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**Mean Eulerian Subsurface Currents Measured
in the Gulf of Maine and Adjacent Scotian
and
New England Shelf and Slope Regions,
1974-1980**

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Abstract

The Bedford Institute of Oceanography, E.G.&G., National Marine Fisheries Service, U. S. Geological Survey, and Woods Hole Oceanographic Institution have conducted separate moored array experiments during 1974-1980 to study various aspects of the regional circulation in the Gulf of Maine and adjacent Scotian and New England shelf and slope regions.

The mean currents and current variances measured in these experiments are summarized here in tabular and graphical form, together with other information about each experiment. While there have been few measurements made in the interior of the Gulf of Maine, the map of mean subsurface currents demonstrate (a) a net inflow of Scotian shelf water past Cape Sable into the Gulf, (b) a net inflow of slope water through the Northeast Channel into the Gulf, (c) a partially closed anticyclonic circulation around Georges Bank, and (d) a net outflow of shelf water south of Nantucket from the Gulf of Maine into the New England shelf.

Abstract

The purpose of this study was to determine the effect of the use of a computer program on the learning of the basic concepts of the theory of the cell. The study was conducted with a group of 30 students in a biology class. The results of the study showed that the use of the computer program had a positive effect on the learning of the basic concepts of the theory of the cell.

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1. Introduction

The Bedford Institute of Oceanography, E.G.&G., the Northeast Fisheries Center of the National Marine Fisheries Service, the U.S. Geological Survey, and the Woods Hole Oceanographic Institution all conducted moored array experiments during 1974-1980 to study different circulation problems in the Gulf of Maine and adjacent Scotian and New England shelf and slope regions. The locations of these experiments are shown in Figure 1 where mooring sites have been sequentially numbered starting on the northern flank of Georges Bank. A detailed description of the mean currents and current statistics measured at Stations 1 through 27 around Georges Bank has been given by Butman et al. (1982). This report represents an extension of their data base and current statistics to incorporate additional moored array data collected within the Gulf of Maine and in the adjacent shelf regions. Brief descriptions of all the different experiments and their supporting programs are given in the next section, and the mean currents and current variances measured in these experiments are presented in the last section. One objective of this report is to present in compact form the basic moored current data sets obtained in this region during the 1974-1980 period to facilitate new research on regional circulation questions by other investigators.

2. Field Program and Support

This report summarizes the mean currents and current statistics measured in the following different field programs. A brief description of each program, principal investigators, station numbers, and supporting agencies is given next for general reference. Also included with each description is a list of the different stations maintained by that program. (Only those field programs which were conducted on the continental shelf or upper slope are described.)

1. A winter study of current, bottom pressure, and water structure in the western Gulf of Maine (J. A. Vermersch, R. C. Beardsley, and

W. Brown, 1974-75) conducted with National Science Foundation (NSF) support. NSF Grants to WHOI and UNH; DES 74-03001 and DES 75-03992. Stations 45-47.

2. A long-term current monitoring study initiated in 1975 by the U.S. Geological Survey (USGS) and Woods Hole Oceanographic Institution (WHOI) (R. C. Beardsley, B. Butman and J. A. Vermersch, 1975-76; B. Butman and M. A. Noble, 1977-present). Support from USGS to WHOI: Contracts 14-08-00001-G-197 and 14-08-00001-15615. Support from the U.S. Bureau of Land Management (BLM) to USGS: Memoranda of Understanding (MOU) AA550-MU6-29, AA551-MU8-24, AA551-MU9-4 and AA551-MU0-18. Stations 10, 11.
3. A moored array on the New England shelf deployed simultaneously with a pilot Georges Bank current-meter array (R. C. Beardsley, J. A. Vermersch and B. Butman, 1976) conducted with National Science Foundation (NSF) support. NSF Grant to WHOI: OCE 76-01813. BLM MOU to USGS: AA550-MU6-29. Stations 2, 8, 16, 26, 27.
4. A study of bottom currents and sediment transport (B. Butman and M. A. Noble, 1976-present) conducted with BLM support to USGS: MOU AA550-MU6-29, AA551-MU8-24, AA551-MU9-4 and AA551-MU0-18. Stations 7, 15, 17, 24, 25.
5. A long-term study of the currents and hydrographic variability over the outer Scotian shelf and continental slope and upper rise (P. C. Smith and B. D. Petrie, 1975-1978) supported by the Atlantic Oceanographic Laboratory* of the Bedford Institute of Oceanography. Stations 28-35.

*Part of the Ocean Science Surveys branch of the Department of Fisheries and Oceans, Government of Canada.

6. A long-term study of the low frequency deep flow through the Northeast Channel (R. Schlitz, S. Ramp, W. R. Wright, and J. Vermersch, 1976-78) conducted with National Marine Fisheries Service (NMFS) support. Stations 42-44.
7. A study of the physical oceanography of Georges Bank (E.G.&G. Environmental Consultants, R. Scarlet, B. Magnell, D. Frye and C. Flagg: Raytheon Company, D. Cook, 1977-80) supported by BLM. BLM contracts to E.G.&G.: AA550-CT6-50 and AA551-CT8-46. BLM contracts to Raytheon: AA550-3CT-53 and AA550-CT8-47. Stations 1, 2, 6, 9, 11-14.
8. A study of hydrography and currents on Nantucket Shoals (R. C. Beardsley and R. Limeburner, 1977-79) conducted with Sea Grant support to WHOI: Grants 04-7-158-44104 and 04-8-M01-149. Stations 19-23.
9. A study of currents in Great South Channel (J. A. Vermersch, R. C. Beardsley and B. Butman, 1978-79) conducted with support from USGS and BLM. BLM MOU AA551-MU8-24 and AA551-MU9-4. Stations 15-18.
10. A study of currents on the northern side of Georges Bank as part of the larval herring patch study (R. Schlitz, W. R. Wright, and A. A. Allen, 1978) conducted with National Marine Fisheries Service (NMFS) support. Stations 3-5.
11. A long-term investigation of the seasonal mean circulation and tidal rectification off southwest Nova Scotia (P. C. Smith, 1978-80) conducted with support of the Atlantic Oceanographic Laboratory of the Bedford Institute of Oceanography. Stations 36-41. A reduced array at Stations 38-39 has been maintained off Cape Sable for monitoring inflow to the Gulf of Maine (P. C. Smith, 1980-present).
12. A study of low frequency current, bottom pressure and water structure variability over the shelf and upper slope south of Nantucket

Shoals (R. C. Beardsley, W. R. Wright, S. R. Ramp, R. J. Schlitz, B. Butman, and W. Brown, 1979-80) conducted with NSF, NMFS, and USGS support. NSF grants to WHOI and UNH: OCE 78-19513 and OCE 78-26229. Stations 48-53.

