INITIAL SURVEY OF CURRENT SPEED AND DIRECTION BY ACOUSTIC DOPPLER CURRENT PROFILER FOR THE NORTON BASIN BASELINE STUDY

DATA REPORT

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1.0 INTRODUCTION

Continental Shelf Associates, Inc. (CSA) was contracted by Barry A. Vittor & Associates, Inc. (BVA) to conduct an initial survey of current speed and direction using an acoustic doppler current profiler (ADCP). The primary objectives of the survey were to assess the utility of ADCPs in an estuarine environment and collect profiles of current velocity and direction along selected transects in Norton Basin, Little Bay, Grass Hassock Channel, and The Raunt, in Jamaica Bay, New York. Coverage and cross-channel and down-channel transects were selected based on directions provided by the USACE. This ADCP survey (and future ADCP surveys) was conducted primarily in support of the U.S. Army Corps of Engineers (USACE) fish bioacoustics study to be conducted by the Waterways Experiment Station (WES) under the Norton Basin Study baseline survey program. In addition, the current velocity and direction data also will be useful in the water quality assessment for the Norton Basin. In the future, the data will be useful in modeling of hydrodynamics and water quality in the Norton Basin. The initial ADCP study also was conducted to assess the utility of a vessel-mounted ADCP in the Norton Basin environment, where there are shallow areas and deep pits. The operational experience will be valuable to designing, planning, and implementing future fish bioacoustics, water quality, and hydrodynamic surveys. As directed by the USACE, the results of the survey are provided with minimal analysis and interpretation.

Figure 1-1 illustrates the location of the study areas within Jamaica Bay, New York. The areas surveyed included Norton Basin and Little Bay as primary survey areas, and Grass Hassock Channel and The Raunt as reference areas. The study areas are located a few kilometers to the south of John F. Kennedy International Airport. A series of cross-channel and down-channel transects were completed in each primary and reference survey area.

This data report has been prepared to document the results of the ADCP survey. The methods used in the survey are discussed in **Section 2.0**. The planned and actual ADCP survey lines are depicted in a series of figures. The results of the survey are presented in **Section 3.0** as figures showing current velocity magnitude and direction for each cross-channel and down-channel transect completed. A brief summary of the report is provided in **Section 4.0**

