Current Profile Timeseries from the FRONT Moored Array

Technical Report

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Abstract

Time periods and locations of current meter deployments from the moored array component of the Front-Resolving Observation Network with Telemetry (FRONT) project are described. The experiment site is the inner continental shelf outside Block Island Sound offshore from Montauk Point and Block Island. Details regarding sampling parameters are provided. The data records (vertical profiles of east and north current components, as well as timeseries of bottom pressure and temperature) are freely available and the means to obtain them is explained.

A brief summary of the data characteristics reveals 27 records of typical duration about 60-70 days (shortest is 45 days, longest 186 days), with most sampling occurring in the fall, winter and spring seasons. Deployments were typically in 20-50 m water depth (shallowest is 14 m, deepest 66 m), with vertical resolution nominally 0.5 – 1 m and sampling interval 15 or 20 minutes.

Contents

1. Background

In a 3-year, multi-institution, interdisciplinary effort funded by the Office of Naval Research through the National Ocean Partnership Program, the Front-Resolving Observation Network with Telemetry (FRONT) project developed real-time measurement capabilities and advanced the understanding of oceanographic processes on the inner continental shelf. Part of the study was an array of moored profiling current meters in two-way real-time communication with shore via networked acoustic modems (see, e.g., Codiga et al, 2002).

In addition to demonstrating and advancing the acoustic networking technology, the moored array program involved multiple deployments of seven UConn acoustic Doppler current profiler (ADCP) units. The resulting large volume of high quality timeseries measurements of current profiles in the region outside the mouth of Block Island Sound offshore from Montauk Point and Block Island is the subject of this report.

There is fairly extensive commercial fishing activity at the site, including dragging of both trawl nets for bottom fish and dredges for scallops. A project objective was to design and build low-profile "trawl-resistant" bottom frames (Codiga et al, 2000) that protect upward-looking ADCPs on the seafloor and minimize their potential effects on fishing gear (while also including azimuthally omnidirectional transducers at their apex for the acoustic network). Bottom frames were physically impacted by trawling gear in at least three deployments. This was determined following recovery based on obvious visible damage to the instrument frame and/or substantial discontinuities in the pitch/roll/heading values recorded internally by the current meter. It is a measure of success for the design and function of the bottom frames that, in the course of more than 30 deployments and recoveries, only a single ADCP showed evidence of damage and none was lost.

2. Timeline of deployments and naming convention

Deployments fall in eight groups (Figure 1), each roughly aligned with a season where winter, spring, summer and fall correspond to months of the year 12-1-2, 3-4-5, 6-7-8, and 9-10-11 respectively.

The naming convention for data records therefore includes a prefix based on the season (WI, SP, FA for winter, spring, and fall respectively) and year (last two digits only) when it started. A suffix (typically -E, -W, -N or -S for east, west, north and south respectively) is appended, based loosely on the geographic position of the instrument relative to the others deployed at the same time.

For certain individual instrument deployments so named, there are multiple records, each with an additional suffix a, b, c, or m. This is because the acoustic communication network enabled the sampling parameters of the instrument to be changed from shore in real time. From each of these instruments, multiple sub-records (a, b, c) were generated during the deployment, and a merged record (m) was created following instrument

