SEARSPORT HARBOR
SEARSPORT, MAINE
NAVIGATION IMPROVEMENT PROJECT

TECHNICAL REPORT 5

ADCP AND TIDE DATA COLLECTION

December 2009

FINAL REPORT
FOR
ADCP AND TIDE DATA COLLECTION
SEARSPORT HARBOR, SEARSPORT, MAINE

Contract No. W912WJ-09-D-0001-0009

Prepared For:
United States Army Corp of Engineers
New England District
696 Virginia Road
Concord, MA 01742

Prepared By:
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East Falmouth, MA 02536

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1.0 INTRODUCTION

This brief report presents the boat-based Acoustic Doppler Current Profiler (ADCP) data and associated tide data observed in the Searsport Harbor region in Searsport, Maine. The data were collected in the Searsport Federal navigation channel as part of the proposed deepening project. The current data will be used to assess the magnitude of the currents in the region and provide data for channel design.

Woods Hole Group (WHG) was responsible for collecting these measurements for the U.S. Army Corps of Engineers under task order contract number W912WJ-09-D-0001-0009.

2.0 TIDE DATA COLLECTION

Time-series of water surface elevation were obtained from two (2) locations over approximately one month at the Searsport Harbor site (Figure 1). This report and the associated files on the companion CD, present the tide data and the data collection procedures and instrumentation. These observations can be used to analyze and define the tidal fluctuations in the region(s), as well as define boundary conditions and calibration points in the potential development of a hydrodynamic model or to assist in ship simulation modeling.

Figure 1. Tide gauge locations within the study area of Searsport Harbor.

Deployment locations in Searsport Harbor were chosen to measure the surface water fluctuations directly in the vicinity of the Federally maintained navigation channel. A tide gauge was deployed at the Sprague Energy Terminal (Station S1) at the upstream end of the federally maintained channel, and approximately 4 miles south/southeast on a private dock on Isleboro Island (Station S2). These locations were selected by the United States Army Corps of Engineers to characterize the local tidal changes that occur in the vicinity of Searsport Harbor, and to provide information for potential ship simulation modeling and/or hydrodynamic modeling of the Searsport Harbor region. Figure 2 shows the tide gage located at the Sprague Energy Terminal, while Figure 3 shows the tide gage located on a provide dock on Isleboro Island. A copy of the field notes from the deployment and recovery of the tide gages is included in Appendix A.

Figure 2. Photograph of tide gage at station S1, the Sprague Energy Terminal in Searsport, ME.

The data from these tide gauges were subsequently compared to data from the National Oceanic and Atmospheric Administration (NOAA) NOS stations in Eastport, Maine to identify the relative tidal attenuation in the system, as well as ground truth the observed data. Table 1 presents the recording interval and frequency of the deployed tide gauges, as well as their exact positions recorded via GPS.

Figure 3. Photograph of station S2, a private dock located on Isleboro Island.

Table 1. Instrument deployment summary.

Tide Station Location (description)	GPS Location (State Plane feet, NAD83)	Log Interval (minutes)	Began Recording	Ended Recording
Searsport: Sprague Terminal	northing: 286063.648	6	6/24/2009	7/23/2009
	easting: 880303.816			
Searsport: Isleboro Island	northing: 262562.338	6	6/24/2009	7/23/2009
	easting: 885574.568			

Tidal pressures were measured using Sea-Bird SBE37-SM MicroCAT conductivity, temperature and pressure gauges. Each of these instruments measured conductivity, temperature and pressure at set intervals, in this case, every six minutes. Pressure data were downloaded using a personal computer and associated software packages.

Each tide gauge measured the pressure above the instrument, which is a combination of the weight of the water and weight of the atmosphere. In order to analyze the tide data (gauge pressure), the atmospheric pressure needs to be removed from the measured signal. The data collected were pressure corrected using regional atmospheric pressure data from the National Oceanic and Atmospheric Administration (NOAA) station in Bar Harbor, Maine. This raw barometric pressure data used for this correction is presented in

Figure 4. Gaps in the NOAA barometric pressure record were filled with by interpolating between the temporal adjacent observations. Subsequently, this tide pressure data were converted to water surface elevation using the hydrostatic relationship based on the density of water. In order to reference the tide gauges to a common vertical datum, tide data from each gauge was referenced to the NAVD 1988 vertical datum. The tide gauges were surveyed in directly to the instruments pressure port via an RTK-GPS survey and verified with local benchmark information. Appendix B presents the results of the survey and adjustment of the tide gage to the NAVD 1988 vertical datum.

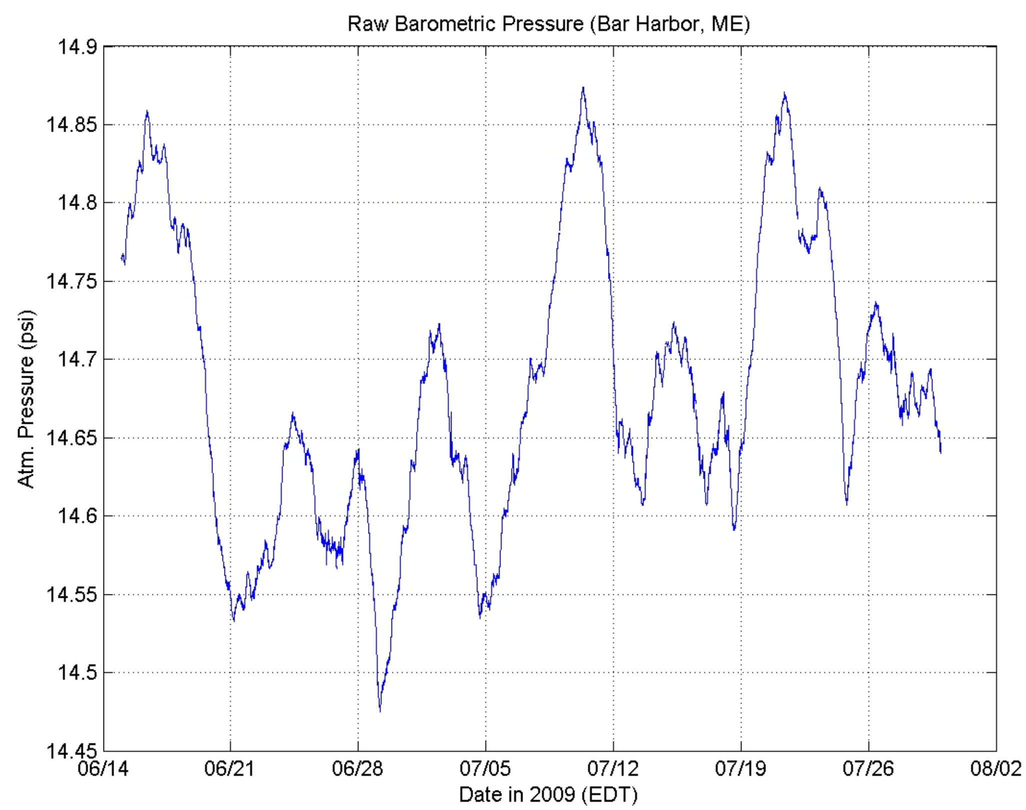


Figure 4. Atmospheric pressure data obtained from National Oceanic and Atmospheric Administration (NOAA) station # 8413320 (Bar Harbor, ME).

Figure 5 presents the results of the atmospherically corrected and vertical referenced tidal observations obtained from the Searsport Harbor gages. The blue line presents the time series of water surface elevation (feet, NAVD88) at Sprague Energy Terminal (station S1), while the red line presents the time series of water surface elevation (feet, NAVD88) at the Isleboro Island dock (station S2). The water surface elevation at both stations is almost identical, with insignificant attenuation or phase shift.

Figure 6 presents the observed data from the Searsport Harbor stations, along with the National Oceanic and Atmospheric Administration stations at Eastport, ME. The NOAA data are provided as a regional reference to the collected at each of the local stations. All tidal data, including the NOAA station data, is provided on the companion CD to this report in the Tide Data directory.