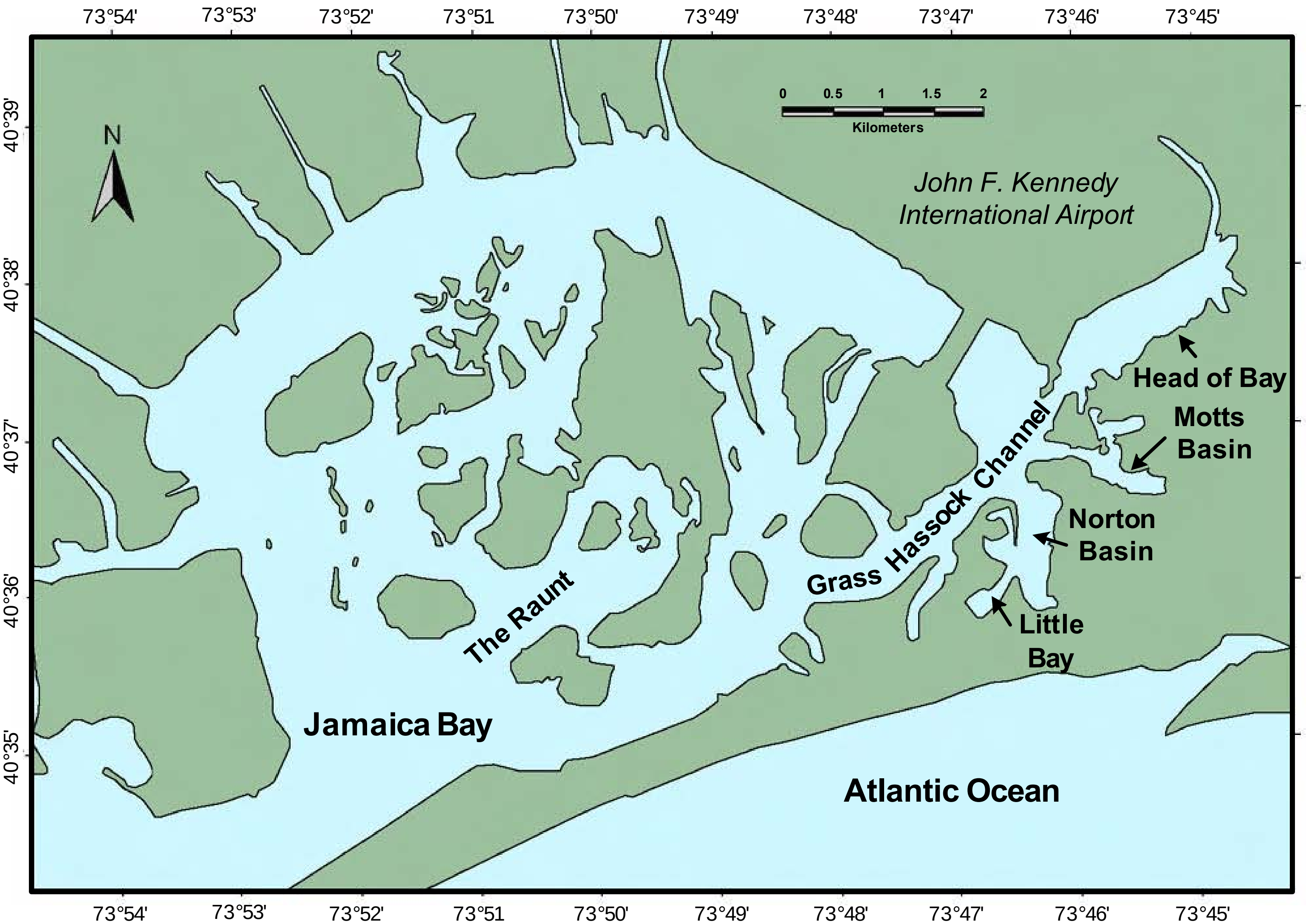

Figure 1-1. Primary study areas, Norton Basin and Little Bay, and reference areas, Grass Hassock Channel and The Raunt, in Jamaica Bay, New York.

2.0 METHODS

2.1 SURVEY AREAS AND TRANSECTS

Two survey modes were used: cross-channel transects and down-channel transects. Cross-channel transects were run perpendicular to the long-axis of a channel or embayment. Down-channel transects were run along the long axis of a channel or an embayment. A cross-channel transect produced a cross-section of the current structure across the channel. The terms “survey line” and “transect” are used synonymously in this report.

All transects were selected based on planned fish bioacoustics survey lines to be conducted by USACE WES researchers. Therefore figures showing planned transects are provided to illustrate where fish bioacoustics/ADCP surveys are not feasible due to certain limitations, allowing WES researchers to compare their original survey plans with what is feasible to complete.

Transects were surveyed in the most efficient sequence possible after considering water depth, tide, time, and channel width. Consequently, current speed and direction along transects were collected in various stages of the tide (flood or ebb) and in various directions (left to right, upstream or downstream). Because of the broad coverage of the survey, it was not possible to collect data from transects in all areas at consistent stages of the tide using a single survey vessel. Although data may have been collected at various stages of the tide and in different directions of movement, the ADCP data are presented in a standardized manner, as described in **Section 2.3.3**. The planned and actual transects surveyed are presented in the following subsection.

Cross-channel transects were numbered in series within each area starting from the mouth (lower part) of the channel. Down-channel transects were numbered in series from left to right as they appear on a map.