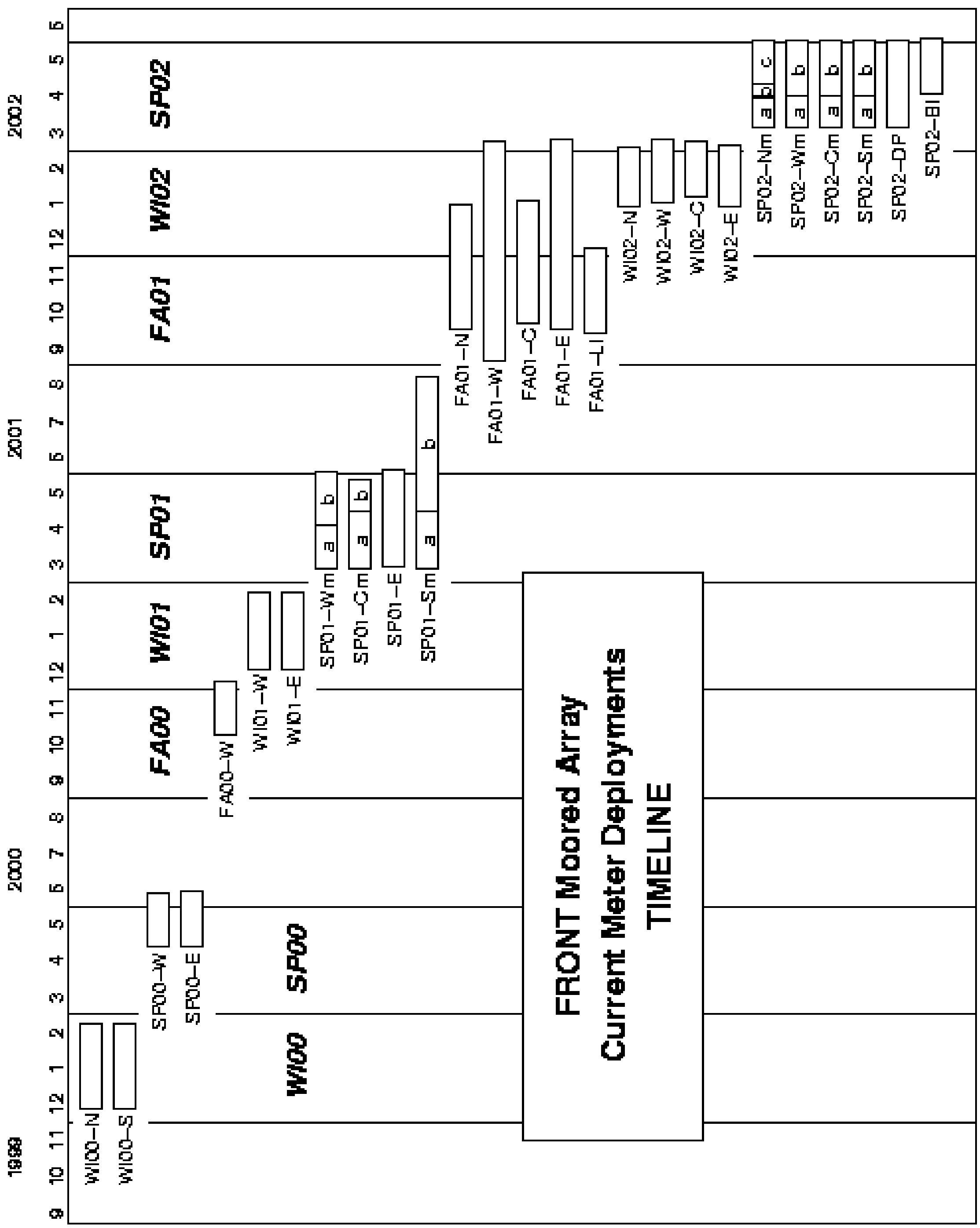

Figure 1. Timeline of deployments by name. See Table 1 for listing of specific dates.

recovery by interpolating and averaging data in the sub-records as necessary to fill a uniform time and depth grid. Both the sub-records and merged records are described here and are available individually.

3. Instrument locations and array configurations

The persistent occurrence of surface frontal zones near the 50-m isobath (Ullman and Cornillon, 1999) was a motivating factor for the choice of experiment site. The deployment locations (Figure 2) are grouped just south of Montauk Point and Block Island, with three additional far-field locations (off Long Island, FA01-LI; at a deep site farther offshore, SP02-DP; and southeast of Block Island, SP02-BI). The goal of providing improved constraints to the regional data-assimilative numerical modeling component of the project helped motivate the far-field deployments.

The number of instruments in a given deployment increased from two to seven as the study proceeded (Figure 3). This is in part because the bottom frame was designed and tested during early deployments, with only two available prior to the SP01 deployment.

The array configuration evolved during the course of the three-year study. Each array design reflected a balance among many goals, with the two primary aims being to achieve relevant oceanographic sampling of the frontal region while simultaneously enabling acoustic networking for real-time communication with shore.

The acoustic networking set two primary constraints on the array configurations. First, the fixed USCG Montauk Point navigation buoy (located at WI00-N in Figure 3a) served as one communication gateway between the site and shore, so all instruments participating in the acoustic network had to be in its general vicinity. Second, the subsurface operating range of the acoustic modems set the maximum separation distance of nodes in the acoustic communication array, which in turn governed the separation distances of the ADCPs.

The WI00 and SP00 deployments (Figure 3a,b) were initial tests, involving two ADCPs, made in association with tests of acoustic equipment. Instrument locations were chosen to gain introductory knowledge of the large-scale north-south (WI00) and east-west (SP00) structure of flow across the experimental site.

The FA00 and WI01 deployments (Figures 3c,d) were similar to WI00 and SP00 in terms of hardware deployed, with inclusion of a third ADCP physically mounted on the autonomous vertically profiling plankton observatory (AVPPO) deployed by Scott Gallager, Heidi Sosik, and Ru Morrison (Woods Hole Oceanographic Institution). The array was configured as a triangle roughly centered on the site of highest frontal activity based on sea-surface temperature (SST) analyses (Ullman and Cornillon, 1999).

SP01 was the first deployment when bottom frames were available for all seven ADCPs so they could be deployed simultaneously. The array design (Figure 3e) incorporates (a) a 5-point cross with a central instrument and four others surrounding it, one each nominally