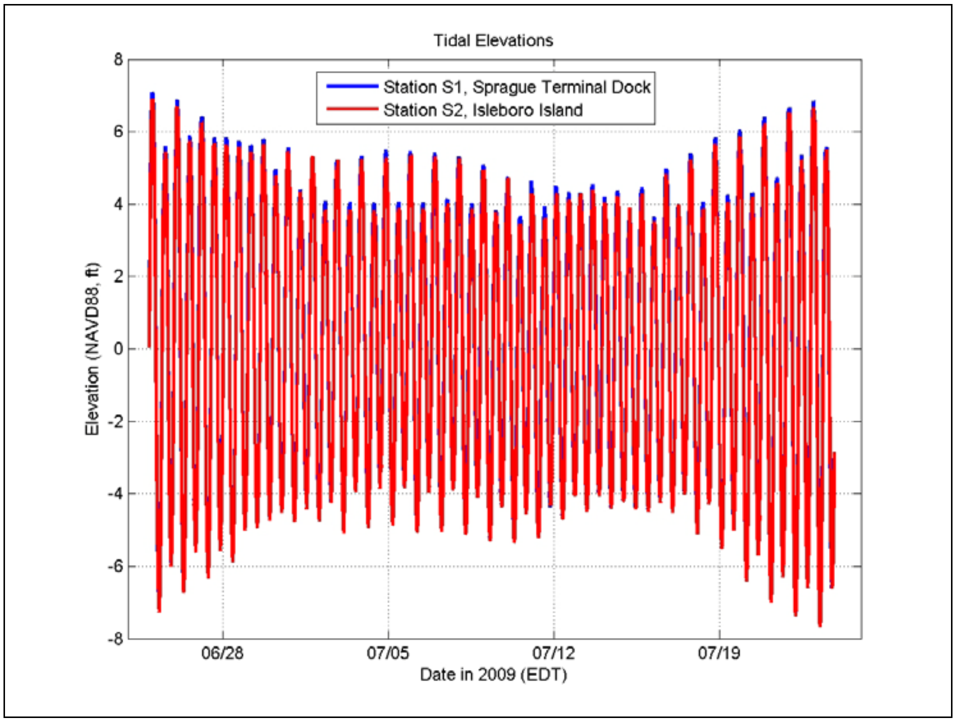


Figure 5. Measured water surface elevation in Searsport Harbor, Maine from June 24 to July 23, 2009.

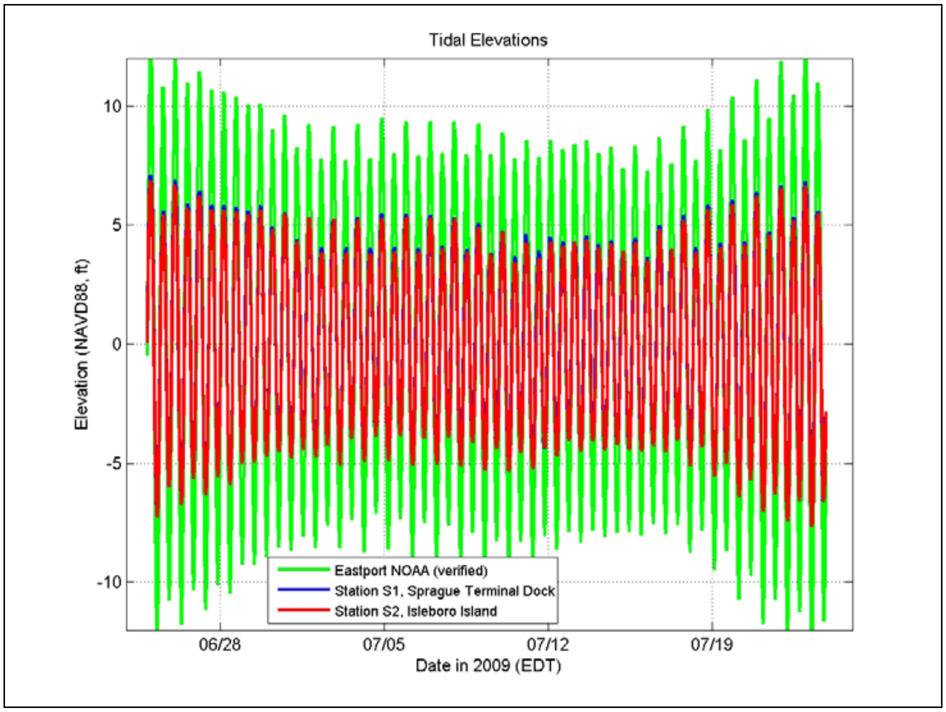


Figure 6. Measured water surface elevation from Searsport Harbor and NOAA's verified water surface elevation from Eastport, ME.

3.0 ADCP DATA COLLECTION

In support of the development of design criteria and potential ship simulation modeling at the Federally maintained navigation channel in Searsport Harbor, ME, Woods Hole Group, Inc. measured the tidal currents at selected locations in the estuary during two spring tide conditions. The observations were obtained using an Acoustic Doppler Current Profiler (ADCP) mounted to a small survey vessel. Data were collected through complete lunar semi-diurnal tidal cycles (12.4 hours) at each location, once in June and once in July. Each transect was traversed from shoreline to shoreline in a direction perpendicular to the channel. The resulting data sets offer an unparalleled view of the temporal variation in spatial structure of tidal currents through these waterways.

This chapter details the survey instrumentation and methods used to perform the measurements. Data representing high-resolution measurements of tidal current structure at these sample locations are also presented. The results are presented in both time series format (spatially averaged results), as well as full color contours of current velocity components for selected stages of the tide. The complete data set and associated figures are also provided in the companion CD to this report in the ADCP Survey Data directory.

3.1 SURVEY REGION AND DATES

The surveys for the Searsport Harbor location were performed on June 25 and July 23, 2009. Five (5) transects were surveyed across the Federally maintained channel in the

Harbor, as shown in Figure 7. These five transects formed a reasonable depiction of the currents across the cross-section of the channel at this location and adequately represent the current regime in this area. Transect 5, which is located in the northern portion of the channel, was added to the original scope of work. The transects were surveyed continuously throughout the day, travelling in the direction of the arrows indicated on Figure 7. Table 2 presents the survey dates, locations, transect repetition period and temporal coverage for each transect line.

Table 2. Survey dates, locations, frequency, and temporal coverage of the ADCP transects.

Transect ID	Easting, Northing Transect Start (State Plane NAD83, ft)	Easting, Northing Transect End (State Plane NAD83, ft)	June 25, 2009 Survey		July 23, 2009 Survey	
			Frequency (minutes)	# of Transects	Frequency (minutes)	# of Transects
1	881864, 284719	880017, 286020	~7.5	11	~7.5	13
2	879697, 284535	881388, 284433	~5	11	~5	13
3	881108, 282470	879558, 282652	~5	11	~5	13
4	879310, 280255	880845, 280097	~4	11	~4	13
5	880600, 286616	882020, 285540	~5.5	11	~5.5	13