2.1.1 Norton Basin

Figure 2-1 illustrates the survey lines in the Norton Basin where 18 cross-channel transects and 4 down-channel transects were planned based on the proposed USACE WES fish bioacoustic survey. The actual transects run in the Norton Basin during the survey are illustrated in **Figure 2-2**. All planned transects were completed. In addition, repeat surveys were done on six of the cross-channel transects and two of the down-channel transects. A survey vessel with a shallower draft should be considered for future surveys to allow a wider tidal window during which surveys are possible.

2.1.2 Little Bay

The planned survey transects in Little Bay, where there were 7 cross-channel transects and 2 down-channel transects planned, are illustrated in **Figure 2-1**. Because of the shallow sill at the mouth of Norton Basin, surveys in Little Bay will be limited to high tides only unless a shallow draft survey vessel is used. All planned transects were surveyed, as shown in **Figure 2-3**.

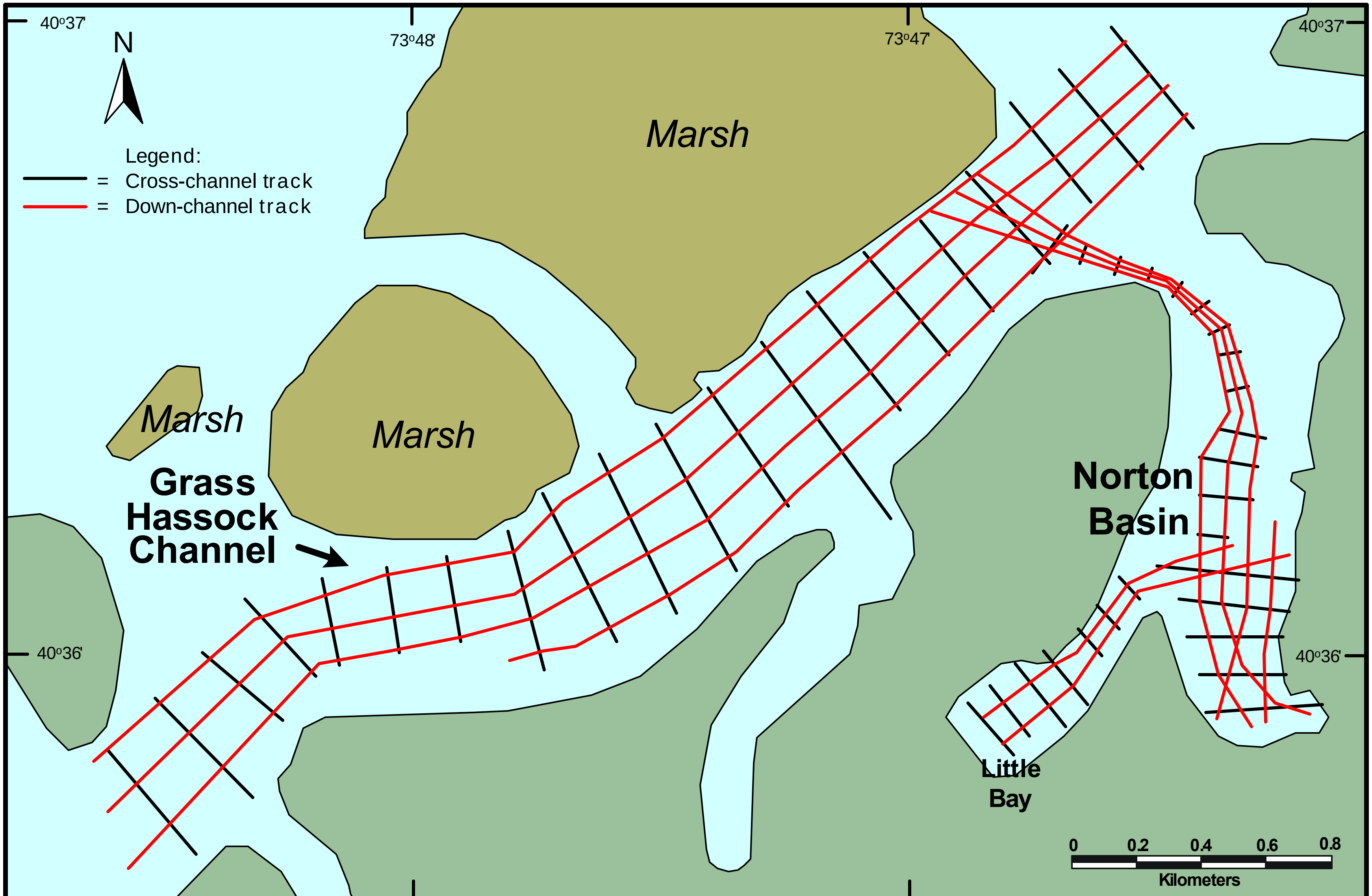

Figure 2-1. Planned Acoustic Doppler Current Profiler survey lines in Norton Basin, Little Bay, and Grass Hassock Channel.