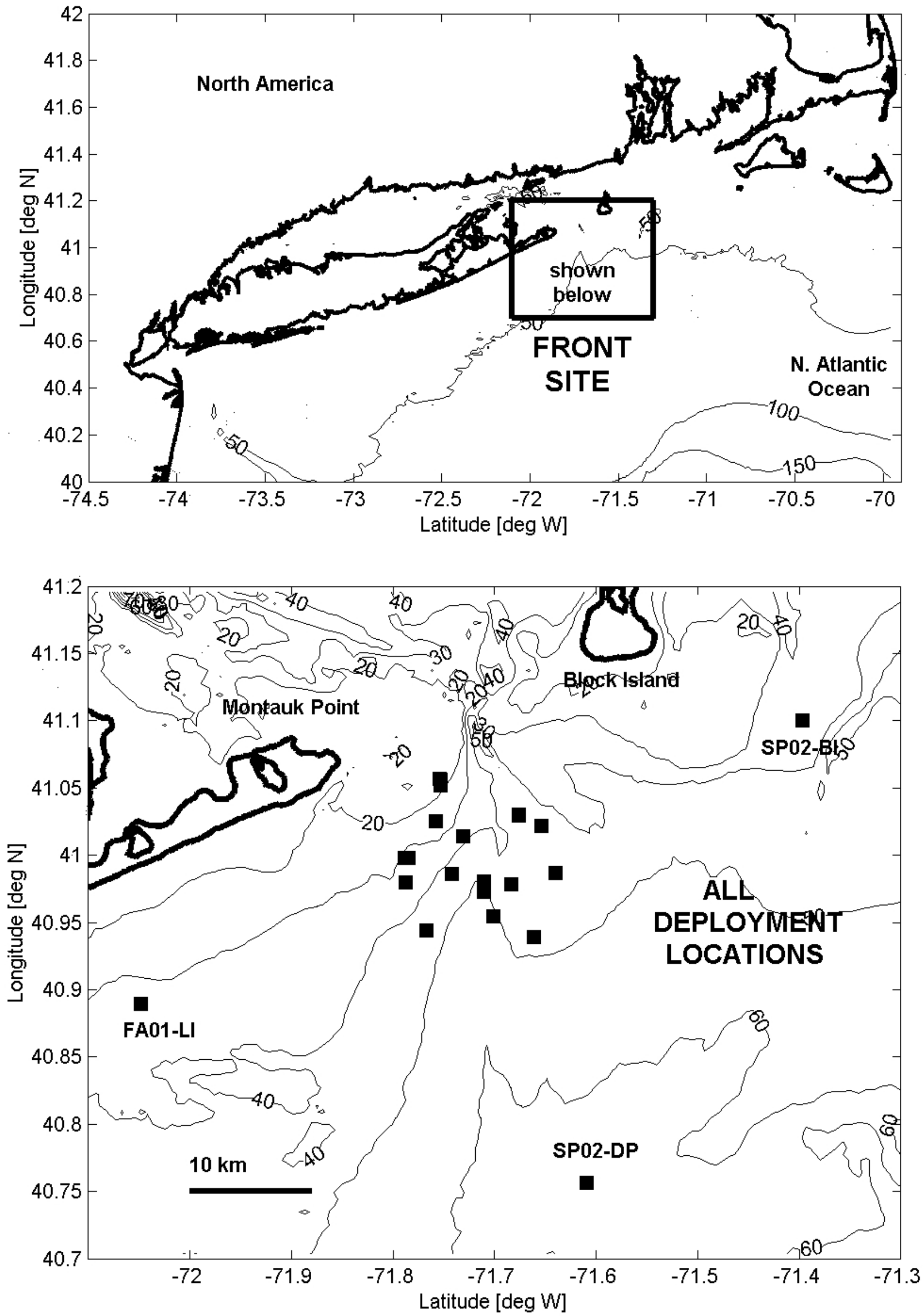

Figure 2. (a, upper) Map with large field of view depicting the experimental site. The 50, 100, and 150 m isobaths are shown. (b, lower) Expanded view of region marked in (a), with topographc contours in meters, and squares marking deployment locations of all data records. Three "far-field" deployment locations are labeled by name here while all others are labeled by name in Figure 3.