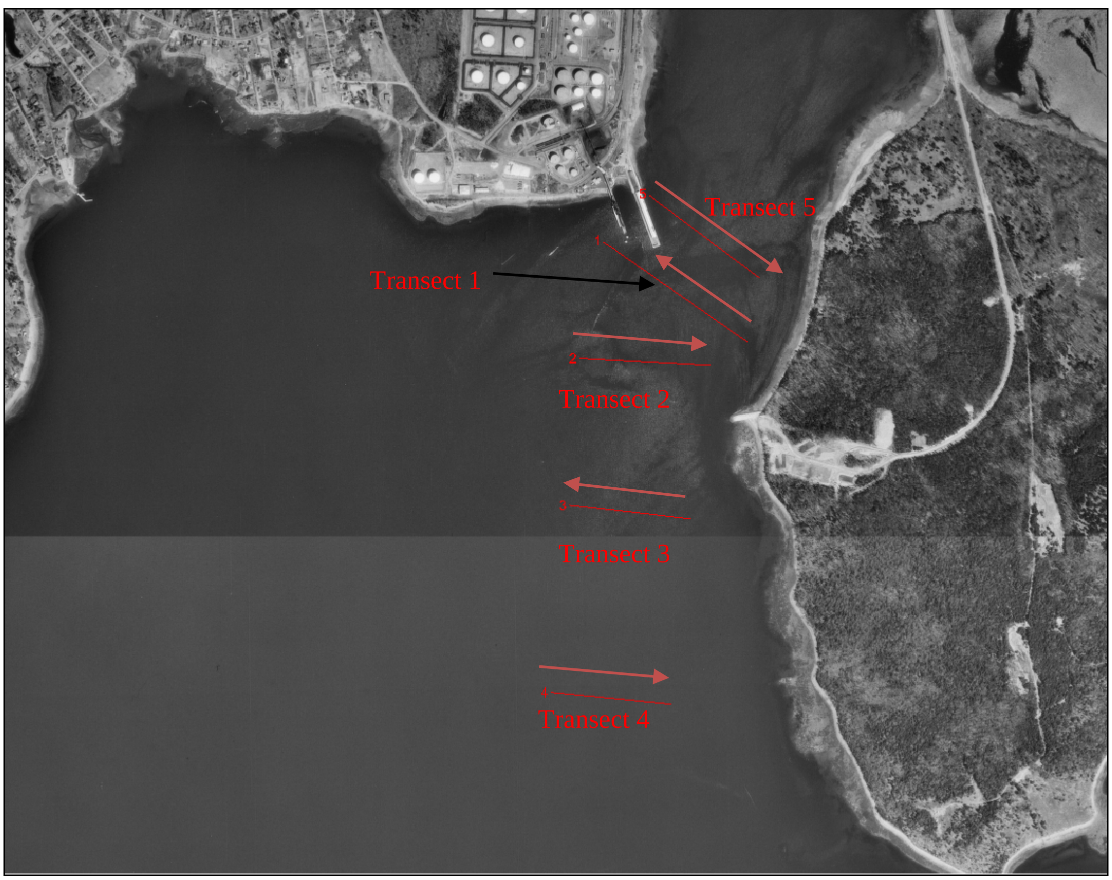


Figure 7. Location of ADCP transects in Searsport Harbor.

3.2 EQUIPMENT DESCRIPTION

Measurements were obtained with a broadband 1200 Khz Acoustic Doppler Current Profiler (ADCP) manufactured by Teledyne/RDInstruments of San Diego, CA. The ADCP was mounted rigidly to the starboard rail of the survey vessel, the 24-foot *Privateer*. Position information was provided by a Trimble 4000-series differential GPS.

The ADCP is capable of high-resolution measurements of the spatial structure of current flow beneath the instrument transducer. When mounted to a moving platform, such as a small vessel, a detailed picture of the current characteristics can be obtained. Repeating the transects at regular time intervals throughout a complete tidal cycle offers an unparalleled determination of the temporal variation in tidal current structure in the study area.

The ADCP measures currents using acoustic pulses emitted individually from four angled (at 20° from the vertical) transducers in the instrument. The instrument listens to the backscattered echoes from discrete depth layers in the water column. The returned echoes, reflected from ambient sound scatters (plankton, debris, sediment, etc.), are compared in the frequency domain to the original emitted pulse. The change in frequency (doppler shift) between the emitted versus the reflected pulse is directly proportional to the speed of the water parallel to the individual beam. For example, an echo of lower frequency indicates water moving away from the transducer while an echo of higher frequency indicates water moving toward the transducer. By combining the doppler velocity components for at least three of the four directional beams, the current velocities can be transformed to an orthogonal earth coordinate system in terms of east, north, and vertical components of current velocity.

Vertical resolution is gained using a technique called ‘range-gating’. Returning pulses are divided into discrete ‘bins’ based on discrete time intervals following the emission of the original pulse. With knowledge of the speed of sound, the discrete time intervals reflect the range (or depth) of each discrete bin from the transducer face.

The collection of accurate current data with an ADCP requires the removal of the speed of the transducer (mounted to the vessel) from the estimates of current velocity. This is performed by ‘bottom tracking’ or, using the doppler shift to measure simultaneously the velocity of the transducer relative to the bottom. Bottom tracking allows the ADCP to record absolute versus relative velocities beneath the transducer. In addition, the accuracy of the current measurements can be compromised by random errors (or noise) inherent to this technique. Improvements in the accuracy of each measurement are achieved typically by averaging several individual pulses together. These averaged results are termed ‘ensembles’; the more pings used in the average, the lower the standard deviation of the random error.

For these studies each ensemble took approximately 1.8 seconds to collect. The vertical resolution was set to 50 cm (approximately 19.7 inches), or one velocity observation per every 50 cm (approximately 19.7 inches) of water depth. The first measurement bin was centered approximately 2.7 feet from the surface, allowing for the transducer draft as well as an appropriate blanking distance between the transducer and the first measurement.

The transducer was set 1.2 feet below the surface to prevent the transducer from coming out of the water due to potential waves and boat wakes.

Position information was collected by Hypack, an integrated navigation software package running on a PC computer, linked to a Trimble 4000-series differential GPS. Position updates were available every 1 second, and raw position data was also sent to the ADCP laptop to assist in verifying the clock synchronization between the GPS and ADCP.

3.3 SURVEY TECHNIQUE

The transect lines presented in Figure 7 were surveyed throughout the 12.4 hour tidal cycle and the completion of each set of transects represented a loop. These loops were repeated throughout the survey period to depict the changing effects of the current regime throughout the tidal cycle. Each repetition of the loop was performed in the same direction to assure consistent results.

Position data for each transect were recorded using Hypack, with the GPS signals distributed to both the Hypack computer and the ADCP recording computer for later comparison. ADCP data were recorded in binary format on the computer hard disk. Data recording was begun as the vessel neared the start of each line and was terminated at the end of each line. Copies of the field notes recorded throughout each of the ADCP surveys are presented in Appendix A. A summary of transects and loops is also presented in Appendix C, which includes the start and stop time of each transect, the associated recorded file names, and any comments during the survey.

3.4 DATA PROCESSING TECHNIQUES

The survey resulted in two types of data: current velocity and vessel position. The ADCP data for a single transect consisted of velocity components at every depth bin for every ensemble. In addition, the raw ADCP (binary) files also include ancillary data such as correlation magnitudes, echo amplitudes, percent good pings, and error velocities (among others). These data can be used to recalculate velocities, as well as assure quality of the results. Each ensemble also includes header information such as the ensemble number, time of the ensemble, and water temperature.

Position data were recorded as time-northing-easting. The northing-easting pairs were referenced to State Plane Coordinates, NAD 1983 (feet). The raw ADCP data were converted to ASCII files using Teledyne/RDI's proprietary software to a user-defined data format.

Subsequently, the ensemble profiles must be merged with the position data to assign a unique x-y pair to every ensemble. This merging operation is done using time and GPS position as the common link between the GPS and ADCP data files. By searching for the unique position at a specific time for each of the data sets, an accurate x-y location was assigned to each ensemble. Further numerical processing was performed to calculate the depth-averaged cross-sectional plots.

3.5 SURVEY RESULTS

3.5.1 Data Files

Detailed ASCII data files, which provide every ensemble of data collected along each transect, are provided on the companion CD in the ADCP survey directory and as indicated in Appendix C. A sample ensemble data set is presented as Table 3.

Table 3. Example data file format for data files provided on the companion CD to this report.

