruments are being calibrated, have shown that no discrepancies occur from source to storage. In earlier deployments, data gaps were produced by failures due to power loss at the control unit and to minor malfunctioning of the equipment (loss of a relay

switch, program flaws, etc.), but these have been essentially eliminated. Loss of telemetry linkage due to high waves coupled with high currents (and tilting of the buoys) remains a problem. When the telemetry fails for this reason, the averaging interval is extended until a successful transmission is made.

A final source of processing error is due to changes in the V/F converters. They have nominal temperature coefficient of $0.01\% \text{ } ^\circ\text{C}^{-1}$ and are calibrated from shore twice per week when storage tapes are changed. No significant drifts have been found, and errors due to this source are negligible.

D. Field Comparisons

A quantitative assessment of the reliability of the BNL system is not obtainable at present, but further information is available from two in situ instrument comparisons.

The first was made in September 1975 with a Bendix Marine Advisors model Q-15 current meter lowered from a small boat tied to an anchored buoy about 50 m from the BNL mooring. Data from 15 comparisons on five different days with synchronized 5- or 10-min averaging intervals at the 3.1-m depth yielded a mean velocity difference of 0.12 cm sec^{-1} with a standard error of 0.73. The directional difference was 4.7° with a standard error of 3.28° . Regression coefficients of 0.63 and 0.99 for speed and direction respectively were significant at the 0.05 and 0.01 levels. At other levels, with fewer sampling intervals used, comparisons showed similar levels of agreement.

The second comparison was made during February to March 1976 and involved investigators from several institutions. Four mooring types and nine different instruments were compared. The complete experiment is reported by Beardsley et al.¹ Six moorings were deployed in an alongshore direction spanning about $1/2 \text{ n.m.}$ with the eastern end located at the buoy marked in Figure 1, 3 n.m. from shore. Two prototype BNL moorings were at either end of the line.

The general conclusions concerning the performance of the electromagnetic current meters and the BNL system were that the speed response was good, but discrepancies in direction caused biases of as much as $\pm 3 \text{ cm sec}^{-1}$ in a component speed. These biases were caused by Type I errors due to inaccurate determination of instrument orientation and by a Type II bias of uncertain origin. Probable causes of the Type II bias are zero offsets or gain changes which occur after launching or effects of the noncosine response (Type III error) combined with the primarily alongshore orientation of the flow. Note that a Type II bias results in high values of speed or direction for opposite directions. Thus directions toward the east would tend to be overestimated while those toward the west would be underestimated (or vice versa).

Since the February-March 1976 comparison the Type I error has been reduced by improvement in the determination of the instrument orientation, and more zero offset checks have been made before and after deployment. The present data sets include these improvements, but no checks on Type II gain offset errors or Type III errors. These latter require somewhat more sophisticated calibration techniques than were available.

E. General Statement on Accuracy

From the experience with the BNL system available at the time of the October 13 to November 23 deployment and the above discussion, the following

general assessment of accuracy is given. The speed response of the instruments is nearly linear, but uncertainties in the resolved directions cause the instruments to have a fixed bias in a particular direction resulting from the Type I and II errors discussed above. That is, the error is not a function of speed but remains the same for all speeds. We are confident that the biases are not greater than ± 3 cm sec⁻¹ for speed in any given component of flow.

IV. DESCRIPTION OF THE PROCESSED DATA

The voltage outputs from the sensors are averaged in situ in the data processor (Figure 2) and converted to frequencies. The data receiving system (at BNL) interrogates the SBOTS moorings at prescribed intervals in sequence. For this deployment, an interrogation occurred every 15 min so that the hourly data from each SBOTS represent a different 59-1/4-min interval. For example, beginning at 1600 hr, Buoy 1 averaged 1501-1600, Buoy 2 averaged 1516-1615, Buoy 3 averaged 1531-1630, and Buoy 4 averaged 1541-1645. In the real-time treatment of the data, the end point of the averaging interval was used.

In order to minimize data loss during transmission, a redundancy check is employed. This requires a second complete transmission at each interval. If redundancy is not satisfied, or if the data signal from a SBOTS is too low (<12 db), the transmitter interrogates again. A total of 5 interrogations are programmed, after which the data tape is marked accordingly and the transmitter waits for transmission of the next SBOTS in the sequence.