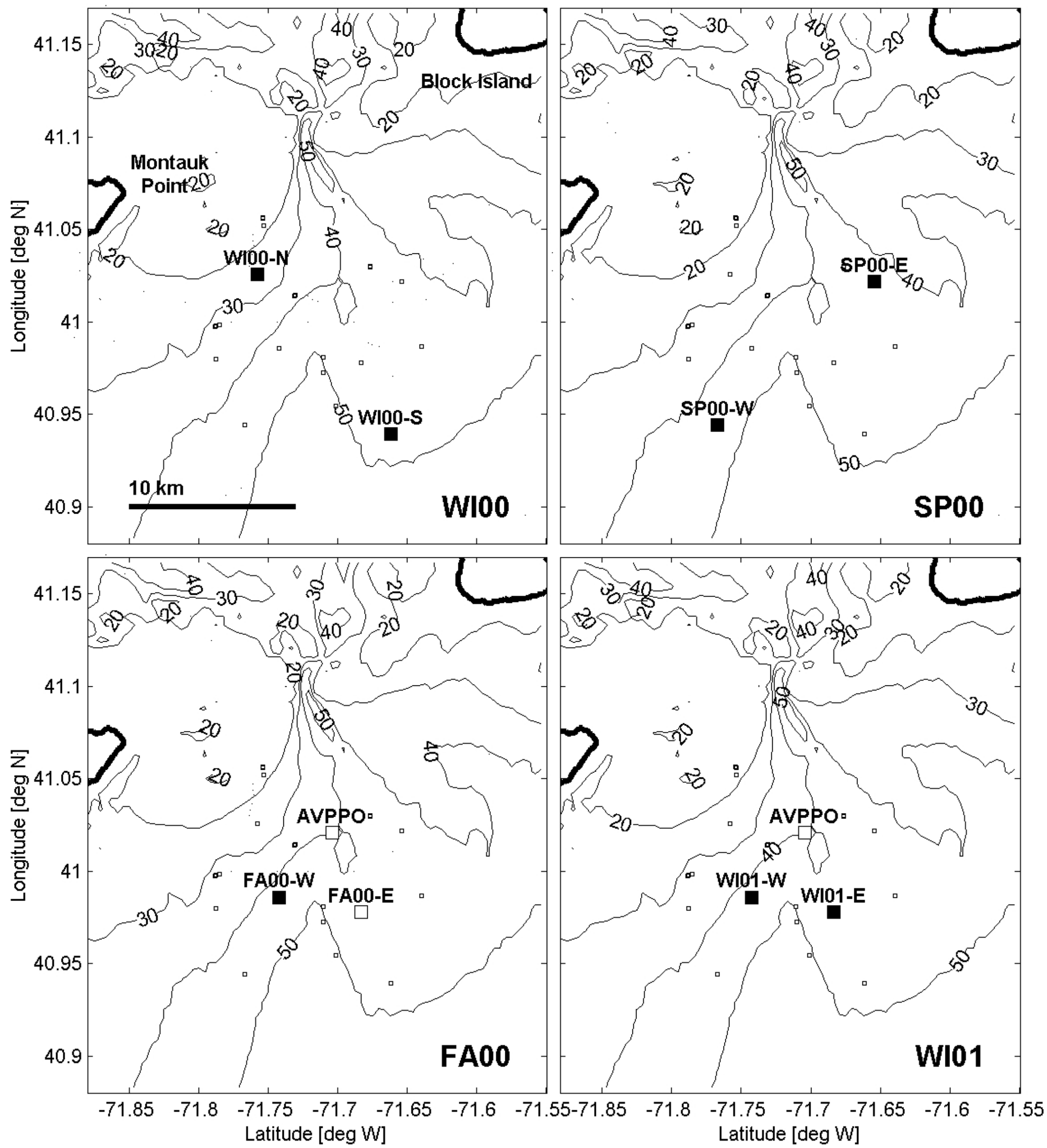

Figure 3. Deployment locations. Each frame shows deployments from one season as large squares labeled by deployment name; in addition, for geographic reference the locations of all deployments (as seen in Figure 2b) are shown as small squares. Hollow squares mark deployments that did not return data of sufficient length or quality for inclusion in this report; detailed notes in section 7 provide more information. (a, upper left) WI00. (b, upper right) SP00. (c, lower left) FA00. (d, lower right) WI01.

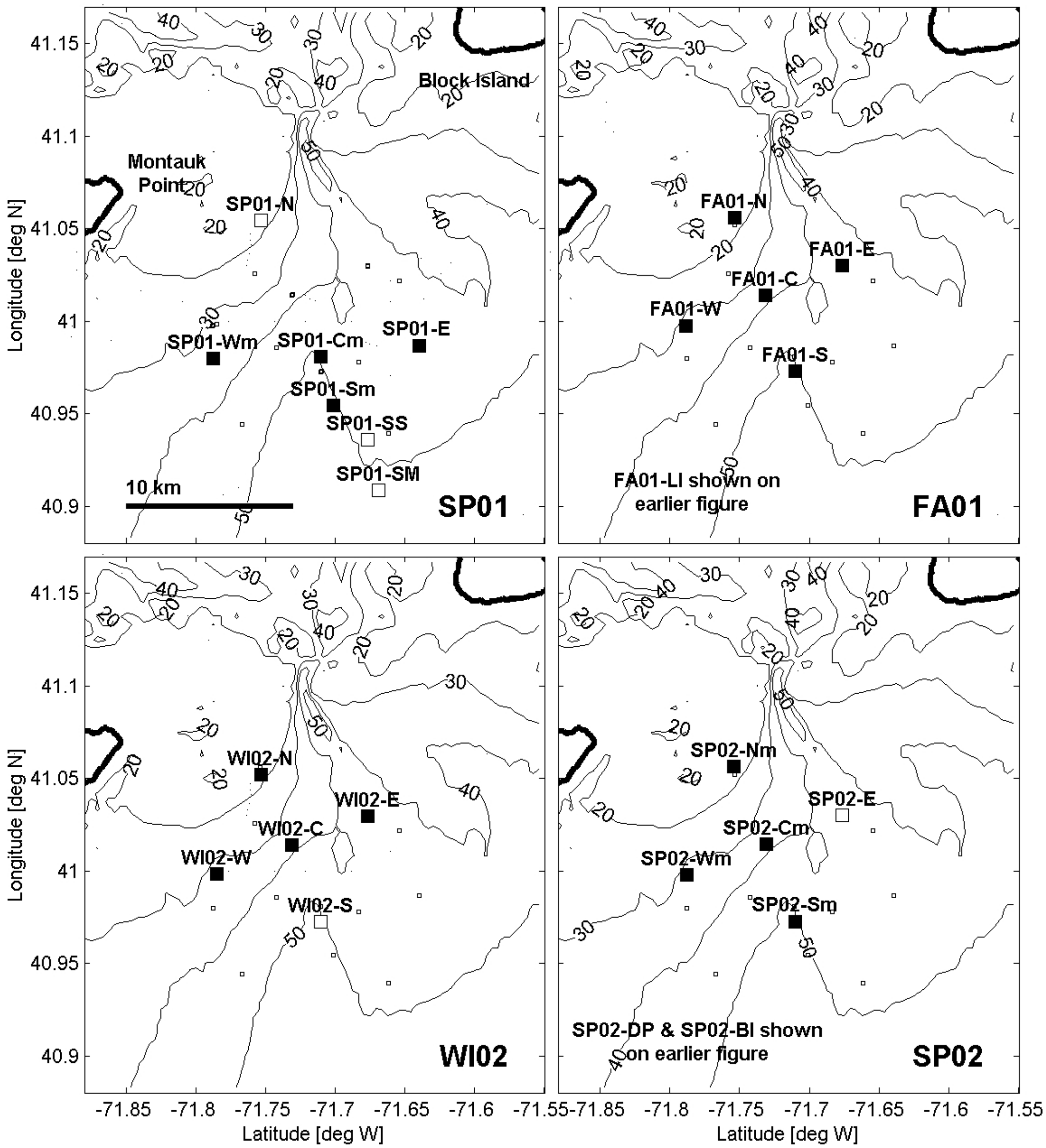

Figure 3 Continued: (e, upper left) SP01. (f, upper right) FA01. (g, lower left) WI02. (h, lower right) SP02.

to the onshore, offshore, upcoast, and downcoast sides, and (b) a more heavily sampled southern leg of the cross intended to straddle the region of high SST frontal activity.

The final sequence of deployments included FA01, WI02, and SP02 (Figure 3f,g,h). Their array design is a 5-point cross centered on the highest SST frontal activity, with selected additional far-field deployment locations (Figure 2b).