Date and Time (EST)	Easting (NAD83, ft)	Northing (NAD83, ft)	Depth (ft)	Ve (ft/s)	Vn (ft/s)	Magnitude (ft/s)	Direction (radians)
25-Jun-2009 08:17:21	881371.866	285081.627	2.723	-0.03	0.13	0.38	6.11
25-Jun-2009 08:17:21	881371.866	285081.627	4.364	0.16	-0.08	1.02	3.39
25-Jun-2009 08:17:21	881371.866	285081.627	6.004	0.32	0.01	0.43	2.54
25-Jun-2009 08:17:21	881371.866	285081.627	7.644	0.37	0.04	0.45	1.36
25-Jun-2009 08:17:21	881371.866	285081.627	9.285	0.16	0.15	0.36	5.86
25-Jun-2009 08:17:21	881371.866	285081.627	10.925	0.16	0.15	0.41	4.74
25-Jun-2009 08:17:21	881371.866	285081.627	12.566	-0.20	0.05	0.79	5.15
25-Jun-2009 08:17:21	881371.866	285081.627	14.206	0.02	0.52	1.63	6.23
25-Jun-2009 08:17:21	881371.866	285081.627	15.846	-0.08	0.24	0.27	5.05
25-Jun-2009 08:17:21	881371.866	285081.627	17.487	-0.21	0.06	0.95	3.33
25-Jun-2009 08:17:21	881371.866	285081.627	19.127	0.06	0.13	0.56	1.92
25-Jun-2009 08:17:21	881371.866	285081.627	20.768	-0.02	-0.00	0.71	1.67
25-Jun-2009 08:17:21	881371.866	285081.627	22.408	-0.17	-0.15	0.42	5.48
25-Jun-2009 08:17:21	881371.866	285081.627	24.049	-0.12	-0.24	0.23	4.30
25-Jun-2009 08:17:21	881371.866	285081.627	25.689	-0.30	-0.25	0.63	4.78
25-Jun-2009 08:17:21	881371.866	285081.627	27.329	NaN	NaN	0.40	3.28
25-Jun-2009 08:17:21	881371.866	285081.627	NaN	NaN	NaN	NaN	NaN
25-Jun-2009 08:17:21	881371.866	285081.627	NaN	NaN	NaN	NaN	NaN
25-Jun-2009 08:17:21	881371.866	285081.627	NaN	NaN	NaN	NaN	NaN

The data files contain information along each transect line throughout depth. The first column is the date and time of the observation, the second and third column is the easting and northing coordinate of the observation (in NAD 1983, feet), the fourth column is the center of each depth bin (in feet), the fifth column is the east component of velocity (in feet/second), the sixth column is the north component of velocity, the seventh column is the magnitude of the current, and the eighth column is the current direction (in radians with 0 being north). The NaN's in the last rows indicate 'bad' results for depth bins below the bottom; these data are ignored. Some of the deepest bins have NaN's in the easting and northing velocity components as well. The bottom bins can become contaminated by the higher amplitude echoes reflected near the bottom and should be discounted.

3.5.2 Color Contour Plots of Current Structure

Color contour plots for every transect observed during each survey are presented in the companion CD to this report. The color contour plots represent measured conditions at the time of the survey. Each pair of plots present the spatial structure of flow through the transect at a discrete time period. Viewing a series of these plots for sequential stops through a complete tidal cycle can offer a unique understanding of how the spatial structure of flow varies with time. Figure 8 presents and example color contour plot for the June 25 survey (transect E5) during a flood tide.

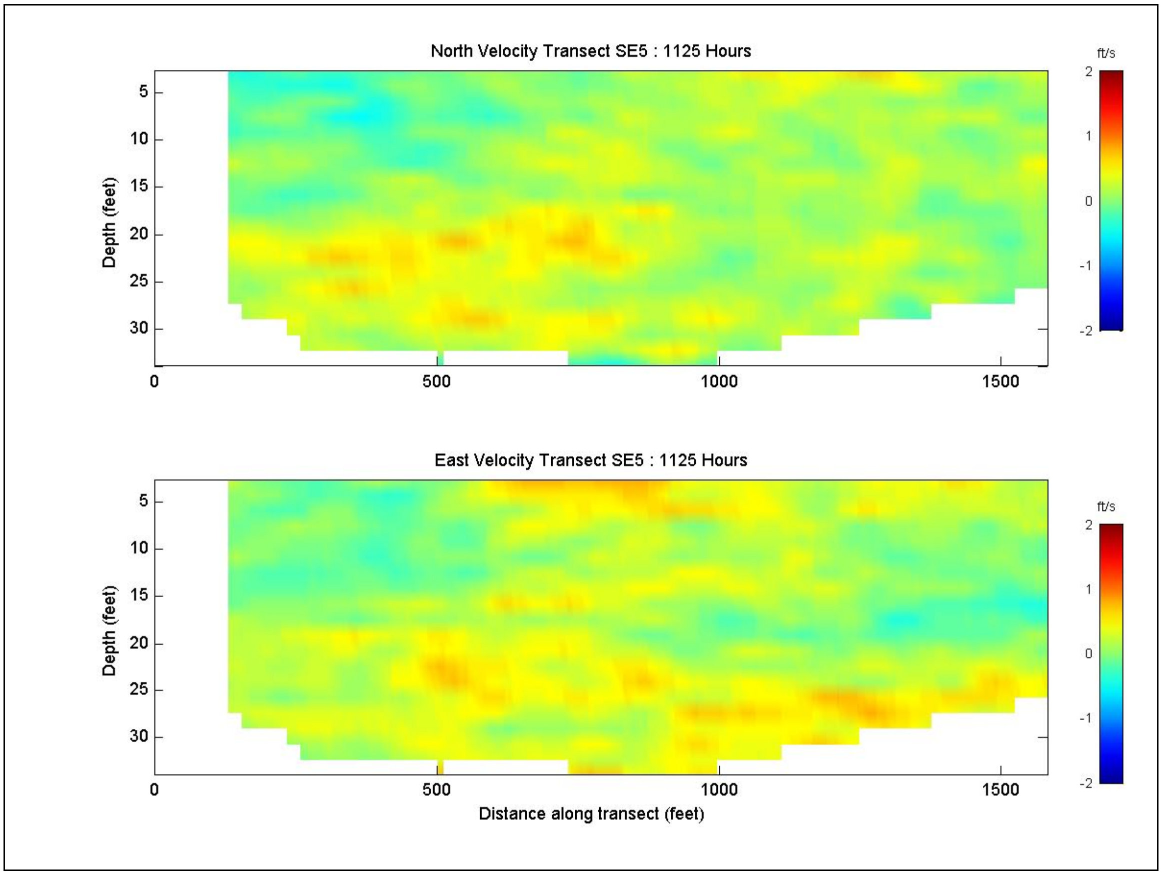


Figure 8. The current velocities, presented in color contour plots, observed during the deployment survey at Searsport Harbor (June 25, 2009) for Transect E5. The upper panel presents the north/south velocity component, while the lower panel presents the east/west velocity component.

Each figure consists of two panels: the top panel presents the north/south component of velocity through the transect, the bottom panel presents the east/west component of velocity through the transect. The directions are referenced to magnetic north. For example, positive north velocities represent water flowing in a northerly direction.

Negative velocities represent water flowing to the south. Positive east velocities represent water flowing to the east; negative east velocities represent flow to the west.

The vertical axis for each plot is depth (in feet), representing the depth of the water column. The horizontal axis represents distance across the transect line. A distance of zero (0) indicates the start of the line, while the end of the transect is indicated by the maximum distance.

The color bar to the right of each plot indicates the magnitude of the north and east current velocities (in feet/second). Strong northerly and easterly flow is indicated by deep red; strong southerly and westerly flow is indicated by deep blue. White areas of each plot indicate regions below the bottom; therefore, this provides a crude indication of the channel bathymetry outlined by the white areas below the color-filled spaces.

For example, Figure 8 shows the relatively weak flood tide that occurs in Searsport Harbor, with a velocity of approximately 1 feet/second to the northeast. On a depth–averaged basis, the strongest flow occurs in the center to southeast portion of the transect (500 to 1500 feet along the transect), while the upper portion of the northwest part of the transect (0-500 feet along the transect) is sheltered from currents by the ocean vessels and dock facility. Figure 8 is provided as an example. The complete data set is presented on the companion CD in the ADCP survey directory.

Overall, the differences between the deployment and recovery ADCP surveys at each site are minimal, as the data collected during each survey occurred during a similar spring tide condition. In general, the currents are relatively weak at Searsport Harbor; however, there is a discernable flood and ebb current flow. The largest observed current occurred during the deployment survey during transect loop D, and specifically transect D1. This observed current of 3-4 feet/second was propeller induced current as an ocean freighter left the Sprague Energy Terminal. In general, maximum flood and ebb currents are less than 1-2 feet/second. Although the current is relatively weak, there appears to be some slight stratification in the flow dynamics that occur throughout the tidal cycle.