3. Data Summary

A time line of all moored current measurements made in the experiments described in the last section is shown in Figure 2. The current data at each site have been rotated into a subjectively determined along-shelf and cross-shelf coordinate system and the mean, standard deviation, and subtidal standard deviation of the rotated current components have been computed for all current records of at least one month duration. The coordinate system orientation, current statistics, and mooring information for each site is summarized in Table 1. The standard error of each component was computed using the subtidal standard deviation, the total record length, and an assumed correlation time scale for all data of five days. This procedure undoubtedly underestimates the standard errors in the offshore measurements (e.g., at Stations 29-33) where the characteristic time scales are larger (Smith and Petrie, 1982). However, considering the difficulties involved in estimating these quantities, a uniform value was adopted.

Maps of the mean currents and subtidal standard deviations are shown in Figures 3 and 4. While most of these measurements were not synoptic (as shown in Figure 2) and there have been few observations made in the western Gulf of Maine, the mean current map demonstrates (a) a net inflow of Scotian shelf water past Cape Sable into the Gulf, (b) a net inflow of slope water through the Northeast Channel into the Gulf, (c) a partially closed anticyclonic (clockwise) circulation around Georges Bank, and (d) a net outflow of shelf water south of Nantucket from the Gulf of Maine into the New England shelf. The reader is referred to Butman et al. (1982) for a description of the general circulation on and around Georges Bank and to Appendix A for a partial list of published references presenting

analyses of the current data collected in the different moored array experiments described in Section 2.

Acknowledgements

We would like to gratefully acknowledge the many individuals who have collected and analyzed the data summarized here. This compilation was started during a visit by P. C. Smith to WHOI. Support for the final preparation of this report has been provided to B. Butman under BLM Memorandum of Understanding AA 551-MUO-18, to R. C. Beardsley and C. A. Mills from NSF Grant OCE 80-14941, and to P. C. Smith from the Atlantic Oceanographic Laboratory of the Bedford Institute of Oceanography.

References

- Butman, B., R. C. Beardsley, B. Magnell, J. A. Vermersch, D. Frye, R. Schlitz, R. Limeburner, W. R. Wright and M. A. Noble, 1982. Recent observations of the mean circulation on Georges Bank. J. Phys. Oceanogr., 12, 569-591.
- Smith, P. C. and B. D. Petrie, 1982. Low-frequency circulation at the edge of the Scotian Shelf. J. Phys. Oceanogr., 12, 28-46.

APPENDIX A

A partial list of references in the published literature which present analyses of the current data in the different moored array experiments described in Section 2.

Experiment Number	Station Number	References
1	45-47	Vermersch, J. A., R. C. Beardsley, W. S. Brown, 1979. Winter circulation in the western Gulf of Maine: Part 2. Current and pressure observations. <u>J. Phys. Oceanogr.</u> , <u>9</u> , 768-784.
2	10-11	Butman, B., R. C. Beardsley, B. Magnell, J. A. Vermersch, D. Frye, R. Schlitz, R. Limeburner, W. R. Wright and M. A. Noble, 1982. Recent observations of the mean circulation on Georges Bank. <u>J. Phys. Oceanogr.</u> , <u>12</u> , 569-591.
3	26-27 57-60	Ou, H.-W., R. C. Beardsley, 1980. On the propagation of free topographic Rossby Waves near continental margins. Part 2: Numerical model. <u>J. Phys. Oceanogr.</u> , <u>10</u> , 1323-1339.
3-4	2,8,16 7,15, 17,24,25	Butman, B., R. C. Beardsley, B. Magnell, J. A. Vermersch, D. Frye, R. Schlitz, R. Limeburner, W. R. Wright and M. A. Noble, 1982. Recent observations of the mean circulation on Georges Bank. <u>J. Phys. Oceanogr.</u> , <u>12</u> , 569-591. Twichell, D. C., C. D. McClennen, and B. Butman, 1981. Morphology and processes associated with accumulation of fine-grained sediment deposits on the southern New England shelf. <u>J. Sed. Petrol.</u> , <u>51</u> : 269-280.
5	28-35	Louis, J. P., and P. C. Smith, 1982. The development of the barotropic radiation field of an eddy over a slope. <u>J. Phys. Oceanogr.</u> , <u>12</u> : 56-73. Louis, J. P., B. D. Petrie and P. C. Smith, 1982. Observations of topographic Rossby waves on the continental margin off Nova Scotia. <u>J. Phys. Oceanogr.</u> , <u>12</u> : 47-55 Smith, P. C. and B. D. Petrie, 1982. Low-frequency circulation at the edge of the Scotian shelf. <u>J. Phys. Oceanogr.</u> , <u>12</u> : 28-46.

- 6 42-44 Ramp, S. R. and J. A. Vermersch, Jr., 1978. Measurements of the deep currents in the Northeast Channel, Gulf of Maine. I.C.E.S. Document No. C.M. 1978/C:40, 9 pp.
- Ramp, S. R. and W. R. Wright, 1979. Northeast Channel Flow: The view after one year's measurements. I.C.E.S. Document No. C.M. 1979/C:54, 17 pp.
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- Ramp, S. R., R. J. Schlitz, and W. R. Wright, 1982. On the deep transport of mass, heat and nutrients through the Northeast Channel, Gulf of Maine. J. Phys. Oceanogr., submitted.
- 7 1,2,6 Magnell, B. A., S. L. Spiegel, R. I. Scarlet, J. B. Andrews, 1980. The relationship between tidal and low-frequency currents on the north slope of Georges Bank. J. Phys. Oceanogr., 10: 1200-1212.
- 9,11-14
- 8 19-23 Limeburner, R. and R. C. Beardsley, 1982. The seasonal hydrography and circulation over Nantucket Shoals. Journal of Marine Research, Supplement to 40, 371-406.
- 10 3-5 Wright, W. R. and R. G. Lough, 1979). The Georges Bank larval herring patch study of 1978: A preliminary report. I.C.E.S. Document No. C.M. 1979/L:36, 13 pp.
- 11 36-41 Smith, P. C., 1983. The mean and seasonal circulation off southwest Nova Scotia. J. Phys. Oceanogr., in press.
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List of Figures

Figure 1: Map of Gulf of Maine and adjacent shelf and slope regions showing the station locations occupied in the different moored array experiments conducted in the period 1974-1980. The station numbering scheme shown here is used throughout this report.