4. Deployment and sampling details

Seven acoustic Doppler current profilers (RD Instruments) were used, two operating at 614 kHz and five at 307 kHz. With the exception of WI02-C (described below), ensemble averaging was over pings distributed across an interval with duration equal to the time between successive samples, which was either 15 or 20 minutes.

Details of the deployment locations, dates, and sampling are given in Table 1. In the table column headings, "zwat" is the water depth, "zmin/zmax" are the center depths of the shallowest and deepest vertical bins, "bin" is vertical bin size, "int" is the ensemble interval (same as time between samples, except for WI02-C), "err" is the minimum standard deviation due to instrument error (as explained in the README), and "frq" is the frequency of the instrument.

In deployments prior to FA01, the bin sizes were generally chosen for each individual instrument to be as small as possible given battery limitations, data storage limitations, and the need obtain range sufficient to sample the entire water column. For FA01 and later deployments the bin size was set at 0.5 m for 614 kHz units and 1.0 m for the 300 kHz units.

In addition to currents, each ADCP deployment generated a timeseries of bottom pressure and bottom temperature values, which are included in the data files. The resolution for the pressure and temperature sensors is visible on close examination of the records.

5. Aspects of data handling

a. Mimimally-processed records

The intent is to process the values as minimally as possible, perform some simple data quality checks, and put them in to matrix form corresponding to evenly spaced time and depth grids. The Appendix includes a README file in which most details are provided.

For nearly all records, the routine "surface.exe" available from RD Instruments (Visbeck and Fischer, 1995) was used to determine the water depth. For others, some combination of pressure measurements, fathometer fixes and chart information was used together with inspection of the data quality in the shallow bins.

Table 1. FRONT Current Meter Deployment Information and Sampling Parameters

file	startday	endday	dur	lon	lat	zwat	zmin/zmax	bin	int	err	frq
name	yy/mm/dd	yy/mm/dd	dys	deg W	deg N	m	m /m	m	min	cm/s	khz
WI00-S	99/12/13	00/02/22	071	71.661930	40.939300	47.9	15.7/45.7	1.00	15.0	0.6	614
WI00-N	99/12/13	00/02/23	072	71.757717	41.025500	26.7	02.6/25.1	0.50	15.0	1.1	614
SP00-W	00/04/28	00/06/12	045	71.766950	40.944083	45.6	04.0/44.0	1.00	15.0	0.4	614
SP00-E	00/04/28	00/06/13	046	71.654350	41.021667	44.9	03.3/42.3	1.00	15.0	0.4	614
FA00-W	00/10/24	00/12/09	046	71.742217	40.985917	44.8	03.5/43.0	0.50	20.0	1.4	614
WI01-W	00/12/19	01/02/22	065	71.742217	40.985917	44.8	03.6/43.1	0.50	20.0	1.4	614
WI01-E	00/12/19	01/02/22	065	71.683517	40.978050	41.6	03.0/38.9	0.32	20.0	2.5	307
SP01-Wa	01/03/12	01/04/17	036	71.787933	40.979900	34.2	02.2/32.6	0.32	20.0	1.4	614
SP01-Wb	01/04/19	01/06/03	045	71.787933	40.979900	34.2	02.9/32.3	0.64	20.0	0.6	614
SP01-Wm	01/03/12	01/06/03	081	71.787933	40.979900	34.2	02.9/32.3	0.64	20.0	0.6	614
SP01-Ca	01/03/12	01/04/29	048	71.710567	40.980783	46.9	04.1/44.0	0.48	20.0	1.6	307
SP01-Cb	01/05/01	01/05/27	026	71.710567	40.980783	46.9	04.4/43.7	0.96	20.0	1.1	307
SP01-Cm	01/03/12	01/05/27	075	71.710567	40.980783	46.9	04.4/43.7	0.96	20.0	1.1	307
SP01-E	01/03/13	01/06/03	082	71.639850	40.986883	43.7	03.5/40.8	0.49	20.0	1.6	307
SP01-Sa	01/03/14	01/05/01	048	71.701367	40.954367	49.2	04.8/46.4	0.42	20.0	1.7	307
SP01-Sb	01/05/01	01/08/23	114	71.701367	40.954367	49.2	05.0/46.1	0.84	20.0	1.2	307
SP01-Sm	01/03/14	01/08/23	162	71.701367	40.954367	49.2	05.0/46.1	0.84	20.0	1.2	307
FA01-LI	01/09/04	01/11/15	072	72.048467	40.889517	32.7	03.3/29.3	1.00	20.0	1.1	307
FA01-W	01/09/04	02/03/09	186	71.788400	40.997650	32.9	03.1/30.6	0.50	20.0	1.1	614
FA01-S	01/10/02	01/12/11	070	71.709917	40.972783	54.7	05.3/51.3	1.00	20.0	1.1	307
FA01-N	01/10/02	02/01/15	105	71.753700	41.056050	14.6	01.8/12.3	0.50	20.0	1.1	614

Table 1. Detailed information corresponding to each deployment. See section 4 for column heading explanations.

Table 1. Continued.