3.5.3 Depth Averaged Velocities

The velocities at selected nodes across each transect were determined for each time step. Each transect was divided into eight (8) equal-length subsections; the center of each subsection was labeled individually as node 1 through node 8. For each node, vertically- and horizontally-averaged (east and north) velocity components were calculated for each time step. The vertical average of each ensemble consisted of the mean velocity for all valid bins. The validity of the bottom bin measurements was determined by comparing the standard deviation of bottom values to the standard deviation of mid-column measurements. If the standard deviation at the bottom was more than twice the standard deviation of mid-column measurements, the bottom bin was discarded from the calculation. If the bottom value was within the limits defined by adjacent measurements, the value was included in the calculation. The horizontal average included all vertically-averaged ensemble velocities within each nodal subsection.

The result of this averaging procedure was a series of values showing the average velocity magnitude and direction for each loop of transects. In addition, the nodal averages included the average time of all ensembles in the subsection, average water depth of all ensembles in the subsection, and x-y position of each node. The values for each contiguous loop were plotted as arrows on separate georeferenced maps to show the current characteristics during each time step. Figure 9 shows an example from the June 25, 2009 ADCP survey for loop E, observed from 1125 to 1209 hours during a flood tide. Each yellow vector presents the magnitude and direction of the horizontally and depth-averaged currents along a transect line. The length of the vector corresponds to the magnitude of the current, relative to the scale arrow shown at the top of the plot. The plot shows an overall characterization of the flow patterns in the vicinity of the federal channel. The series of loop figures (presented on the companion CD in the ADCP survey directory) provide a time series of the depth-averaged current patterns for the Searsport Harbor survey location.

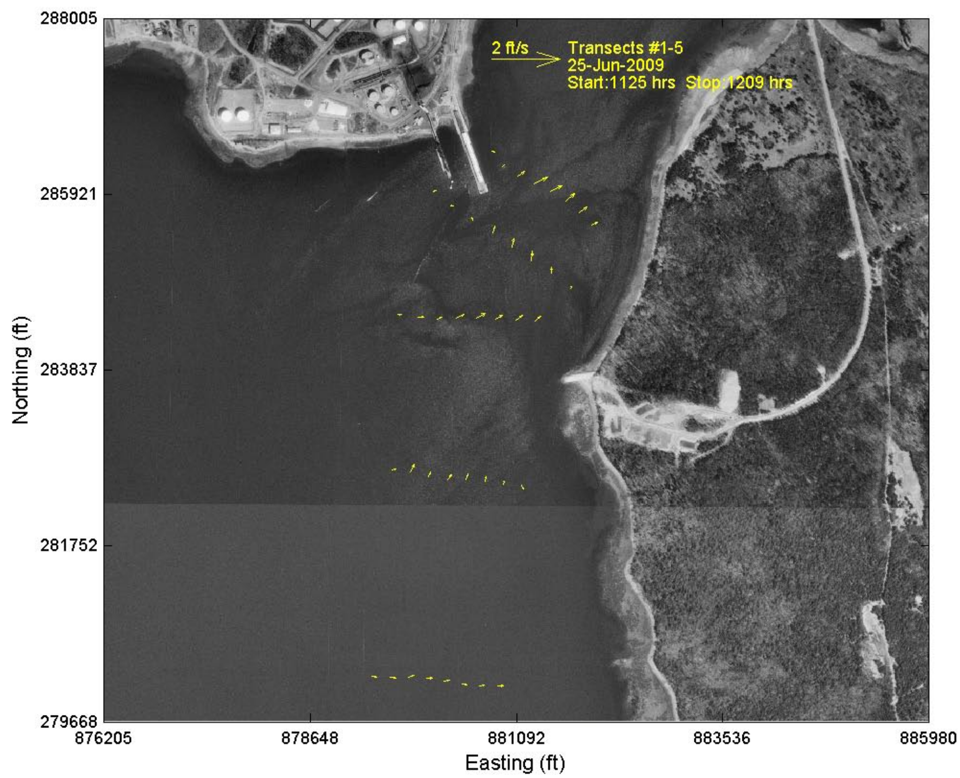


Figure 9. Depth-averaged current results for the transects of Loop E during the June 25, 2009 ADCP survey.

Additionally, a similar method was used to output a depth-averaged velocity (magnitude and direction) at every 25 feet along a transect line, as requested in the RFP. These data files are provided on the companion CD in the ADCP Survey directory, and the tile name nomenclature is presented in Appendix C.

APPENDIX A FIELD NOTES

LOOP-TRANSECT	START TIME	STOP TIME	FILES	COMMENTS
EE-1	1919	1922	PISCATAQUA_0125.*	
EE-2	1924	1925	PISCATAQUA_0126.*	END OF
EE-3	1926	1928	PISCATAQUA_0127.*	GBB
EE-4	1929	1931	PISCATAQUA_0128.*	
FF-1	1937	1942	PISCATAQUA_0129.*	
FF-2	1944	1947	PISCATAQUA_0130.*	
FF-3	1947	1950	PISCATAQUA_0131.*	
FF-4	1951	1954	PISCATAQUA_0132.*	

— END OF SURVEY —

SEARSPORT

6/29/2009

11:42 - SET UP PPK UNIT AT SPRAGUE TERMINAL

11:55 - UP AND RUNNING

CALLED BASE STATION - PPKBASE-TERMINAL

12:25 - PPK ~~[illegible]~~ CORPS BENCH MARK ON SEARSPORT PUBLIC BOAT RAMP TWICE

SEARSPORT - BM & SEARSPORT - BM2

- PPK BENCHMARK ON ISLEBORO ISLAND

ISLEBORO-T1 & ISLEBORO T2

(1827)

ISLEBORO TIDE GAGE DEPLOYED AT 4:04 PM

8.7' FEET FROM PRESSURE PORT TO TOP OF 2x4, THEN 6.95' FROM TOP OF 2x4 TO PPK ~~[illegible]~~ MEASURED POINT ON IBEAM.

SO FROM PRESSURE PORT TO TOP OF IBEAM

= 15.65'

GAGE 1827

6/24/09

- SEARSPORT HARBOR CAGE DEPLOYMENT
  1828 # @ 1709 HRS

- AT END PILE OF SHORTER PIER (WESTERN DOCK)

- BENCHMARK DISTANCE
  1) FROM PORT TO TOP OF 2x4 = 8'
  2) FROM TOP OF 2x4 TO BOTTOM OF CONCRETE = 4.35'
  3) FROM CONCRETE BOTTOM TO TOP OF CONCRETE = 5.95' FOR SPRAGUE-1 & -2
     PPK POINTS
  4) FROM LOWER CONCRETE TOP TO UPPER
     Concrete Top = 1.95'
     FOR SPRAGUE TOP-1, SPRAGUE-TOP-2
     PPK POINTS