Figure 2: Time line of moored current measurements made in the Gulf of Maine and adjacent shelf and slope region during 1975-1980. Dashed lines indicate partial data collection (temperature only, for example). Time lines in brackets indicate data not included in this compilation. The group which made the observations is listed in the first column. BIO is Bedford Institute of Oceanography, EG&G is EG&G Environmental Consultants, NMFS is National Marine Fisheries Service, USGS is U.S. Geological Survey and WHOI is Woods Hole Oceanographic Institution. For the BIO and USGS stations, the station designation commonly used by that group is also listed in Column 1. The station number keys the measurements to Table 1 and Figure 1. Groups of measurements made as part of individual field experiments are indicated by large brackets.

Figure 3: Mean Eulerian subsurface currents observed in the Gulf of Maine and adjacent Scotian and New England shelf region. The shallowest current measurements were made at a depth of 10 m, and the mean current vectors shown are not synoptic measurements, but are based on measurements of varying length (one-month minimum) made at different times during the period 1974-1980. Each measurement site is identified by a boldface station number located at the origin of the vector. This station number is the key to the additional data in Table 1. The number in parentheses following the station identifier indicates the water depth in meters at that station. The number at the top

of the mean velocity vector indicates the measurement depth in meters. The speed scale has been chosen so that the magnitude of the current vector is equivalent to the mean displacement of a water particle during a 6.0 day period.

Figure 4: Standard Deviation of Subtidal Current Components. The subtidal current variability at each station is shown as a cross oriented in the alongshelf/cross-shelf direction where the length of each axis is proportional to the observed standard deviation of the low-frequency current components. The bold-face station number keys measurements to Table 1. The number in parentheses following the station identifier indicates the water depth in meters of that station. The number near the top of the vector indicates the measurement depth in meters. For clarity, only the near-surface and near-bottom values are shown, and some stations have been displaced slightly from their time positions. The speed scale has been chosen so actual water particle excursions at map scale caused by the low-frequency currents are one-half as large as those shown (assuming a typical five-day period for the subtidal motions).

Table Caption

Table 1: The data in this table and in Figures 3 and 4 are organized by site number. The primary group that collected the data is indicated in parentheses next to the site number. The instrument type code is: VACM (AMF Vector Averaging Current Meter), 102 (E.G.&G. Model 102 current meter), 850 (Geodyne Model 850 current meter), ACM (Aanderaa current meter), RAY (Marsh-McBirney electro-magnetic meter mounted on a special buoy fabricated by Raytheon Ocean Systems), BRNCN (Braincon Current Meter), and END (Endeco Model 174 current meter). The mooring code is: S (surface mooring), SS (subsurface mooring), and SPEC (the special Raytheon buoy). The current statistics have been computed at most sites in a subjectively determined alongshelf/cross-shelf rotated coordinate system. The coordinate orientation angle θ indicates the clockwise rotation of the new primed coordinate system, so that θ is the angle between true North and the new North component, N' . E' and N' are aligned with true East and North when $\theta = 0$. Both the total standard deviation computed from vector averaged one hour time series and the low-frequency (LF) standard deviation computed from a low-passed time series are presented. The low-pass filters used typically had a half-power cutoff frequency of 0.03 cycles per hour. The standard error in each component was computed using the LF standard deviation, the record length and an assumed correlation time scale for all data of five days.

Figure 1: Map of Gulf of Maine and adjacent shelf and slope regions showing the station locations occupied in the different moored array experiments conducted in the period 1974-1980. The station numbering scheme shown here is used throughout this report.

TABLE 1

Site Number	Location (N/W)	Water Depth (m)	Nominal Instrument Depth (m)	Instrument Type	Moor- ing Type	Measurement Start/Stop Date (Yr-Mo/Yr-Mo)	Records Length (Days)	Coord- inate Rotation (Degree)	E' (cm/sec)			N' (cm/sec)				
									Mean	Standard Error	LF Standard Deviat'n	Total Standard Deviat'n	Mean	Standard Error	LF Standard Deviat'n	Total Standard Deviat'n
1 (EG G)	42°04.5' 67°52.4'	200	10	VACM	S	78-01/78-02 78-07/78-09 79-04/79-06	150	62	1.2	± 1.3	7.4	21.5	14.0	± 2.8	15.6	25.5
		77		102	SS	78-01/78-05 78-05/78-07 79-04/79-07	277	62	0.6	± 0.5	4.1	10.8	5.8	± 0.9	7.0	8.8
		192		102/ ACM	SS SS	77-09/78-05 78-05/78-08 78-11/79-01 79-04/79-07	450	62	-1.3	± 0.5	4.4	19.5	-0.3	± 0.7	6.4	11.6
2 (EG G)	41°59.0' 67°47.0'	85	10	VACM	S	78-01/78-01 78-04/78-07 79-04/79-07	191	62	3.5	± 0.9	5.8	26.7	29.5	± 1.6	9.9	20.4
		44		102	SS	78-04/78-07 79-07/79-09	161	62	4.4	± 0.9	5.4	25.7	23.4	± 1.4	8.2	17.7
		77		102	SS	77-09/78-01 78-04/78-07 79-07/79-09	264	62	-8.4	± 0.8	5.5	26.5	9.7	± 0.8	6.2	15.0
(USGS)	41°59.0' 67°47.1'	85	15	VACM	S	76-04/76-08	114	65	2.6	± 0.9	4.4	27.8	29.1	± 1.8	8.7	20.5
3 (NMFS)	42°12.5' 66°40.8'	218	79	VACM	SS	78-09/78-11	45	0	17.1	± 1.5	4.6	37.1	1.1	± 1.3	3.9	31.8
		129		VACM	SS	78-09/78-11	45	0	6.6	± 1.7	5.2	22.3	6.0	± 1.4	4.3	34.6
4 (NMFS)	42°02.0' 66°40.3'	75	19	VACM	S	78-09/78-11	46	0	10.3	± 1.8	5.7	50.1	-2.0	± 1.4	4.4	64.2
		44		VACM	SS	78-09/78-11	46	0	5.8	± 1.2	3.8	39.9	-2.9	± 1.1	3.4	51.4
5 (NMFS)	41°52.6' 66°41.2'	66	11	VACM	S	78-09/78-11	58	0	4.6	± 1.7	5.9	49.4	0.4	± 1.0	3.6	61.7
		26		VACM	SS	78-09/78-11	58	0	2.7	± 1.1	3.7	45.8	0.1	± 0.8	2.8	55.3
			36	VACM	SS	78-09/78-11	57	0	1.5	± 0.9	3.0	43.0	0.1	± 0.8	2.6	49.8