Table 1, Continued.

file	startday	endday	dur	lon	lat	zwat	zmin/zmax	bin	int	err	frq
name	yy/mm/dd	yy/mm/dd	dys	deg W	deg N	m	m /m	m	min	cm/s	khz
FA01-E	01/10/02	02/03/12	161	71.676733	41.030083	48.7	05.3/45.3	1.00	20.0	1.1	307
FA01-C	01/10/03	02/01/14	103	71.731500	41.014000	36.7	04.3/33.3	1.00	20.0	1.1	307
WI02-N	02/01/14	02/03/05	050	71.753400	41.051920	17.2	01.2/14.2	0.50	20.0	1.4	307
WI02-E	02/01/14	02/03/07	052	71.676767	41.029700	48.6	04.3/45.3	1.00	20.0	1.1	307
WI02-W	02/01/17	02/03/12	054	71.785117	40.998150	33.1	02.9/31.4	0.50	20.0	1.0	614
WI02-C	02/01/22	02/03/10	047	71.731500	41.014000	36.7	04.3/33.3	1.00	80.0	1.6	307
SP02-Na	02/03/21	02/04/16	026	71.753950	41.056467	14.3	02.1/12.1	0.50	20.0	1.0	614
SP02-Nb	02/04/17	02/04/27	010	71.753950	41.056467	14.3	02.1/12.1	0.50	20.0	1.0	614
SP02-Nc	02/04/27	02/06/04	038	71.753950	41.056467	14.3	02.1/12.1	0.50	20.0	1.0	614
SP02-Nm	02/03/21	02/06/04	075	71.753950	41.056467	14.3	02.1/12.1	0.50	20.0	1.0	614
SP02-Ca	02/03/21	02/04/16	026	71.730883	41.014367	36.5	04.2/33.2	1.00	20.0	1.0	307
SP02-Cb	02/04/17	02/06/03	047	71.730883	41.014367	36.5	04.2/33.2	1.00	20.0	1.0	307
SP02-Cm	02/03/21	02/06/03	073	71.730883	41.014367	36.5	04.2/33.2	1.00	20.0	1.0	307
SP02-Wa	02/03/21	02/04/17	027	71.787533	40.998033	32.6	03.3/30.8	0.50	20.0	1.0	614
SP02-Wb	02/04/17	02/06/03	047	71.787533	40.998033	32.6	03.3/30.8	0.50	20.0	1.0	614
SP02-Wm	02/03/21	02/06/03	074	71.787533	40.998033	32.6	03.3/30.8	0.50	20.0	1.0	614
SP02-Sa	02/03/21	02/04/17	027	71.710250	40.972733	54.6	05.3/51.3	1.00	20.0	1.0	307
SP02-Sb	02/04/17	02/06/03	047	71.710250	40.972733	54.6	05.3/51.3	1.00	20.0	1.0	307
SP02-Sm	02/03/21	02/06/03	074	71.710250	40.972733	54.6	05.3/51.3	1.00	20.0	1.0	307
SP02-DP	02/03/21	02/06/04	075	71.609483	40.756500	66.3	06.0/63.0	1.00	20.0	1.0	307
SP02-BI	02/04/19	02/06/04	046	71.396667	41.100033	38.4	04.1/35.1	1.00	20.0	1.0	307

As the vertical-mean east and north components of velocity are of interest to at least some of the users of this data, they have been calculated using values from all available depth bins, and are included in the data records.

A crude correction to the pressure values has been applied (as explained in the README) to account for biases. All corrected pressure records indicate a peak to peak tidal component in the range of about 0.6 (neap) to 1.4 m (spring). The consistency of these values across the relatively small region from which they have been collected suggests the correction has removed the lowest order biases without distorting the signal.

Currents from the shallowest bins are subject to contamination by surface reflection of acoustic energy and should be used with caution. In general, such contamination can vary depending on the sea state and whether the tide is neap or spring. Shallow bins for which contamination was evident at any time were generally excluded, but in some cases the shallowest 1-2 bins that were retained are contaminated for some fraction of the record.

The initial 5 hours of temperature data for most deployments generally reveals a nearly exponential equilibration, from the air temperature prior to entering the water to the ambient bottom value. These values have therefore been excluded.

For deployments that generated multiple sub-records (suffixes a, b, c) the means by which they have been merged into single records (suffix m) is described in section 7.

The "echo intensity", "percent good", and "correlation" fields from the ADCP, as well as the pitch/roll/heading timeseries, are available on request but have been excluded from the data records in the interest of minimizing their size.

b. Low-pass filtered records

It is anticipated that at least some users of these data will be interested primarily in the low-frequency or sub-tidal component of flow, that which survives a low-pass filter, as opposed to the unfiltered data which tends to be dominated by the tidal components. As a result, a second group of files is available that incorporates the additional data processing step of a low-pass filter in time, together with subsequent subsampling.

The low-pass filter is a triangular-weighted running mean with half-width of 25 hours and the subsampling is to one value each 5 hours. This filter suppresses fluctuations with period less than 25 hours, including the dominant semidiurnal tidal currents as well as diurnal tidal currents and inertial motions.

6. How to obtain the data

The data files can be acquired by file transfer via the internet at the site

www.nopp.uconn.edu/ADCP/index.html

by following the "archived data" link. They are in the form of Matlab .mat files. If there is a need to obtain them by a different means or in a different format, contact Dan Codiga (d.codiga@uconn.edu; 860-405-9165) directly.

Details of the contents of each file are explained by the README variable embedded within it, which can be viewed by typing README at the Matlab prompt after loading the record. The Appendix includes sample READMEs.

a. Minimally processed records.

This group of files has undergone minimal processing, as described above. There is one file for each deployment, named as listed in Table 1. For deployments with sub-records (suffixes a, b, c) and a merged record (suffix m), each is available separately.

b. Low-pass filtered records

The low-pass filtered records have been treated as described above. They are named as the minimally-processed files but with the additional suffix "-lp" to indicate they have been low-passed. In the case of the deployments that have sub-records (suffixes a, b, c), the low pass filter has only been applied to the merged file (suffix m).

7. Auxiliary information for selected data records

a. Data records shown in Table 1

The following detailed comments for selected deployments contain auxiliary information intended to be useful to those who obtain and use the data. For deployments not listed here all relevant information is included elsewhere in this report.