A. Data Acquisition

The transmitted data are recorded in duplicate on 9-track tape by a DEC PDP/11 model 40 housed in an air-conditioned trailer under the BNL radio tower. The receiving system also has a teletype output for online data monitoring which displays a processed version of the data in engineering units. At the beginning of each tape, a calibration sequence is initiated which checks the processing and transmission components, i.e., 5 v are simulated on the input side of the processor and the signal is transmitted and recorded. Changes in output from this fixed voltage calibration are treated as linear drifts and during data processing are corrected accordingly. These calibration signals remained virtually constant throughout the deployment interval for Buoys 2, 3, and 4. The calibration signal for Buoy 1 was missed both at the beginning and end of the data sequence; the middle values were extended to apply to the entire data set.

The new data tapes are merged and processed on the CDC CYBER70 by a program designated CALALL, which converts the raw frequency counts to engineering units incorporating the V/F calibration information. It performs the following secondary calculations:

1. Conversion of conductivity to salinity after Fofonoff et al.⁴
2. Calculation of σ_t after the University of Washington IRIS algorithm.
3. Rotation of the x-y axis of the velocity probe into both a true north and an alongshore-onshore reference system.

For the data presented herein, the following sensor calibration inputs were used:

1. Velocity sensors. The zero voltage (2.50 V) was set on each sensor prior to deployment. The data were adjusted for drifts in the zero voltage, as measured after recovery. The drift varied from 0.0 to 0.5 cm/sec. Speeds were computed after the algorithm specified by the manufacturer. Attempts to calibrate the speed sensors on the BNL calibration tank individually were judged unsuccessful on the basis that the variance per sensor was greater than that between sensors.

2. Compasses. The mooring orientation information provided by the in situ compasses (Humphrey, Inc., San Diego, CA) was judged less reliable than that obtained by divers using an underwater compass. The problem with the Humphrey compass is that the calibration correction depends on the swing of the compass. A number of diver checks were made to provide information also on the torsional variability of the SBOTS moorings (Table 2). The underwater compass is accurate to $\pm 5^\circ$.

3. Thermistors. Post-launch calibrations were based on comparisons between individual thermistors and a quartz thermistor, Dymec (Hewlett Packard). The quartz thermistor was in turn calibrated by reversing thermometers (Gola, Keil, Germany). The temperature corrections are given in Table 3.

4. Conductivity sensors. Several attempts were made to calibrate the conductivity sensors immediately after the deployment, but the results were unsatisfactory because of poor control. Satisfactory control was finally obtained 10 months post launch: each sensor was immersed in an insulated tank, voltage outputs for temperature and salinity were recorded, and simultaneous temperatures from a quartz thermometer and salinity sampler (Guildline AUTOSAL 8400) were recorded as control. These calibration offset values are given in Table 3. Because the delay in calibration was so long, an additional offset was used, based on a series of in situ CTD measurements from the WHOI data set (Table 3).

B. Data Reduction

The data are presented on pages following the text. They are organized in a sequential way by buoy and by depth, starting with Buoy 1 top sensor and ending with Buoy 4 bottom sensor. Each format has self-explanatory captions, but the following notes are given as a supplement.

1. Data Gaps. Failure to receive data at the prescribed hourly interval causes a data gap in the record. Data gaps are of two types:

a. No transmission but averaging continues. When finally a transmission succeeds, then the averaging interval is some hourly multiple.

b. Power failure at transmitter or receiver. Only Buoy 2 transmitted continuously. Buoy 4 did not transmit for 4 h on 9 May and 8 h on 10 May, and Buoy 3 for 2 h on 4 May and 6 h on 10 May. These gaps resulted in long averaging intervals. The failure was due to weak transmission during a storm period. Buoy 1 had a weak transmitter and consequently its data record had numerous gaps, mostly of the first sort, i.e., long averaging interval.

Table 2
Sensor Cage Orientation

Date	Buoy #	Orientation by sensor, top to bottom			
14 June '77	1	283	290	299	289
27 May '77		289	303	290	287
18 May '77		270*	278*	297	288
	Value used	286	296	295	288
14 June '77	2	158	150	142	134
18 May '77		152	147	139	131
4 May '77		140*	140*	130*	125*
	Value used	155	148	140	133
1 June '77	3	83	79	76	73
12 May '77		73	70	69	72
	Value used	78	74	72	72
27 May '77	4	138	133	145	120*
12 May '77		149	136	145	136
	Value used	143	135	145	136

*Judged unreliable, discarded.