TABLE 1

Site Number	Location (N/W)	Water Depth (m)	Nominal Instrument Depth (m)	Instrument Type	Moor- ing Type	Measurement Start/Stop Date (Yr-Mo/Yr-Mo)	Records Length (Days)	Coord- inate Rotation (Degree)	E' (cm/sec)			N' (cm/sec)				
									Mean	Standard Error	LF Standard Deviat'n	Total Standard Deviat'n	Mean	Standard Error	LF Standard Deviat'n	Total Standard Deviat'n
6 (EG G)	41°56.0' 66°20.0'	85	10	VACM	S	79-04/79-07	99	62	6.7	± 1.2	5.5	61.2	-0.6	± 1.6	7.3	45.4
			44	102	SS	79-04/79-05	37	62	1.7	± 0.7	1.9	60.2	2.4	± 1.0	2.8	38.2
			77	102	SS	79-04/79-08 79-08/79-10	173	62	2.3	± 0.9	5.5	44.9	1.2	± 0.6	3.8	25.9
7 (USGS)	41°41.8' 66°36.2'	66	51	VACM	SS	78-10/79-03	162	0	-0.7	± 0.8	4.7	38.5	-3.8	± 0.8	4.4	44.5
8 (USGS)	41°24.0' 67°39.1'	38	15	VACM	S	76-04/76-08	136	61	0.9	± 0.3	1.4	55.7	-3.1	± 0.5	2.5	42.3
9 (EG G)	41°20.4' 67°16.9'	40	35	VACM	SS	78-04/78-08	114	62	-0.1	± 0.3	1.5	46.7	-4.2	± 0.7	3.2	33.7
10 (USGS)	41°02.2' 67°33.5'	60	15	VACM	S	78-10/78-12 79-03/79-08	328	64	0.0	± 0.5	4.1	41.9	-10.2	± 0.8	6.6	30.0
			50	VACM	SS	79-03/79-04 79-08/79-09	116	64	1.3	± 0.4	2.0	33.9	-3.2	± 0.8	3.6	21.9
			56	VACM	SS	78-01/78-05	108	64	2.6	± 0.4	1.9	31.4	-4.3	± 1.2	5.6	21.4
11 (USGS)	40°51.4' 67°24.1'	85	15	VACM	S	75-09/75-12 77-07/77-09 78-01/78-03 78-05/78-09	324	58	-1.3	± 0.8	6.1	25.9	-13.0	± 2.0	16.0	29.5
			45	VACM	SS	75-05/75-08 75-09/76-01 76-08/78-05 78-10/79-02	1007	58	-0.6	± 0.3	4.0	29.7	-8.6	± 0.8	11.4	23.6
			75	VACM	SS	75-05/75-07 75-09/76-01 76-08/79-03	1113	58	0.4	± 0.2	3.3	25.0	-3.6	± 0.4	6.5	17.2
(EG G)	40°51.2' 67°24.2'	85	10	RAY	Spec	78-06/78-08 78-11/79-02 79-03/79-03	172	62	-0.3	± 1.1	6.7	28.1	-9.4	± 1.2	7.3	21.6

TABLE 1

Nominal			E' (cm/sec)						N' (cm/sec)						
Site Number	Location (N/W)	Water Depth (m)	Instrument Depth (m)	Instrument Type	Mooring Type	Measurement Start/Stop Date (Yr-Mo/Yr-Mo)	Records Length (Days)	Coordinate Rotation (Degree)	E'			N'			
									Mean	Standard Error	Standard Deviat'n	Mean	Standard Error	Standard Deviat'n	
12 (EG G)	40°55.9' 66°58.2'	85	10	VACM/ RAY	Spec	77-11/77-11 78-11/79-02 79-03/79-03	147	62	Mean	Standard Error	Standard Deviat'n	Mean	Standard Error	Standard Deviat'n	
									-2.1	± 0.9	4.8	31.3	-8.8	± 1.3	7.1
									-0.6	± 0.6	3.8	24.6	-2.6	± 0.9	6.0
									1.9	± 0.7	6.6	29.4	-15.2	± 1.1	8.6
13 (EG G)	40°43.7' 66°49.0'	200	77	RAY 102/	SS/ Spec	78-06/78-08 78-09/78-12 78-12/79-05	285	62	-2.0	± 0.7	5.6	26.5	-14.4	± 1.1	9.0
									0.6	± 0.4	3.9	21.6	-4.1	± 0.7	6.4
									2.4	± 1.6	9.9	22.1	-15.0	± 2.5	15.0
									-1.0	± 0.4	3.9	12.3	-8.7	± 1.3	11.3
14 (EG G)	40°40.0' 68°42.0'	60	10	RAY/ 102/ ACM	SS/ Spec	78-06/78-08 78-09/79-01 79-01/79-04 79-05/79-08	348	62	1.8	± 0.6	4.7	19.2	-2.0	± 1.3	11.0
									-6.1	± 0.7	5.4	50.2	-7.4	± 1.0	7.6
									-3.8	± 0.7	4.0	47.1	-3.6	± 1.1	6.2
									-4.4	± 0.5	2.4	35.7	-6.8	± 0.9	3.9