1. WI00-S

This record was collected by a 614-kHz ADCP in about 48 m water depth with 1-m bin size. Because they are near the maximum range limit for an ADCP with these sampling parameters, bins shallower than about 15 m deep showed evidence of degraded quality and have been omitted.

2. SP01-W(a,b,m)

This deployment had two sub-records, a and b. The bin size for record b was twice that for record a, and the duration of record b was longer than that of record a. Therefore, in creating the merged record m, a time and depth grid aligned with that of record b was used so the values from record b remained unchanged. Values from record a were interpolated to the grid subsequent to averaging of pairs of adjacent vertical bins.

3. SP01-C(a,b,m)

This deployment had two sub-records, a and b. The bin size for record b was twice that for record a, and the duration of record a was longer than that of record b. Therefore, in creating the merged record m, a time grid aligned with that of record a was used and a depth grid aligned with that of record b was used. Pairs of adjacent vertical bins in record a were averaged then interpolated in depth to match the depths in record b. Values in record b were interpolated in time only.

A moored profiling CTD co-located with this instrument measured a profile each ~2 hours for about the first month of the deployment.

4. SP01-S(a,b,m)

This deployment had two sub-records, a and b. The bin size for record b was twice that for record a, and the duration of record b was longer than that of record a. Therefore, in creating the merged record m, a time and depth grid aligned with that of record b was used so the values from record b remained unchanged. Values from record a were interpolated to the grid subsequent to averaging of pairs of adjacent vertical bins.

5. FA01-S

A moored profiling CTD co-located with this instrument measured a profile each ~2 hours for about the first month of the deployment.

6. WI02-W

This record is redundant with FA01-W in the sense that it is deployed at very nearly the same location, with the same sampling parameters, and during a time period nearly encompassed by that of FA01-W. This overlap occurred due to a failed acoustic release, which caused FA01-W to remain deployed for longer than planned, combined with the need to have an ADCP with acoustic modem containing fresh battery packs operating at this location during WI02.

7. WI02-C

The sampling for WI02-C was ensemble averaging over a 20-minute interval once each 80 minutes. Times assigned to data values are therefore 80 minutes apart ("int" in Table 1 is 80 minutes) although the ensemble averaging interval is a 20-minute duration centered on each time. WI02-C was collected by the same instrument as FA01-C, due to a failed acoustic release that caused the bottom frame to remain deployed for longer than planned. The sampling during WI02-C was set in the manner described above based on the need to conserve its on-board battery power through the unplanned extended duration of the deployment. Because WI02-C and FA01-C have substantially different sampling, they were not treated as sub-records to be merged with each other.

8. WI02-E

This record is redundant with FA01-E in the sense that it is deployed at very nearly the same location, with the same sampling parameters, and during a time period encompassed by that of FA01-E. This overlap occurred due to a failed acoustic release, which caused FA01-E to remain deployed for longer than planned, combined with the need to have an ADCP with an acoustic modem (WI02-E was deployed with a modem, while FA01-E was not) operating at this location during WI02.

9. SP02-N(a,b,c,m)

This deployment had three sub-records, a, b, and c. The bin size was the same all three. The duration of record c was longer than the others. Therefore, in creating the merged record m, a time grid aligned with that of record c was used so the values from record c remained unchanged. Values from records a and b were interpolated in time only.

10. SP02-W(a,b,m)

This deployment had two sub-records, a and b. The bin size was the same for both. The duration of record b was longer than that of record a. Therefore, in creating the merged record m, a time grid aligned with that of record b was used so the values from record b remained unchanged. Values from record a were interpolated in time only.

11. SP02-C(a,b,m)

This deployment had two sub-records, a and b. The bin size was the same for both. The duration of record b was longer than that of record a. Therefore, in creating the merged record m, a time grid aligned with that of record b was used so the values from record b remained unchanged. Values from record a were interpolated in time only.

12. SP02-S(a,b,m)

This deployment had two sub-records, a and b. The bin size was the same for both. The duration of record b was longer than that of record a. Therefore, in creating the merged record m, a time grid aligned with that of record b was used so the values from record b remained unchanged. Values from record a were interpolated in time only.

b. Deployments not listed in Table 1

For completeness, brief comments are now given for deployments that did not return data of sufficient length or quality to be included in this report. These are marked with hollow squares in Figure 3.

1. FA00-E

This ADCP malfunctioned for an unknown reason. The problem may have been associated with the choice of small vertical bin size, though other deployments with the same combination of parameters produced good records.

2. AVPPO

This instrument produced a record of good quality, which is available on request. It has not been included here because it is much shorter duration as a result of damage to the AVPPO that necessitated its early recovery.

3. SP01-N

This instrument collected good quality data for about one week, which is available on request. Subsequently it was buried by a sand wave. The sedimentary environment was most mobile at the northernmost deployments, such as this one. This is expected, due to the stronger tidal currents found closer to the mouth of the Block Island Sound and Long Island Sound estuary systems.

4. SP01-SS

This instrument collected a long data record but the quality was poor so it was rejected. In general, the north-south component of velocity in the shallowest bins was correlated well with that of independently collected HF radar data (D. Ullman, personal communication), but this was not true of the east-west component of velocity. The data suggested a counterclockwise-rotary tidal motion that contradicts several other deployments in the close nearby vicinity. A coordinate rotation to minimize the misfit with the HF radar velocities, as would correct for a fixed compass error, gave little improvement. An unknown problem internal to the unit is considered responsible.

5. SP01-SM

This instrument malfunctioned for an unknown reason, possibly due to the interface with the acoustic modem to which it was connected.

6. FA01-BI

This ADCP unit was the same one as SP01-SS. It collected a long record but with the same problematic characteristics as SP01-SS, and was rejected on the same grounds.