Table 3
Temperature and Salinity Corrections

Buoy	Sensor depths	Temp. offset	Sal. calib. offset	Sal. <u>in situ</u> offset	Sal. total offset
1	3.8	-0.014	-0.063	0.16 $\pm$ 0.08*(9)**	-0.097
	7.8	-0.037	-0.065	0.09 $\pm$ 0.07	-0.025
	12.3	0.041	0.074	0.17 $\pm$ 0.04	0.244
	17.9	-0.072	-0.082	0.30 $\pm$ 0.10	-0.218
2	3.8	-0.036	0.005	0.12 $\pm$ 0.05(15)	0.125
	7.8	-0.036	0.458	-0.27 $\pm$ 0.06	0.188
	16.0	-0.042	0.103	1.85 $\pm$ 0.04	1.953
	25.3	-0.059	0.098	-0.19 $\pm$ 0.05	-0.092
3	3.8	-0.047	0.029	0.14 $\pm$ 0.07(18)	0.169
	7.8	-0.286	0.201	0.17 $\pm$ 0.05	0.371
	16.0	-0.069	0.031	0.25 $\pm$ 0.07	0.281
	28.4	0.037	0.053	-0.10 $\pm$ 0.03	-0.047
4	3.8	-0.045	0.226	-0.19 $\pm$ 0.10(7)	0.036
	7.8	-0.248	0.945	-0.97 $\pm$ 0.11	-0.025
	16.0	-0.045	-0.090	0.32 $\pm$ 0.08	0.230
	29.9	-0.033	0.110	0.07 $\pm$ 0.06	0.180

*95% confidence interval.

**Number of CTD Comparisons buoy.

2. Statistics. The sample size, N , denotes the number of data points. N is not the same for any of the buoys because of the different operational times and, in the case of Buoy 1, numerous data gaps; this should be kept in mind when comparing averages between buoys. For example, the mean surface temperature at Buoy 4 is lower than at Buoy 3 because the operational time of Buoy 3 extended 14 days longer into May.

3. Time series plots. These contain the hourly values of temperature, salinity, σ_t , alongshore speed and onshore speed. The data for buoys 2, 3, and 4 start on 29 April, and for Buoy 1 on 5 May, and continue to their last points. When the averaging interval was greater than an hour, the points are not connected. When the averaging interval was less than the time interval, the points are omitted. Care must be used in comparing records because the parameter axes vary in scale. For the speed plots, positive alongshore corresponds to 068°T and positive onshore to 338°T .

4. Progressive vector diagrams. These are constructed from the cumulative onshore and alongshore speed components. The diagrams are marked at every 12th data point; consequently, every second mark corresponds to a day, except in the case of Buoy 1. The orientation of the axes is as seen by a polychete, not by a seagull.

5. Stick diagrams. These represent the daily average vectors; the arrow stick is located at 2400 hr of the day ending. Only hourly data points were used during any daily average so that data gaps were excluded.

V. REFERENCES

1. R.C. Beardsley, W. Boicourt, L.C. Huff, and J.T. Scott, CMICE 76: A Current Meter Intercomparison Experiment Conducted Off Long Island in February-March 1976, Woods Hole Oceanographic Inst. 77-62 (unpublished, 123 pp.), Oct. 1977.
2. V. Cushing, Electromagnetic water current meter, Oceans' 76 Proc. 256, 1-7, IEEE and MTS, Washington, DC, Sept. 1976.
3. D.G. Dimmler, S. Rankowitz, D.W. Huszagh, and J.T. Scott, A controllable real-time data collection system for coastal oceanography, Ibid. 14E, 1-13.
4. N.P. Fofonoff, S.P. Hayes and R.C. Millard, Jr., WHOI/Brown CTD Microprofiler: Methods of Calibration and Data Handling, Woods Hole Oceanographic Inst. Tech. Rep. 74-89 (unpublished, 64 pp.), 1974.
5. J.R. Olsen, J. Marine Tech. Soc. 6, 19 (1972).
6. J.T. Scott and G.T. Csanady, J. Geophys. Res. 81(30), 5401 (1976).
7. J.T. Scott, T.S. Hopkins, R.D. Pillsbury, and E.G. Davis, Velocity and Temperature Off Shinnecock, Long Island, in October-November 1976, BNL 50895, May 1978.
8. J.J. Walsh, T.E. Whitledge, F.W. Barvenik, C.D. Wirick, S.O. Howe, W.E. Esaias, and J.T. Scott, Wind events and food chain dynamics within the New York Bight, Limnol. Oceanog. 23(4), 659-87 (1978).
9. Appell, Gerald F. and William E. Woodward, Interim report on the evaluation of electromagnetic current meters, National Oceanographic Instrumentation Center, Washington, D.C. (unpublished report).