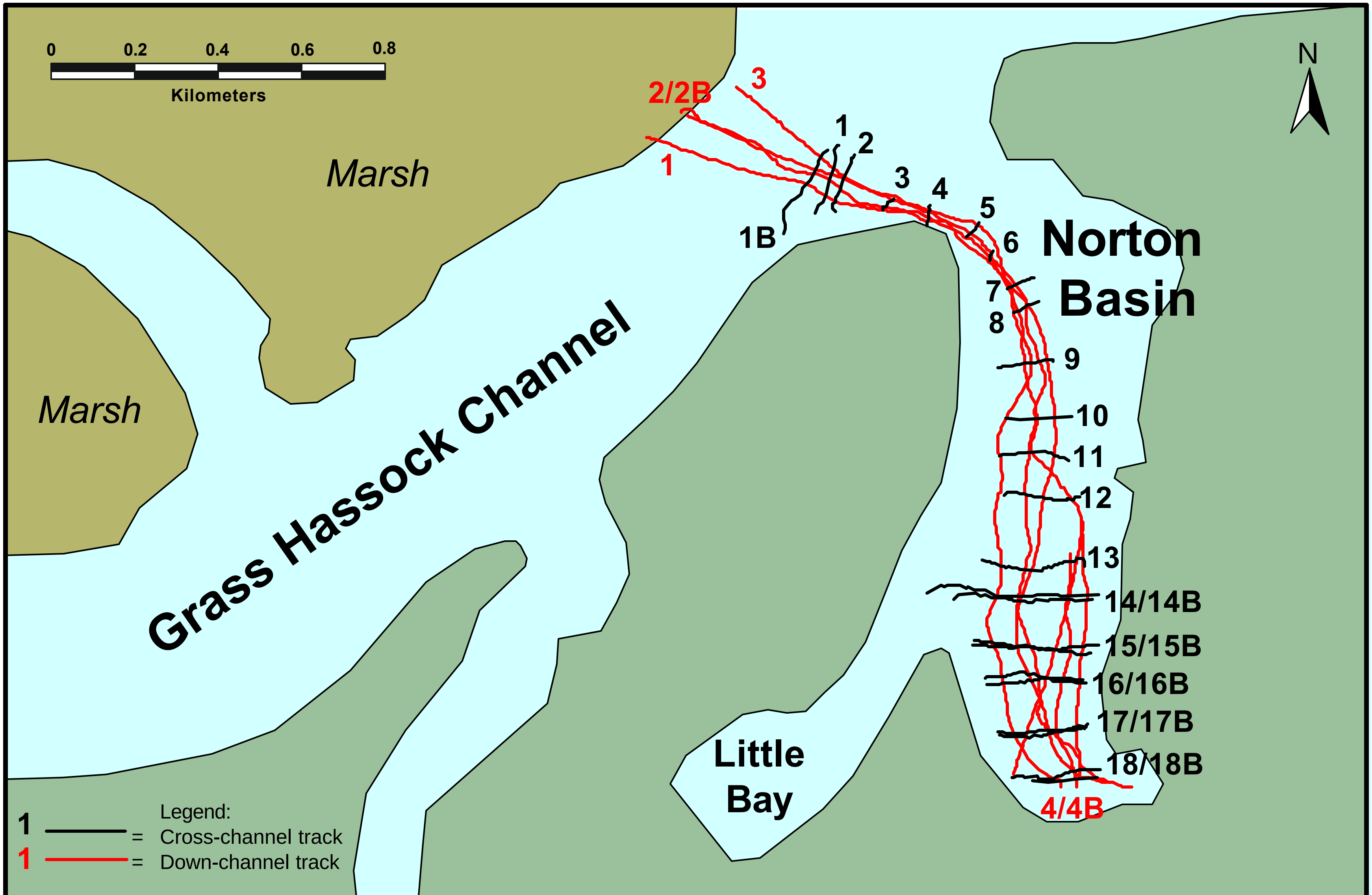

Figure 2-2. Actual Acoustic Doppler Current Profiler survey lines in Norton Basin.