TABLE 1

Site Number	Location (N/W)	Water Depth (m)	Instrument Depth (m)	Instrument Type	Moor- ing Type	Measurement Start/Stop Date (Yr-Mo/Yr-Mo)	Records Length (Days)	Coordinate Rotation (Degree)	E' (cm/sec)			N' (cm/sec)				
									Mean	Standard Error	LF Standard Deviat'n	Total Standard Deviat'n	Mean	Standard Error	LF Standard Deviat'n	Total Standard Deviat'n
15 (USGS)	40°50.8' 68°58.5'		10	VACM	S	78-09/79-03	169	22	-2.6	± 0.9	5.3	27.8	3.7	± 1.4	8.1	53.7
			51	VACM	SS	78-09/79-01	121	22	-2.0	± 0.5	2.6	24.6	3.7	± 1.5	7.6	43.9
16 (USGS)	40°49.0' 60°0.0'	78	58	VACM	SS	76-04/76-07	99	16	-2.3	± 0.5	2.1	14.7	4.5	± 1.2	5.3	43.1
17 (WHOI)	40°50.8' 69°01.0'	81	10	VACM	S	78-09/78-12	107	8	-6.1	± 1.8	8.5	24.2	10.6	± 1.8	8.2	56.3
			32	VACM	SS	78-09/79-01	149	8	-4.9	± 1.2	6.5	22.0	8.1	± 1.9	10.2	55.5
18 (WHOI)	40°52.0' 69°11.0'	64	27	VACM	SS	78-09/79-01	146	0	1.0	± 0.8	4.2	23.3	-0.3	± 1.4	7.6	47.4
			49	VACM	SS	78-09/79-01	146	0	-1.0	± 0.8	4.3	22.2	1.1	± 1.2	6.4	37.8
19 (WHOI)	41°30.4' 69°35.9'	33	5	ENDECO	SS	79-01/79-03	60	0	3.2	± 2.5	8.6	12.9	-7.2	± 3.3	11.3	52.6
			25	ENDECO	SS	79-01/79-03	60	0	-3.7	± 1.6	5.6	9.6	-7.0	± 2.2	7.7	46.3
20 (WHOI)	41°36.4' 69°43.8'	33	16	ENDECO	SS	79-07/79-08	41	0	-4.4	± 1.5	4.4	19.6	-2.3	± 1.4	4.1	32.6
21 (WHOI)	41°26.0' 69°44.1'	22	10	ENDECO	SS	79-07/79-08	41	0	-3.3	± 0.5	1.5	28.9	-10.5	± 0.9	2.5	48.3
22 (WHOI)	41°26.6' 69°59.2'	16	8	ENDECO	SS	79-07/79-08	41	0	5.8	± 1.0	2.9	36.9	0.5	± 0.5	1.5	12.6
23 (WHOI)	40°59.0' 70°04.0'	22	10	ENDECO	SS	79-07/79-08	41	0	1.6	± 0.8	2.4	37.4	1.3	± 0.9	2.7	31.2
24 (USGS)	40°42.5' 70°0.5'	41	18	850	SS	76-12/77-02	45	23	-4.2	± 4.3	13.0	29.1	-3.0	± 1.6	4.9	21.9

TABLE 1

Site Number	Location (N/A)	Water Depth (m)	Nominal Instrument Depth (m)	Instrument Type	Moor- ing Type	Measurement Start/Stop Date (Yr-Mo/Yr-Mo)	Records Length (Days)	Coordinate Rotation (Degree)	E' (cm/sec)			N' (cm/sec)		
									Mean	Standard Error	LF Standard Deviat'n	Mean	Standard Error	LF Standard Deviat'n
25 (USGS)	40°29.0' 70°30.2'	71	61	VACM	SS	78-11/79-02	106	18	-3.2	± 2.3	10.7	-9	± 1.2	5.7
26 (WHOI)	40°21.7' 71°12.0'	83	38	VACM	SS	76-02/76-07	131	67	1.8	± 0.8	4.1	-5.8	± 1.3	6.9
			73	VACM	SS	76-02/76-04	67	67	0.2	± 0.8	3.1	-4.0	± 2.4	8.9
27 (WHOI)	39°58.9' 71°57.4'	83	38	VACM	SS	76-02/76-08	168	58	1.2	± 0.6	3.2	-6.0	± 1.4	8.2
														11.1
28 (BIO)	43°00.0' 63°30.0'	170	20	BRNCN	SS	76-10/77-06	245	0	-1.7	± 1.8	12.9	-10.1	± 1.5	10.5
			50	ACM	SS	76-07/76-10 76-12/78-06	482	0	0.2	± 0.8	8.0	-1.8	± 0.8	7.6
			100	ACM	SS	77-07/78-01	177	0	1.0	± 1.6	9.6	-1.5	± 1.6	9.4
			150	ACM	SS	76-12/77-07	276	0	3.1	± 1.0	7.2	-0.3	± 1.3	10.2
29 (BIO)	42°48.0' 63°30.0'	250	20	BRNCN	SS	76-04/76-06 76-07/76-07 76-10/76-11 77-03/77-09	285	0	-1.2	± 1.5	11.0	-3.0	± 1.1	8.4
														19.8
			50	ACM	SS	75-12/76-01 76-07/78-01	742	0	1.2	± 0.9	10.8	0.0	± 0.6	6.8
			100	ACM	SS	77-07/78-01	175	0	-0.3	± 1.7	10.3	1.5	± 0.7	4.3
			150	ACM	SS	75-12/76-06 76-10/78-01	640	0	0.4	± 1.0	11.2	2.1	± 0.4	4.3
			220	ACM	SS	75-12/76-06 76-12/78-01	579	0	-2.7	± 0.9	9.8	-1.5	± 0.4	4.1
														10.0
30 (BIO)	42°45.0' 63°30.0'	710	230	ACM	SS	76-07/77-07	366	0	4.0	± 1.3	11.1	0.7	± 0.4	3.6
			500	BRNCN	SS	77-04/77-07	92	0	2.9	± 1.4	5.9	0.6	± 0.3	1.4
			690	ACM	SS	76-10/77-07	257	0	-1.0	± 0.3	2.4	0.1	± 0.2	1.2
														5.6