THIS PAGE
WAS INTENTIONALLY
LEFT BLANK

VI. MAY DATA FIGURES

THIS PAGE
WAS INTENTIONALLY
LEFT BLANK

Sensor Statistics

A. Buoy 1 (N = 407)					
Depth	Parameter	Mean	S.D.	Max	Min
1	T(°C)	9.75	1.77	14.71	6.91
3.8	T(°C)	9.35	1.49	12.31	7.09
3.8	S	32.16	0.38	32.73	31.40
3.8	σ_t	24.86	0.43	25.49	23.96
3.1	S(cm/sec)	19.68	10.70	57.70	0.31
3.1	V(cm/sec)	-10.39	6.54	11.01	-26.71
3.1	U(cm/sec)	15.57	-0.27	21.60	-55.63
-	T(°C)	-	-	-	-
7.8	T(°C)	8.81	1.20	11.70	7.11
7.8	S	32.23	0.34	32.76	31.43
7.8	σ_t	25.00	0.34	25.50	24.23
7.8	S(cm/sec)	12.68	8.23	46.56	0.28
7.1	V(cm/sec)	-2.86	5.48	14.86	-19.39
7.1	U(cm/sec)	-2.78	13.53	30.19	-44.85
-	T(°C)	-	-	-	-
12.3	T(°C)	8.30	1.00	10.54	6.54
12.3	S	32.44	0.29	33.00	31.62
12.3	σ_t	25.24	0.26	25.79	24.56
11.6	S(cm/sec)	12.93	7.32	38.84	0.81
11.6	V(cm/sec)	-2.99	4.59	10.01	-13.99
11.6	U(cm/sec)	-5.20	12.81	28.37	-38.63
16.5	T(°C)	8.13	0.93	10.33	6.53
17.9	T(°C)	7.88	0.91	10.04	6.38
17.9	S	32.53	0.26	33.03	31.84
17.9	σ_t	25.37	0.27	25.82	24.79
17.2	S(cm/sec)	7.93	4.37	22.25	0.32
17.2	V(cm/sec)	-1.07	3.65	10.17	-13.83
17.2	U(cm/sec)	-1.45	8.10	18.19	-21.42

Sensor Statistics (Cont.)

B. Buoy 2 (N = 616)					
Depth	Parameter	Mean	S.D.	Max	Min
	T(°C)				
3.8	T(°C)	8.55	1.34	11.54	6.20
3.8	S	32.02	0.37	32.67	31.30
3.8	σ_t	24.87	0.35	25.42	24.14
3.1	S(cm/sec)	17.91	11.72	53.62	0.29
3.1	V(cm/sec)	-3.85	9.24	21.64	-22.87
3.1	U(cm/sec)	-2.46	18.78	39.47	-51.87
11.0	T(°C)	7.72	1.13	10.17	5.18
7.8	T(°C)	8.08	1.17	11.05	5.76
7.8	S	32.10	0.35	32.69	31.33
7.8	σ_t	25.00	0.31	25.61	24.27
7.1	S(cm/sec)	15.76	10.99	55.52	0.64
7.1	V(cm/sec)	-2.19	7.05	15.82	-21.25
7.1	U(cm/sec)	-4.94	17.05	37.28	-55.35
-	T(°C)	-	-	-	-
16.0	T(°C)	7.05	1.13	9.27	4.45
16.0	S	32.56	0.22	32.94	31.82
16.0	σ_t	25.50	0.20	25.97	25.10
15.3	S(cm/sec)	13.47	8.48	50.54	0.50
15.3	V(cm/sec)	1.30	5.99	16.10	-18.01
15.3	U(cm/sec)	-2.17	14.54	39.03	-49.30
22.0	T(°C)	6.64	1.30	9.05	4.22
25.3	T(°C)	6.50	1.32	8.82	4.12
25.3	S	32.79	0.18	33.11	32.04
25.3	σ_t	25.76	0.22	26.07	25.22
24.6	S(cm/sec)	7.70	3.80	19.84	0.22
24.6	V(cm/sec)	2.13	3.94	12.42	-7.07
24.6	U(cm/sec)	-0.95	7.27	15.70	-19.81

Sensor Statistics (Cont.)