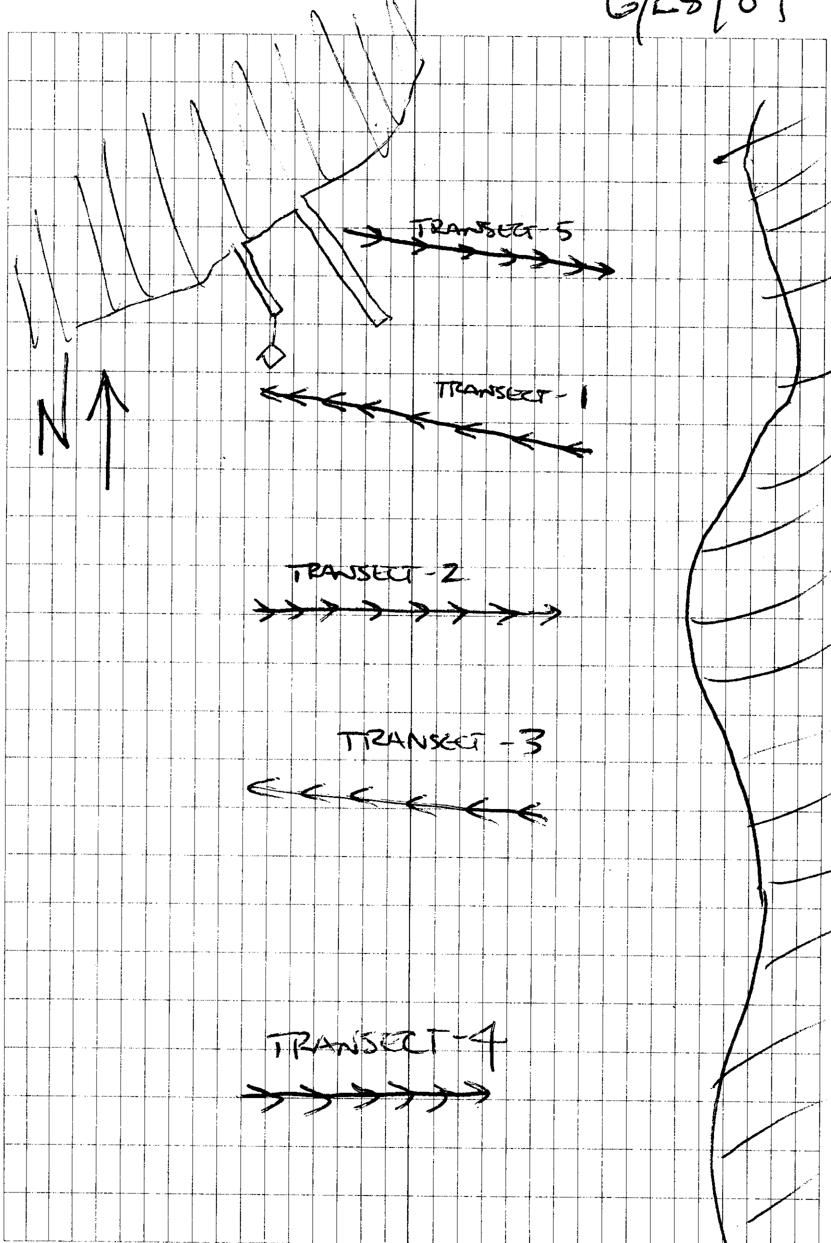
6/25/09

- Stopped Survey AT 6:45 pm
  (1845 pm)

ADCP SURVEY FOR SEARSPORT
STARTED ON DOCK AT 5:00 AM

6/25/09

LOOP-TRANSECT	START TIME	STOP TIME	FILES	COMMENTS
A-5	0656	0701	SEARSPORT -001.*	HEAVY FOG
A-1	0704	0713	SEARSPORT -002.*	LOW TIDE
A-2	0720	0726	SEARSPORT -003.*	
A-3	0733	0739	SEARSPORT -004.*	
A-4	0748	0753	SEARSPORT -005.*	
B-5	0808	0813	SEARSPORT -006.*	
B-1	0815	0822	-007.*	RISING TIDE / FLOOD
B-2	0826	0831	-008.*	
B-3	0840	0845	-009.*	
B-4	0852	0856	-010.*	
C-5	0911	0917	-011.*	
C-1	0919	0926	-012.*	
C-2	~~09xx~~ 0937	0942	-014.*	← -013.* WAS BAD TRACKLINE RE-DO C-2
C-3	09~~xx~~51	0957	-016.*	-015.* WAS BAD TRACKLINE RE-DO C-3
C-4	1004	1008	-017.*	
D-5	1024	1030	-018.*	
D-1	1033	1040	-019.*	← STRONG BOAT WAKE AND EDDIES FROM OCEAN TANKER LEAVING PORT ENSEMBLE 45-65
D-2	1043	1049	-020.*	
D-3	1054	1100	-021.*	
D-4	1106	1111	-022.*	~1008 FOG CLEARED
E-5	1125	1130	-023.*	BOAT WAKE THROUGHOUT TRANSECT
E-1	1132	1139	-024.*	
E-2	1143	1148	-025.*	
E-3	1152	1159	-026.*	
E-4	1204	1209	-027.*	FOG LIFTED 1008



LOOP TRANSECT	START TIME	STOP TIME	FILES	COMMENTS
F-5	1223	1230	SEARSPORT _028.*	
~~E-6~~ F-1	1232	1240	_029.*	
F-2	1245	1250	_030.*	
F-3	1254	1259	_031.*	
F-4	1306	1311	_032.*	HIGH TIDE
G-5	1326	1330	_033.*	SUPER HIGH
G-1	1333	1339	_034.*	
G-2	1343	1348	_035.*	DATA CARD
G-3	~~1~~1453	1458	_048.*	ON ADCP
G-4	1503	1509	_049.*	FULL,
H-5	1522	1527	_050.*	CLEARED ~~DATA~~
H-1	~~1526~~ 1534	1539	_052.*	CARD, COPIED DATA
H-2	1542	1547	_053.*	"Communications
H-3	1551	1556	_054.*	Error"
H-4	1602	1605	_055.*	
I-5	1618	1622	_056.*	* RE-DO
I-1	1624	1629	_057.*	LINE, BAD
I-2	1633	1637	_058.*	NAVIGATION
I-3	1648	1652	_059.*	
I-4	1656	1700	_060.*	
J-5	1714	1717	_061.*	EBB
J-1	1719	1724	SEARSPORT _062.*	
J-2	1727	1732	_063.*	
J-3	17~~3~~36	1740	_064.*	FOG COMING
J-4	1745	1749	_065.*	BACK IN

LOOP - TRANSECT	START TIME	STOP TIME	FILES	COMMENTS
K-5	1800	1804	SEASPARC -066.*	HEAVY FOG
K-1	1806	1810	-067.*	ON THIS TRANSECT UNIQUE FLOW PATTERN (SLOW DOWN IN MAGNITUDE, WHEN CROSSING WEST PIER)
K-2	1814	1818	-068.*	
K-3	1822	1825	-069.*	
K-4	1830	1834	-070.*	WAVE HGT ↑ INCREASING

— — END OF SURVEY — — — —

Moved to 5412

Shot 6: 5412 → Base Rod=73

260.46 260.50 Tot = 65'

-1.76 -1.76

7/23/09 Searsport, ME

Nate Dill, Mitch Buck, Len Perry

Arrive @ Boat Ramp Steamboat Ave. 0530

- Problem w/ Inverter tide too low to get boat in

Boat in water 0815

ADCP on Deck test

PA Pass all but ~~H~~/W

PC2 Looks ok

PC1 Pass all

rr

re ErAsE

CZ

Transect		Start	Filename	End
5	A	08:54	Searsport2_001.*	9:00
1	A	9:05	Searsport2_002.*	9:11
2	A	9:15	" _003.*	9:19
3	A	9:24	" _004.*	9:28
4	A	9:33	" _005.*	9:37
5	B	9:49	" _006.*	9:54
1	B	9:55	" _007.*	10:01
2	B	10:04	" _008.*	10:07
3	B	10:16	" _009.*	10:20
4	B	10:25	" _010.*	10:29
5	C	10:41	" _011.*	10:46
1	C	10:48	" _012.*	10:53
2	C	10:57	" _013.*	11:01
3	C	11:06	" _014.*	11:10
4	C	11:16	" _015.*	11:20
5	D	11:32	" _016.*	11:36
1	D	11:38	" _017.*	11:43
2	D	11:46	" _018.*	11:51
3	D	11:55	" _019.*	11:59
4	D	12:04	" _020.*	11:07
5	E	1220	_021*	1224
1	E	1226	_022*	1232
2	E	1235	_023*	1239
3	E	1243	_024*	1247
4	E	1251	_025*	1255

Had Error files → _028 are tests

Problem	transect		Start	filename	END
	5	F	1322	Searsport2_029.*	1327
	1	F	Restarted computer		
	2	F			
	3	F			
	4	F			
	5	F	1344	Searsport2_032.*	1348
	1	F	1350	_033.*	1356
	2	F	1358	_034.*	1403
	3	F	1407	_035.*	1412
	4	F	1417	_036.*	1421
	5	G	1434	_037.*	1439
	1	G	1440	_038.*	1446
	2	G	1450	_039.*	1454
	3	G	1458	_040.*	1502
	4	G	1507	_041.*	1511
	5	H	1524	_042.*	1528
	1	H	1531	_043.*	1536
	2	H	1540	_044.*	1545
	3	H	1549	_045.*	1553
	4	H	1558	_046.*	16:02
	5	~~H~~ I	16:15	_047.*	16:19
	1	~~H~~ I	16:21	_048.*	16:27
	2	~~H~~ I	16:30	_049.*	16:35
	3	~~H~~ I	16:39	_050.*	16:43
	4	I	16:48	_051.*	16:52