TABLE 1

Site Number	Location (N/W)	Water Depth (m)	Nominal Instrument Depth (m)	Instrument Type	Mooring Type	Measurement Start/Stop Date (Yr-Mo/Yr-Mo)	Records Length (Days)	Coordinate Rotation (Degree)	E' (cm/sec)			N' (cm/sec)		
									Mean	Standard Error	LF Standard Deviat'n	Mean	Standard Error	LF Standard Deviat'n
31 (BIO)	42°40.0' 63°30.0'	1010	50	ACM	SS	76-07/76-11 76-12/78-01	574	0	1.5	± 1.1	11.8	0.2	± 0.8	8.1
				ACM	SS	77-07/77-12	152	0	-2.0	± 2.4	13.0	1.5	± 1.2	6.6
				ACM	SS	76-07/76-11 76-12/78-01	574	0	2.5	± 1.1	11.6	0.6	± 0.6	6.0
				BRNCN	SS	77-04/78-01	270	0	-2.7	± 0.7	5.0	0.3	± 0.3	2.2
				ACM	SS	76-07/76-10 76-12/77-04	200	0	-2.6	± 0.7	4.7	-0.6	± 0.3	1.9
32 (BIO)	42°30.0' 63°30.0'	1560	50	ACM	SS	76-04/76-07 76-07/76-10 76-12/77-07	406	0	-1.3	± 0.5	4.2	0.5	± 0.3	2.3
				ACM	SS	76-07/76-12 77-04/77-07	252	0	6.3	± 1.5	10.7	1.6	± 1.2	8.5
				ACM	SS	76-07/76-12 77-04/77-07	252	0	5.4	± 1.3	9.0	2.7	± 1.1	7.7
				ACM	SS	76-07/77-07	365	0	-2.2	± 0.4	3.6	-1.1	± 0.3	2.3
				ACM	SS	76-07/77-02 76-12/77-04	312	0	8.2	± 1.7	13.4	-1.0	± 1.3	10.2
33 (BIO)	42°00.0' 63°30.0'	2550	1500	ACM	SS	76-07/77-02 77-04/77-07	299	0	-1.9	± 0.6	4.3	0.1	± 0.5	4.0
				BRNCN	SS	76-12/77-07	196	0	-2.6	± 0.6	3.6	-2.7	± 0.6	3.8
				BRNCN	SS	77-07/77-09	79	0	-5.8	± 1.9	7.6	-2.4	± 1.5	6.1
				ACM	SS	76-06/77-04 77-07/78-01	442	0	-7.1	± 1.1	10.5	-2.0	± 0.8	6.4
				ACM	SS	76-12/77-02 77-07/78-01	236	0	-6.2	± 1.8	12.3	-5.2	± 0.6	7.0
34 (BIO)	42°46.0' 64°00.0'	250	230	ACM	SS	76-12/77-02 77-07/78-01	236	0	-6.2	± 1.8	12.3	-5.2	± 0.6	7.0
				ACM	SS	76-12/77-02 77-07/78-01	236	0	-6.2	± 1.8	12.3	-5.2	± 0.6	7.0
				ACM	SS	76-12/77-02 77-07/78-01	236	0	-6.2	± 1.8	12.3	-5.2	± 0.6	7.0
				ACM	SS	76-12/77-02 77-07/78-01	236	0	-6.2	± 1.8	12.3	-5.2	± 0.6	7.0
				ACM	SS	76-12/77-02 77-07/78-01	236	0	-6.2	± 1.8	12.3	-5.2	± 0.6	7.0

TABLE 1

Site Number	Location (N/W)	Water Depth (m)	Nominal Instrument Depth (m)	Instrument Type	Moor- ing Type	Measurement Start/Stop Date (Yr-Mo/Yr-Mo)	Records Length (Days)	Coordinate Rotation (Degree)	E' (cm/sec)			N' (cm/sec)				
									Mean	Standard Error	LF Standard Deviat'n	Total Standard Deviat'n	Mean	Standard Error	LF Standard Deviat'n	Total Standard Deviat'n
35 (B10)	42°42.0' 64°00.0'	710	230	ACM	SS	76-06/77-06	333	0	3.3	± 1.3	10.5	12.8	1.5	± 0.7	4.8	8.5
		690	ACM	SS	76-06/76-10 76-12/77-07	302	0	-0.9	± 0.3	2.8	4.7	-1.1	± 0.2	2.0	7.5	
36 (B10)	43°34.5' 65°06.0'	60	15	ACM	SS	79-04/80-03	340	53	0.8	± 1.2	10.3	14.2	-5.2	± 1.9	15.4	25.6
		30	ACM	SS	79-04/80-03	340	53	-2.1	± 0.8	6.8	11.0	-5.1	± 1.4	11.4	18.4	
		50	ACM	SS	79-04/80-03	340	53	1.0	± 0.4	3.2	8.6	-1.3	± 0.9	7.3	12.7	
37 (B10)	43°29.0' 65°02.0'	110	15	ACM	SS	79-04/80-03	336	53	0.4	± 1.0	8.6	14.3	-5.0	± 1.9	15.4	22.8
		50	ACM	SS	79-04/79-10	174	53	-1.7	± 0.5	2.9	14.4	-6.1	± 1.2	7.4	6.5	
		100	ACM	SS	79-04/80-03	336	53	2.7	± 0.4	3.1	11.2	-2.8	± 0.7	5.7	10.9	
38 (B10)	43°11.50' 63°43.0'	60	15	VACM	SS	79-04/80-03	312	104	7.5	± 0.7	7.0	16.0	-6.7	± 1.1	9.0	68.3
		30	ACM	SS	79-04/79-07 79-10/80-03	231	104	3.4	± 0.9	4.4	8.8	-4.5	± 1.2	7.8	59.8	
		50	ACM	SS	79-04/80-03	298	104	-1.5	± 0.6	4.8	9.6	-1.7	± 0.6	4.8	37.7	
39 (B10)	43°02.0' 65°46.0'	110	15	VACM	SS	79-04/80-03	336	104	3.2	± 1.3	10.4	16.8	-2.6	± 1.6	12.8	45.8
		50	ACM	SS	79-04/80-03	336	104	2.6	± 0.6	5.1	10.0	-5.0	± 1.1	8.7	51.1	
		100	ACM	SS	79-04/80-03	336	104	-1.6	± 0.6	4.7	12.5	0.5	± 0.6	4.8	34.1	
40 (B10)	42°50.0' 65°50.0'	110	15	ACM	SS	79-08/80-03	233	104	2.1	± 2.0	13.6	24.1	8.1	± 2.3	16.0	44.6
		50	ACM	SS	79-04/79-09	174	104	2.4	± 1.0	6.3	20.3	12.3	± 1.3	7.4	45.2	
		100	ACM	SS	79-04/80-03	297	104	-4.5	± 0.7	5.5	18.3	6.1	± 0.9	7.2	34.1	
41 (B10)	42°34.0' 65°56.0'	110	15	ACM	SS	79-04/80-03	336	104	2.4	± 1.4	11.2	26.7	-7.5	± 1.7	14.2	38.3