C. Buoy 3 (N = 746)					
Depth	Parameter	Mean	S.D.	Max	Min
11.0	T(°C)	8.27	1.33	11.10	5.69
7.8	T(°C)	8.57	1.47	12.37	5.42
7.8	S	32.12	0.37	32.83	31.41
7.8	σ_t	29.94	0.33	25.63	23.91
7.1	S(cm/sec)	16.61	11.14	73.25	0.11
7.1	V(cm/sec)	1.84	8.61	23.16	-19.27
7.1	U(cm/sec)	-7.91	16.13	27.56	-71.93
20.0	T(°C)	7.05	0.97	9.23	4.50
16.0	T(°C)	7.33	1.02	10.12	4.64
16.0	S	32.64	0.21	33.09	31.79
16.0	σ_t	25.53	0.17	25.94	25.02
15.3	S(cm/sec)	14.01	8.96	55.37	0.24
15.3	V(cm/sec)	1.59	7.09	18.47	-21.01
15.3	U(cm/sec)	-4.46	14.29	37.11	-55.11
24.0	T(°C)	6.67	1.04	8.20	4.34
28.4	T(°C)	6.42	1.19	7.95	4.31
28.4	S	32.96	0.15	33.28	32.34
28.4	σ_t	25.90	0.17	26.26	25.51
27.7	S(cm/sec)	7.69	4.24	26.27	0.46
27.7	V(cm/sec)	1.89	3.71	11.44	-8.86
27.7	U(cm/sec)	-1.99	7.48	16.71	-26.17

Sensor Statistics (Cont.)					
D. Buoy 4 (N = 437)					
Depth	Parameter	Mean	S.D.	Max	Min
1.0	T(°C)	8.57	0.98	11.25	6.02
3.8	T(°C)	8.26	0.89	10.74	5.70
3.8	S	31.94	0.40	32.99	31.22
3.8	σ_t	24.85	0.31	25.82	24.19
3.1	S(cm/sec)	21.23	13.70	65.39	0.89
3.1	V(cm/sec)	-3.48	11.30	28.09	-30.66
3.1	U(cm/sec)	-10.49	19.73	33.37	-62.26
-	T(°C)	-	-	-	-
7.8	T(°C)	7.76	0.81	9.33	5.55
7.8	S	32.08	0.38	32.99	31.47
7.8	σ_t	25.03	0.31	25.85	24.56
7.1	S(cm/sec)	19.24	12.10	62.28	0.58
7.1	V(cm/sec)	-3.25	10.24	21.61	-28.01
7.1	U(cm/sec)	-9.09	17.87	32.81	-57.37
20.0	T(°C)	6.54	0.82	7.69	4.38
16.0	T(°C)	6.80	0.69	8.94	4.48
16.0	S	32.70	0.27	33.11	31.89
16.0	σ_t	25.66	0.20	26.01	25.05
15.3	S(cm/sec)	14.82	9.35	59.38	0.69
15.3	V(cm/sec)	2.47	7.60	19.99	-17.02
15.3	U(cm/sec)	5.95	14.43	27.67	-58.51
24.0	T(°C)	6.06	1.02	7.49	4.01
29.9	T(°C)	5.35	1.26	7.27	3.59
29.9	S	33.03	0.11	33.25	32.74
29.9	σ_t	26.09	0.16	26.40	25.73
29.2	S(cm/sec)	9.03	4.91	32.12	0.44
29.2	V(cm/sec)	0.04	4.59	10.34	-11.58
29.2	U(cm/sec)	-2.03	8.98	20.54	-32.09

Time Series, Buoy 1

THIS PAGE
WAS INTENTIONALLY
LEFT BLANK

Time Series, Buoy 2

THIS PAGE
WAS INTENTIONALLY
LEFT BLANK

Time Series, Buoy 3

THIS PAGE
WAS INTENTIONALLY
LEFT BLANK

Time Series, Buoy 4

THIS PAGE
WAS INTENTIONALLY
LEFT BLANK

Stick Diagrams, Buoy 1

THIS PAGE
WAS INTENTIONALLY
LEFT BLANK

Stick Diagrams, Buoy 2

THIS PAGE
WAS INTENTIONALLY
LEFT BLANK

Stick Diagrams, Buoy 3

THIS PAGE
WAS INTENTIONALLY
LEFT BLANK

Stick Diagrams, Buoy 4

THIS PAGE
WAS INTENTIONALLY
LEFT BLANK

Progressive Vector Diagrams, Buoy 1

THIS PAGE
WAS INTENTIONALLY
LEFT BLANK

Progressive Vector Diagrams, Buoy 2

CURRENT
Buoy 2
Depth 16 m

CURRENT
Buoy 2
Depth 16 m

THIS PAGE
WAS INTENTIONALLY
LEFT BLANK

Progressive Vector Diagrams, Buoy 3

THIS PAGE
WAS INTENTIONALLY
LEFT BLANK

Progressive Vector Diagrams, Buoy 4

CURRENT

Buoy 4
Depth 30 m

CURRENT

Buoy 4
Depth 30 m