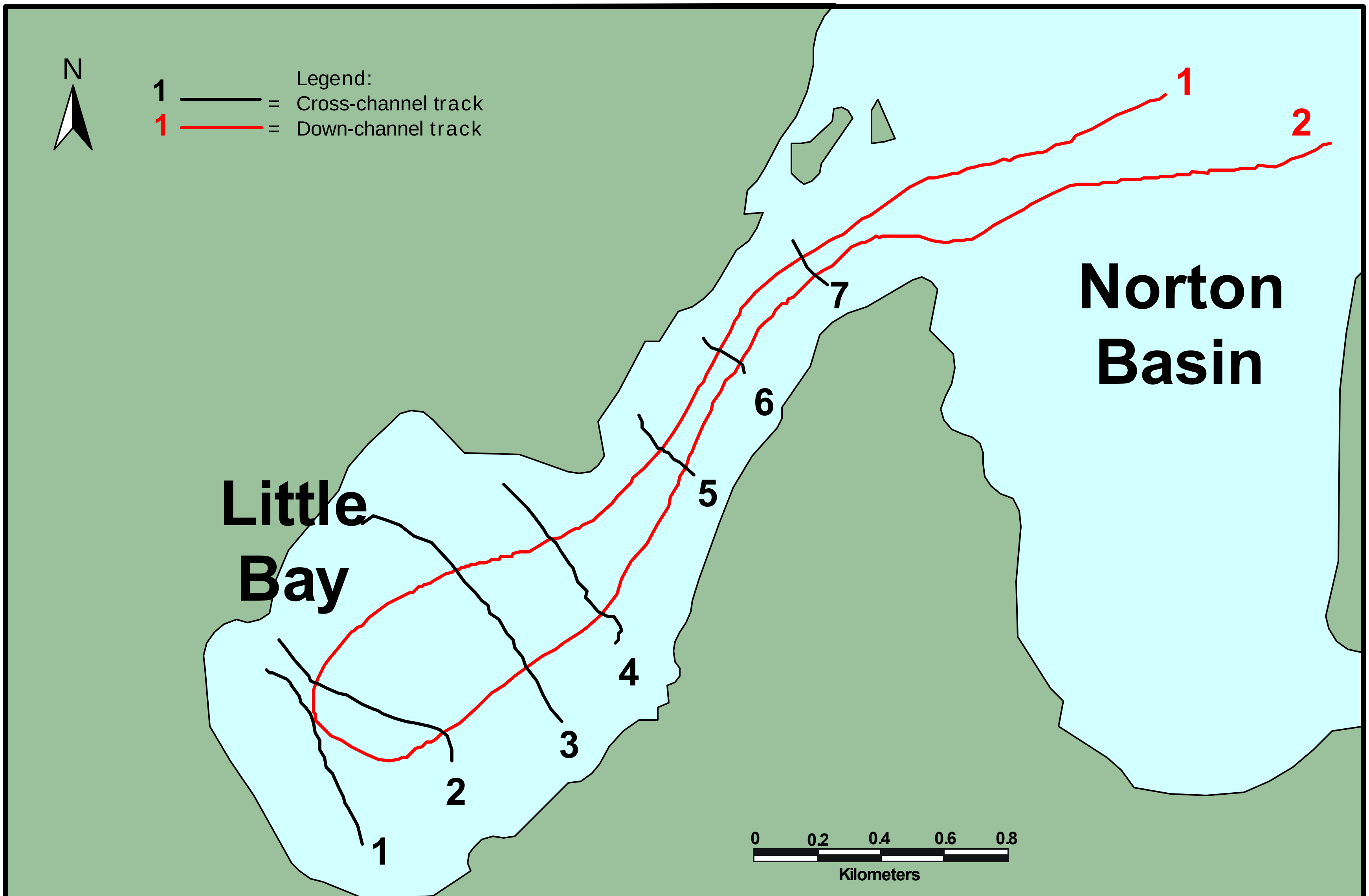

Figure 2-3. Actual Acoustic Doppler Current Profiler survey lines in Little Bay.

2.1.3 Grass Hassock Channel

In Grass Hassock Channel, 20 cross-channel transects and 4 down-channel transects were planned (**Figure 2-1**). All planned transects were completed. **Figure 2-4** shows the actual transects run in Grass Hassock Channel during the survey.

Because of the depth and width of Grass Hassock Channel, surveys were possible under most tidal conditions. However, caution in future surveys is advised because of numerous uncharted sandbars located along the sides of the channel that may be encountered.

2.1.4 The Raunt

Figure 2-5 illustrates the planned survey transects in The Raunt, where 23 cross-channel transects and 4 down-channel transects were planned. Water depths limited surveys in The Raunt, especially in the upper reaches of the area. Consequently most of the cross-channel transects and one of the down-channel transects were not done. The actual transects completed during the survey are illustrated in **Figure 2-6**.

Any future surveys in this area will need to be timed with the onset of a spring tide to survey the upper reaches and cross-channel transects. A survey vessel with a shallower draft also will be required.

2.2 DATA COLLECTION

2.2.1 Vessel

The 55-ft Research Vessel (R/V) WALFORD operated by the New Jersey Marine Sciences Consortium and based in Sandy Hook, New Jersey, was used during the survey. Crew personnel included Jim Hughes (Captain) and Juan Miguel Nunez (Assistant). Survey personnel consisted of Luis Lagera, Jr. and Frank Johnson, both of CSA.

2.2.2 Navigation

A Leica 12-channel differential global positioning system (DGPS) receiver was used for navigation and positioning. Positions were recorded in Universal Transverse Mercator (UTM) Zone 18N in meters (WGS84 datum) with an offset entered to correct for the position of the DGPS antenna relative to the ADCP. GPS fixes were taken every 5 to 10 m, depending on the length of the line.

Water depth was recorded using a Sitex® AVS 107 fathometer. The transducer was mounted on a retractable pole mounted on the starboard side of the survey vessel. Water depth in meters was recorded at each GPS fixpoint. A KVH® flux gate compass corrected for magnetic declination was used for bearing. Navigation and positioning was done using Coastal Oceanographics Hypack® software running on a Pentium® III computer. ArcView® 3.2 software was used for mapping.