TABLE 1

Site Number	Location (N/W)	Water Depth (m)	Instrument Depth (m)	Instrument Type	Moor- ing Type	Measurement Start/Stop Date (Yr-Mo/Yr-Mo)	Records Length (Days)	Coord- inate Rotation (Degree)	E' (cm/sec)				N' (cm/sec)			
									Mean	Standard Error	LF Standard Deviat'n	Total Standard Deviat'n	Mean	Standard Error	LF Standard Deviat'n	Total Standard Deviat'n
42 (NMFS)	42°22.0' 66°02.3'	221	50	ACM	SS	79-04/80-03	336	104	-0.1	± 0.9	7.2	23.9	-12.7	± 1.2	10.9	38.2
			100	ACM	SS	79-04/80-03	336	104	0.7	± 0.9	7.1	18.9	-5.1	± 1.2	9.8	25.7
			102	VACM	SS	76-09/77-04 77-06/77-09 77-09/77-12 78-03/78-09	555	-48	0.6	± 0.5	5.7	15.0	10.1	± 1.1	11.2	39.5
			152	VACM	SS	76-09/77-04 77-06/77-09 77-09/78-03 78-03/78-09	655	-48	-0.6	± 0.4	5.1	17.9	7.8	± 1.1	12.5	43.6
43 (NMFS)	42°16.8' 65°57.0'	232	204	VACM	SS	76-09/77-04 77-06/77-09 77-09/78-01 78-03/78-09	599	-48	0.3	± 0.3	3.9	13.5	3.3	± 1.2	12.8	38.1
			105	VACM	SS	78-03/78-05	63	-48	0.9				2.5			
			155	VACM	SS	77-07/78-03 78-03/78-09	352	-48	1.4	± 0.8	6.7	20.7	6.2	± 2.3	19.1	47.4
			216	VACM	SS	76-09/77-04 77-06/77-07 77-09/78-03	422	-48	0.5	± 0.4	3.8	16.7	4.5	± 1.7	15.8	41.0
44 (NMFS)	42°10.7' 66°02.3'	229	108	VACM	SS	77-06/77-09 77-09/77-10 78-03/78-09	319	-48	3.5	± 0.5	3.8	15.7	-6.2	± 0.8	6.8	45.3
			158	VACM	SS	77-06/77-09	99	-48	1.6	± 0.6	2.7	22.3	-1.3	± 1.6	7.1	46.1
			211	VACM	SS	77-09/78-03 78-03/78-09	372	-48	1.1	± 0.6	4.9	17.4	9.4	± 2.7	22.7	41.2
			33	VACM	SS	74-11/75-01	57	0	-7.1	± 4.6	9.9	13.5	0.7	± 3.6	8.4	13.3
45 (WHOI)	43°10.9' 69°05.0'	190	68	FCM	SS	74-11/75-01	57	0	-3.4	± 1.4	4.3	7.4	1.4	± 1.8	4.4	7.8
			118	FCM	SS	74-11/75-01	57	0	-1.3	± 1.1	3.4	6.6	0.9	± 1.4	3.9	8.2

TABLE 1

Site Number	Location (N/W)	Water Depth (m)	Instrument Depth (m)	Instrument Type	Moor- ing Type	Measurement Start/Stop Date (Yr-Mo/Yr-Mo)	Records Length (Days)	Coord- inate Rotation (Degree)	E' (cm/sec)			N' (cm/sec)				
									Mean	Standard Error	LF Standard Deviat'n	Total Standard Deviat'n	Mean	Standard Error	LF Standard Deviat'n	Total Standard Deviat'n
46 (WHOI)	48°40.3' 69°22.7'	98	33	VACM	SS	74-11/75-01	57	0	-7.5	± 2.1	6.5	7.7	-1.8	± 1.0	3.4	7.0
			68	FCM	SS	74-11/75-01	57	0	-3.7	± 1.3	4.0	5.7	0.3	± 0.4	2.0	4.9
47 (WHOI)	43°12.9' 70°16.6'	98	33	VACM	SS	74-11/75-01	57	0	-1.1	± 1.4	5.4	7.5	-4.6	± 1.0	4.2	7.7
48 (NMFS)	40°41.60' 70°08.60'	46	10	VACM	SS	79-03/79-09	172	14	-9.2	± 1.5	9.0	25.5	0.8	± 1.0	6.2	21.2
			30	VACM	SS	79-03/79-07 79-09/80-04	348	14	-4.8	± 1.4	11.4	23.7	-1.1	± 0.6	5.3	19.6
49 (USGS)	40°30.0' 70°12.5'	66	10	VACM	S	79-03/79-09	194	16	-8.0	± 1.6	9.9	19.5	-2.1	± 1.0	6.2	18.2
			37 30	VACM	SS	79-03/79-08 79-08/79-12 80-01/80-05	423	16	-6.7	± 1.3	12.3	18.2	-1.0	± 0.5	4.4	13.9
			50	VACM	SS	79-03/79-08 79-08/79-12 80-01/80-05	423	16	-4.9	± 1.2	11.3	17.4	-2.5	± 0.4	3.9	14.2
50 (NMFS)	40°20.60' 70°16.10'	88	10	VACM	S	79-09/79-10	46	14	-6.4	± 4.2	12.7	21.6	-2.8	± 2.3	6.7	19.4
			30	VACM	SS	79-03/80-04	392	14	-7.7	± 1.4	12.6	15.9	-0.5	± 0.6	5.4	11.3
			70	VACM	SS	79-03/80-04	392	14	-4.2	± 1.3	11.6	15.8	-0.6	± 0.4	3.6	11.5
51 (NMFS)	40°12.90' 70°18.20'	105	10	VACM	S	79-03/79-09	170	14	-12.4	± 1.8	10.6	17.0	-2.1	± 1.3	7.4	15.8
			30	VACM	SS	79-09/80-04	223	14	-10.4	± 2.2	14.7	17.4	-2.1	± 1.1	7.4	12.3
			60	VACM	SS	79-03/79-09	170	14	-8.5	± 1.2	7.2	11.3	0.3	± 0.7	4.0	9.1
			90	VACM	SS	79-03/80-04	393	14	-3.6	± 1.1	9.9	13.6	-0.3	± 0.4	3.8	10.3