7. WI02-S

This bottom frame was hit by trawling gear, as evidenced by a shattered ball float in its recovery module and discontinuities in the pitch/roll/heading timeseries recorded internally by the ADCP. The ADCP data was acceptable only for a relatively short duration prior to the trawling incident. It is available on request.

8. SP02-E

This bottom frame was hit by trawling gear, as evidenced by deep scrapes in its aluminum frame. Shortly after the trawling incident, the acoustic modem to which the ADCP was connected began to malfunction. This interrupted ADCP data collection and precluded further communication with the ADCP from shore. As a result the record generated was not long enough to be included here. It is available on request.

8. Acknowledgements

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9. References cited

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10. Appendix: Sample READMEs

a. README for minimally-processed data record:

```
%
% Upward-looking bottom-mounted ADCP measurements.
% Dan Codiga, University of Connecticut
%  (860) 405-9165 / d.codiga@uconn.edu
%  These data are available on request. In return, I expect the
%  courtesy of an explanation of how you intend to use them; my
%  analysis is ongoing and potential for collaboration is
%  encouraged.  If appropriate, the offer for me to co-author
%  publications that use these data is expected and greatly
%  appreciated.
%
% MATRICES
%   These are same-sized matrices (depth & time the two dimensions).
%   Bad values (32768 by standard RDI processing) have been
%   replaced by NaN. The matrix indexing has been chosen so that when
%   displayed within matlab, the UPPER, LEFT part of these matrices
%   is the SHALLOW (near water surface) bins, at START of the series.
%   Matlab function "imagesc" (try "imagesc(u); colorbar;") plots:
%       time increasing rightward, and
%       depth increasing downward.
%
%  1. u = East velocity, cm/s
%  2. v = North velocity, cm/s
%  3. w = vertical velocity, cm/s, positive upward
%  4. hvelmag = horizontal velocity magnitude, cm/s
%  5. hveldir = horizontal velocity direction, deg T

% VECTORS
% The following are row vectors matching the length of the
% above matrices.
```

```
%  1. t = center time of ensemble, yearday GMT
%     a. yearday defined such that midnight new year's eve
%       is 0.0 (not 1.0)
%     b. reference year is scalar variable refydyear
%  2. p = corrected bottom pressure in dBar
%  3. temperature = bottom temperature in deg C
%  4. u_zm,v_zm = vertical-mean east & north velocities, cm/s
%
% The following are column vectors matching the height of the
% above matrices.
%  1. z = center depth of bin, m (negative; 0 = surface)
%  2. zmab = distance of bin center from seafloor, m
%
% SCALARS
% Scalar variables are
%  1. lat [dec deg N]
%  2. lon [dec deg W]
%  3. refydyear (see t above)
%  4. minhvelerr: minimum random error standard deviation
%       for horizontal velocity values [cm/s]
%
% NOTES
%  1. Bin size can be found by differencing z values and
%  ensemble interval length can be found by differencing t values.
%
%  2. Pressure values are corrected through multiplication by pcoeff,
%  where pcoeff is defined such that
%       mean(uncorrected pressure) x pcoeff = sw_pres(bottomdepth,lat)
%  using the routine sw_pres.m (SEAWATER package, Phil Morgan).
%
%  3. There are two contributions to random error in the horizontal
%  velocity values: internal (associated with instrument processing)
%  and external (associated with turbulence, internal waves, and
%  instrument motion).
%     Internal random error standard deviation ( = minhvelerr ) =
%                single-ping error / sqrt( pings per ensemble ).
%     External random error =
%               std-dev ( error velocity )
%  Use of external random error has not been made here.
%
%  4. The vertical-mean velocities u_zm and v_zm are nan if the
%  percent of adcp bins with good values is < vertavgmingoodpct.
%
```

b. README for low-pass filtered record:

```
% MATRICES
%  These are same-sized matrices (depth & time the two dimensions).
%  The matrix indexing has been chosen so that when
%  displayed within matlab, the UPPER, LEFT part of these matrices
%  is the SHALLOW (near water surface) bins, at START of the series.
%  Matlab function "imagesc" (try "imagesc(u); colorbar;") plots:
%       time increasing rightward, and
%       depth increasing downward.
%
%  1. u_lp = East velocity, cm/s
```

```
%  2. v_lp = North velocity, cm/s
%  3. w_lp = vertical velocity, cm/s, positive upward

% VECTORS
% The following are row vectors matching the length of the
% above matrices.
%  1. t = center time of ensemble, Yearday GMT
%     a. yearday defined such that midnight new year's eve
%        is 0.0 (not 1.0)
%     b. reference year is scalar variable refydyear
%  2. p_lp = corrected bottom pressure in dBar
%  3. temperature_lp = bottom temperature in deg C
%  4. u_zm_lp,v_zm_lp = vertical-mean east & north velocities, cm/s
%
% The following are column vectors matching the height of the
% above matrices.
%  1. z = center depth of bin, m (negative; 0 = surface)
%  2. zmab = distance of bin center from seafloor, m
%
% SCALARS
% Scalar variables are
%  1. lat [dec deg N]
%  2. lon [dec deg W]
%  3. refydyear (see t above)
%  4. nanensinterp
%  5. lphalfwidth, hours
%  6. subsamp, hours
%
% NOTES
% See README for the datafile prior to the lowpass treatment (named
% identically to this one but without the "-lp" suffix).
%
% The lowpass filter is a triangular-weighted running mean with
triangle
% halfwidth = lphalfwidth. It is applied after interpolation across
% gaps shorter than nanensinterp; such gaps are replaced by nans after
% the filtering. Finally, data are subsampled to one value each subsamp
% hours.
%
```