Transect	Start time	Filename	End time
5 J	17:03	_052.*	17:08
1 J	17:10	_053.*	17:15
2 J	17:18	_054.*	17:23
3 J	17:27	_055.*	17:31
4 J	17:35	_056.*	17:39
5 K	1750	_057.*	1755
1 K	1756	_058.*	1802
2 K	1805	_059.*	1809
3 K	1813	_060.*	1816
4 K	1821	_061.*	1824
5 L	1913	_062*	1917
1 L	1919	_063*	1925
2 L	1929	_064*	1933
3 L	1937	_065*	1942
4 L	1943	_066*	1952
5 M	2004	_067*	2008
1 M	2010	_068*	2016
2M	2020	_069*	2024
3M	2028	_070*	2033
4M	2038	_071*	2041

End Survey

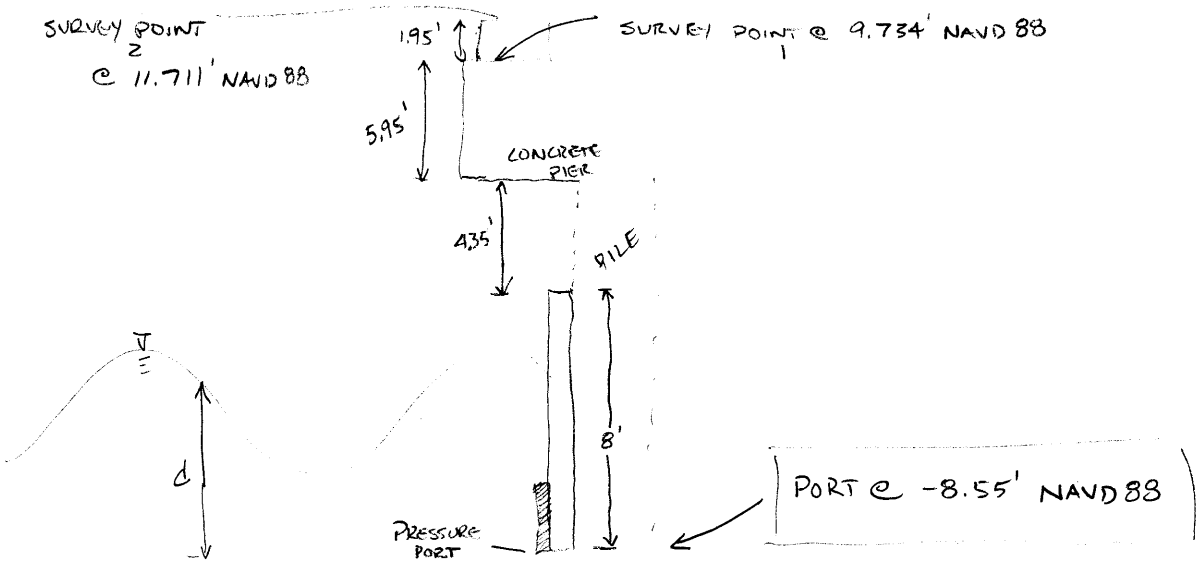
Recover sn 1827
from Isle bolo 21:00

Recover sn 1828
from terminal 2116

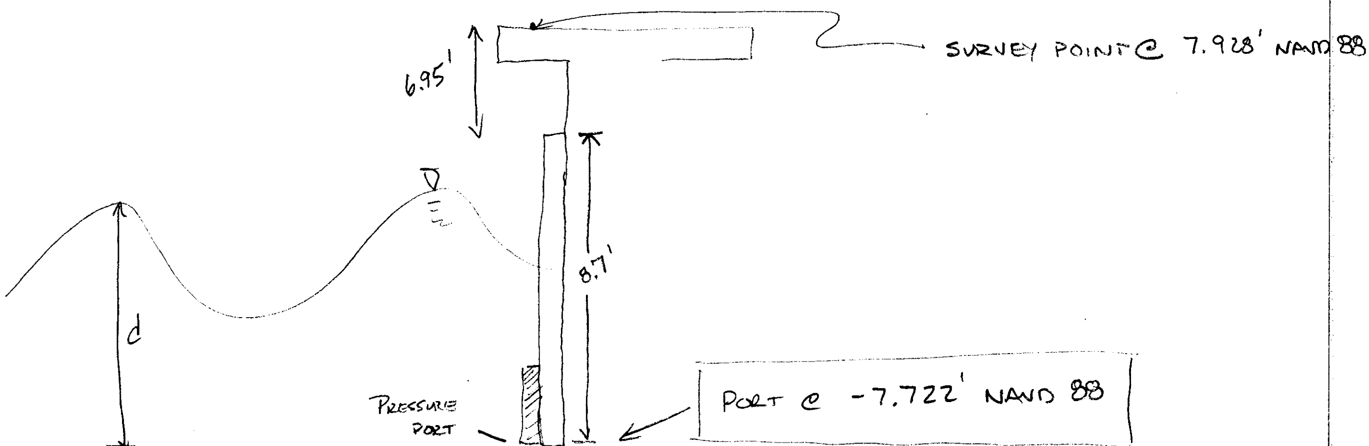
APPENDIX B TIDE DATA BENCHMARKING

SEARSPORT HARBOR TIDAL SURVEY ADJUSTMENT TO DATUM

· STATION S1, AT SPRAGUE TERMINAL DOCKS, GAUGE S/N 1828
DEPLOYED AT 1709 HRS 6/24/09



STATION S2, AT ISLEBORO ISLAND, GAUGE S/N 1827
DEPLOYED AT 1604 6/24/2009



APPENDIX C ADCP TRANSECT AND LOOP SUMMARY

SEARSPORT HARBOR DEPLOYMENT SURVEY, June 23, 2009						
				Entire	Depth-Averaged	
Loop	Transect	Start Time	Stop Time	Data File	Data File	Comments
A	5	656	701	SA5_0656.dat	DA_SA5_0656.dat	Heavy Fog, Low Tide
A	1	704	713	SA1_0704.dat	DA_SA1_0704.dat	
A	2	720	726	SA2_0720.dat	DA_SA2_0720.dat	
A	3	733	739	SA3_0733.dat	DA_SA3_0733.dat	
A	4	748	753	SA4_0748.dat	DA_SA4_0748.dat	
B	5	808	813	SB5_0808.dat	DA_SB5_0808.dat	Flood Tide
B	1	815	822	SB1_0815.dat	DA_SB1_0815.dat	
B	2	826	831	SB2_0826.dat	DA_SB2_0826.dat	
B	3	840	845	SB3_0840.dat	DA_SB3_0840.dat	
B	4	852	856	SB4_0852.dat	DA_SB4_0852.dat	
C	5	911	917	SC5_0911.dat	DA_SC5_0911.dat	
C	1	919	926	SC1_0919.dat	DA_SC1_0919.dat	
C	2	937	942	SC2_0937.dat	DA_SC2_0937.dat	
C	3	951	957	SC3_0951.dat	DA_SC3_0951.dat	
C	4	1004	1008	SC4_1004.dat	DA_SC4_1004.dat	
D	5	1024	1030	SD5_1024.dat	DA_SD5_1024.dat	Strong Prop-induced current from ocean vessel leaving Sprague Terminal
D	1	1033	1040	SD1_1033.dat	DA_SD1_1033.dat	
D	2	1043	1049	SD2_1043.dat	DA_SD2_1043.dat	
D	3	1054	1100	SD3_1054.dat	DA_SD3_1054.dat	
D	4	1106	1111	SD4_1106.dat	DA_SD4_1106.dat	
E	5	1125	1130	SE5_1125.dat	DA_SE5_1125.dat	
E	1	1132	1139	SE1_1132.dat	DA_SE1_1132.dat	
E	2	1143	1148	SE2_1143.dat	DA_SE2_1143.dat	Fog Clearing
E	3	1152	1159	SE3_1152.dat	DA_SE3_1152.dat	
E	4	1204	1209	SE4_1204.dat	DA_SE4_1204.dat	
F	5	1223	1230	SF5_1223.dat	DA_SF5_1223.dat	
F	1	1232	1240	SF1_1232.dat	DA_SF1_1232.dat	
F	2	1245	1250	SF2_1245.dat	DA_SF2_1245.dat	
F	3	1254	1259	SF3_1254.dat	DA_SF3_1254.dat	
F	4	1306	1311	SF4_1306.dat	DA_SF4_1306.dat	
G	5	1326	1330	SG5_1326.dat	DA_SG5_1326.dat	Data card full on ADCP at end of G2, communications error, cleared card and restarted survey
G	1	1333	1339	SG1_1333.dat	DA_SG1_1333.dat	
G	2	1343	1348	SG2_1343.dat	DA_SG2_1343.dat	
G	3	1453	1458	SG3_1453.dat	DA_SG3_1453.dat	
G	4	1503	1509	SG4_1503.dat	DA_SG4_1503.dat	
H	5	1522	1527	SH5_1522.dat	DA_SH5_1522.dat	
H	1	1534	1539	SH1_1534.dat	DA_SH1_1534.dat	
H	2	1542	1547	SH2_1542.dat	DA_SH2_1542.dat	
H	3	1551	1556	SH3_1551.dat	DA_SH3_1551.dat	
H	4	1602	1605	SH4_1602.dat	DA_SH4_1602.dat	
I	5	1618	1622	SI5_1618.dat	DA_SI5_1618.dat	Ebb tide
I	1	1624	1629	SI1_1624.dat	DA_SI1_1624.dat	
I	2	1633	1637	SI2_1633.dat	DA_SI2_1633.dat	
I	3	1648	1652	SI3_1648.dat	DA_SI3_1648.dat	
I	4	1656	1700	SI4_1656.dat	DA_SI4_1656.dat	
J	5	1714	1717	SJ5_1714.dat	DA_SJ5_1714.dat	
J	1	1719	1724	SJ1_1719.dat	DA_SJ1_1719.dat	Fog returns
J	2	1727	1732	SJ2_1727.dat	DA_SJ2_1727.dat	
J	3	1736	1740	SJ3_1736.dat	DA_SJ3_1736.dat	Wave Height increasing
J	4	1745	1749	SJ4_1745.dat	DA_SJ4_1745.dat	
K	5	1800	1804	SK5_1800.dat	DA_SK5_1800.dat	
K	1	1806	1810	SK1_1806.dat	DA_SK1_1806.dat	
K	2	1814	1818	SK2_1814.dat	DA_SK2_1814.dat	
K	3	1822	1825	SK3_1822.dat	DA_SK3_1822.dat	
K	4	1830	1834	SK4_1830.dat	DA_SK4_1830.dat	