TABLE 1

Site Number	Location (N/W)	Water Depth (m)	Nominal Instrument Depth (m)	Instrument Type	Moor- ing Type	Measurement Start/Stop Date (Yr-Mo/Yr-Mo)	Records Length (Days)	Coord- inate Rotation (Degree)	E' (cm/sec)			N' (cm/sec)				
									Mean	Standard Error	LF Standard Deviat'n	Total Standard Deviat'n	Mean	Standard Error	LF Standard Deviat'n	Total Standard Deviat'n
52 (WHOI)	40°02.20' 70°22.10'	198	10	VACM	S	79-03/79-09	171	14	1.1	± 2.1	12.5	17.4	1.0	± 1.5	8.6	15.1
			30	VACM	SS	79-03/80-03	373	14	-2.7	± 1.4	12.1	15.5	-0.9	± 0.9	7.5	12.3
			90	VACM	SS	79-03/79-09	171	14	3.9	± 1.4	8.1	10.1	2.3	± 0.9	5.1	8.1
			120	VACM	SS	79-03/80-03	373	14	0.3	± 1.2	10.8	12.6	1.0	± 0.5	4.2	8.0
			185	VACM	SS	79-03/79-09	171	14	-0.8	± 1.1	6.7	9.4	-1.5	± 0.5	2.7	7.9
53 (NMFS)	39°51.18' 70°25.37'	810	10	VACM	S	79-03/80-04	396	14	3.6	± 1.8	15.9	19.5	-1.0	± 1.2	10.7	15.6
54 (WHOI)	39°25.6' 69°59.6'	2504	181	VACM	SS	74-04/74-12	236	0	-4.9			15.6	1.3			20.5
			983	VACM	SS	74-04/74-12	237	0	-4.1			4.0	-0.1			2.4
			1991	VACM	SS	74-04/74-12	237	0	-2.6			3.9	-0.2			2.1
55 (WHOI)	39°07.5' 69°69.9'	2664	200	VACM	SS	74-04/74-12	236	0	-8.4			12.8	1.1			17.9
			496	VACM	SS	74-04/74-12	236	0	-5.4			4.4	0.1			5.3
			1005	VACM	SS	74-04/74-12	236	0	-4.3			3.7	-0.3			3.0
			2013	VACM	SS	74-04/74-12	235	0	-3.0			3.5	-0.4			3.1
			2512	VACM	SS	74-04/74-12	235	0	-2.5			3.9	-0.6			4.7
56 (WHOI)	39°07.1' 70°32.6'	2759	195	VACM	SS	74-04/74-12	236	0	-11.3			12.9	-4.6			16.7
			997	VACM	SS	74-04/74-12	236	0	-3.8			3.9	-0.7			2.6
			2005	VACM	SS	74-04/74-12	235	0	-2.3			4.5	-0.4			2.5
57 (WHOI)	39°56.1' 71°02.9'	496	147	VACM	SS	76-02/76-08	177	74	-1.5	± 1.2	5.1	6.8	-0.3	± 2.4	10.2	11.2

TABLE 1

Site Number	Location (N/W)	Water Depth (m)	Nominal Instrument Depth (m)	Instrument Type	Moor- ing Type	Measurement Start/Stop Date (Yr-Mo/Yr-Mo)	Records Length (Days)	Coordinate Rotation (Degree)	E' (cm/sec)			N' (cm/sec)		
									Mean	Standard Error	LF Standard Deviat'n	Mean	Standard Error	LF Standard Deviat'n
58 (WH01)	39°36.8' 70°56.5'	2300	300	VACM	SS	76-02/76-08	177	70	0.6	± 0.7	3.9	-3.7	± 1.5	6.4
									0.9	± 0.3	2.0	-3.3	± 1.5	4.6
59 (WH01)	39°16.7' 70°48.9'	2650	2000	VACM	SS	76-02/76-08	177	89	-0.1	± 0.3	1.8	-1.8	± 0.7	3.0
									-0.3	± 0.7	3.0	1.3	± 1.7	7.2
60 (WH01)	39°42.5' 71°47.0'	504	304	VACM	SS	76-02/76-08	180	47	-0.3	± 0.7	3.0	1.3	± 1.7	7.2
														7.4

Figure 2

Time line of moored current measurements made in the Gulf of Maine and adjacent shelf and slope region during 1975-1980. Dashed lines indicate partial data collection (temperature only, for example). Time lines in brackets indicate data not included in this compilation. The group which made the observations is listed in the first column. BIO is Bedford Institute of Oceanography, EG&G is EG&G Environmental Consultants, NMFS is National Marine Fisheries Service, USGS is U.S. Geological Survey and WHOI is Woods Hole Oceanographic Institution. For the BIO and USGS stations, the station designation commonly used by that group is also listed in Column 1. The station number keys the measurements to Table 1 and Figure 1. Groups of measurements made as part of individual field experiments are indicated by large brackets.

1975-1980

Figure 3: Mean Eulerian subsurface currents observed in the Gulf of Maine and adjacent Scotian and New England shelf region. The shallowest current measurements were made at a depth of 10 m, and the mean current vectors shown are not synoptic measurements, but are based on measurements of varying length (one-month minimum) made at different times during the period 1974-1980. Each measurement site is identified by a boldface station number located at the origin of the vector. This station number is the key to the additional data in Table 1. The number in parentheses following the station identifier indicates the water depth in meters at that station. The number at the top of the mean velocity vector indicates the measurement depth in meters. The speed scale has been chosen so that the magnitude of the current vector is equivalent to the mean displacement of a water particle during a 6.0 day period.

Figure 4: Standard Deviation of Subtidal Current Components. The subtidal current variability at each station is shown as a cross oriented in the alongshelf/cross-shelf direction where the length of each axis is proportional to the observed standard deviation of the low-frequency current components. The bold-face station number keys measurements to Table 1. The number in parentheses following the station identifier indicates the water depth in meters of that station. The number near the top of the vector indicates the measurement depth in meters. For clarity, only the near-surface and near-bottom values are shown, and some stations have been displaced slightly from their time positions. The speed scale has been chosen so actual water particle excursions at map scale caused by the low-frequency currents are one-half as large as those shown (assuming a typical five-day period for the subtidal motions).

Figure 4: Standard Deviation of Subtidal Current Components. The subtidal current variability at each station is shown as a cross oriented in the longitudinal direction where the length of each axis is proportional to the observed standard deviation of the low-frequency current components. The bold-face station number keys measurements to Table 1. The number in parentheses following the station identifier indicates the water depth in meters of that station. The number near the top of the vector indicates the measurement depth in meters. For clarity, only the near-surface and near-bottom values are shown, and some stations have been displaced slightly from their true positions. The speed scale has been chosen so actual water particle excursions at map scale caused by the low-frequency currents are one-half as large as those shown (assuming a typical five-day period for the subtidal motions).

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