SEARSPORT HARBOR RECOVERY SURVEY, July 23, 2009						
				Entire	Depth-Averaged	
Loop	Transect	Start Time	Stop Time	Data File	Data File	Comments
A	5	754	800	SA5_0754.dat	DA_SA5_0754.dat	
A	1	804	811	SA1_0804.dat	DA_SA1_0804.dat	
A	2	814	819	SA2_0814.dat	DA_SA2_0814.dat	
A	3	824	828	SA3_0824.dat	DA_SA3_0824.dat	
A	4	833	837	SA4_0833.dat	DA_SA4_0833.dat	
B	5	849	854	SB5_0849.dat	DA_SB5_0849.dat	
B	1	855	901	SB1_0855.dat	DA_SB1_0855.dat	
B	2	904	907	SB2_0904.dat	DA_SB2_0904.dat	
B	3	916	920	SB3_0916.dat	DA_SB3_0916.dat	
B	4	925	929	SB4_0925.dat	DA_SB4_0925.dat	
C	5	941	946	SC5_0941.dat	DA_SC5_0941.dat	
C	1	948	953	SC1_0948.dat	DA_SC1_0948.dat	
C	2	957	1001	SC2_0957.dat	DA_SC2_0957.dat	
C	3	1005	1010	SC3_1005.dat	DA_SC3_1005.dat	
C	4	1016	1020	SC4_1016.dat	DA_SC4_1016.dat	
D	5	1032	1036	SD5_1032.dat	DA_SD5_1032.dat	
D	1	1038	1043	SD1_1038.dat	DA_SD1_1038.dat	
D	2	1046	1051	SD2_1046.dat	DA_SD2_1046.dat	
D	3	1055	1059	SD3_1055.dat	DA_SD3_1055.dat	
D	4	1104	1107	SD4_1104.dat	DA_SD4_1104.dat	
E	5	1120	1124	SE5_1120.dat	DA_SE5_1120.dat	
E	1	1126	1132	SE1_1126.dat	DA_SE1_1126.dat	
E	2	1134	1139	SE2_1134.dat	DA_SE2_1134.dat	
E	3	1143	1147	SE3_1143.dat	DA_SE3_1143.dat	
E	4	1151	1155	SE4_1151.dat	DA_SE4_1151.dat	
F	5	1243	1248	SF5_1243.dat	DA_SF5_1243.dat	Computer/ADCP communication error, restarted ADCP and computer
F	1	1250	1259	SF1_1250.dat	DA_SF1_1250.dat	
F	2	1259	1303	SF2_1259.dat	DA_SF2_1259.dat	
F	3	1307	1312	SF3_1307.dat	DA_SF3_1307.dat	
F	4	1317	1321	SF4_1317.dat	DA_SF4_1317.dat	
G	5	1334	1339	SG5_1334.dat	DA_SG5_1334.dat	
G	1	1340	1346	SG1_1340.dat	DA_SG1_1340.dat	
G	2	1349	1354	SG2_1349.dat	DA_SG2_1349.dat	
G	3	1358	1402	SG3_1358.dat	DA_SG3_1358.dat	
G	4	1407	1411	SG4_1407.dat	DA_SG4_1407.dat	
H	5	1424	1428	SH5_1424.dat	DA_SH5_1424.dat	
H	1	1430	1439	SH1_1430.dat	DA_SH1_1430.dat	
H	2	1441	1445	SH2_1441.dat	DA_SH2_1441.dat	
H	3	1449	1453	SH3_1449.dat	DA_SH3_1449.dat	
H	4	1458	1502	SH4_1458.dat	DA_SH4_1458.dat	
I	5	1515	1519	SI5_1515.dat	DA_SI5_1515.dat	
I	1	1521	1527	SI1_1521.dat	DA_SI1_1521.dat	
I	2	1530	1535	SI2_1530.dat	DA_SI2_1530.dat	
I	3	1539	1543	SI3_1539.dat	DA_SI3_1539.dat	
I	4	1548	1552	SI4_1548.dat	DA_SI4_1548.dat	
J	5	1603	1608	SJ5_1603.dat	DA_SJ5_1603.dat	
J	1	1610	1615	SJ1_1610.dat	DA_SJ1_1610.dat	
J	2	1619	1623	SJ2_1619.dat	DA_SJ2_1619.dat	
J	3	1627	1631	SJ3_1627.dat	DA_SJ3_1627.dat	
J	4	1635	1639	SJ4_1635.dat	DA_SJ4_1635.dat	
K	5	1650	1655	SK5_1650.dat	DA_SK5_1650.dat	
K	1	1656	1702	SK1_1656.dat	DA_SK1_1656.dat	
K	2	1705	1709	SK2_1705.dat	DA_SK2_1705.dat	
K	3	1713	1716	SK3_1713.dat	DA_SK3_1713.dat	
K	4	1721	1724	SK4_1721.dat	DA_SK4_1721.dat	

L	5	1813	1817	SL5_1813.dat	DA_SL5_1813.dat	
L	1	1819	1825	SL1_1819.dat	DA_SL1_1819.dat	
L	2	1829	1833	SL2_1829.dat	DA_SL2_1829.dat	
L	3	1838	1842	SL3_1838.dat	DA_SL3_1838.dat	
L	4	1848	1852	SL4_1848.dat	DA_SL4_1848.dat	
M	5	1904	1908	SM5_1904.dat	DA_SM5_1904.dat	
M	1	1910	1916	SM1_1910.dat	DA_SM1_1910.dat	
M	2	1919	1924	SM2_1919.dat	DA_SM2_1919.dat	
M	3	1928	1933	SM3_1928.dat	DA_SM3_1928.dat	
M	4	1938	1941	SM4_1938.dat	DA_SM4_1938.dat	