Pre-plots of survey track transects were prepared in ArcView® prior to the survey. Waypoints for each planned survey line were exported from ArcView® as DXF files, entered into the navigation software, and used to guide the vessel along the active trackline and assess deviations from the planned track. A computer monitor was mounted near

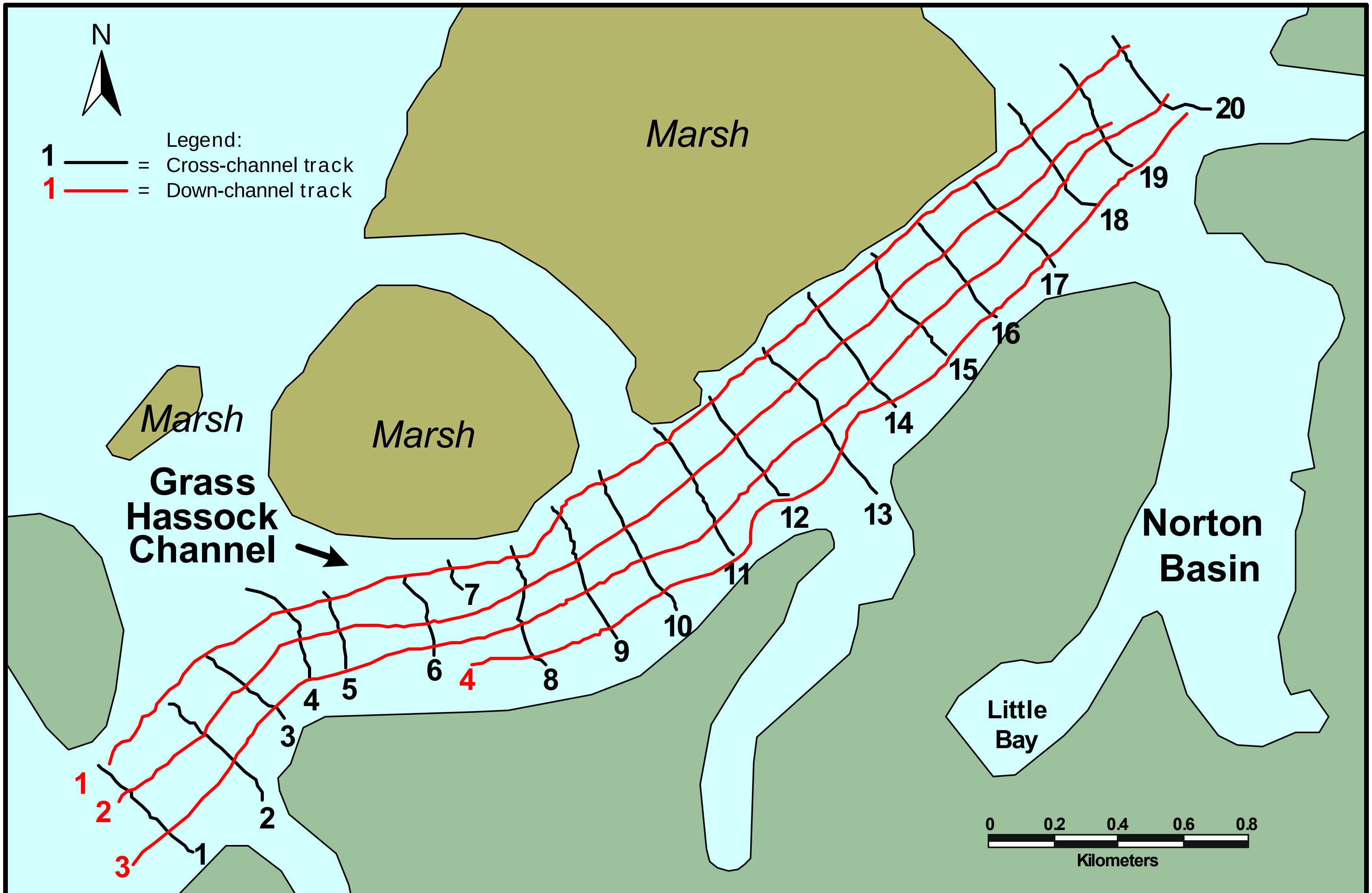

Figure 2-4. Actual Acoustic Doppler Current Profiler survey lines in Grass Hassock Channel.

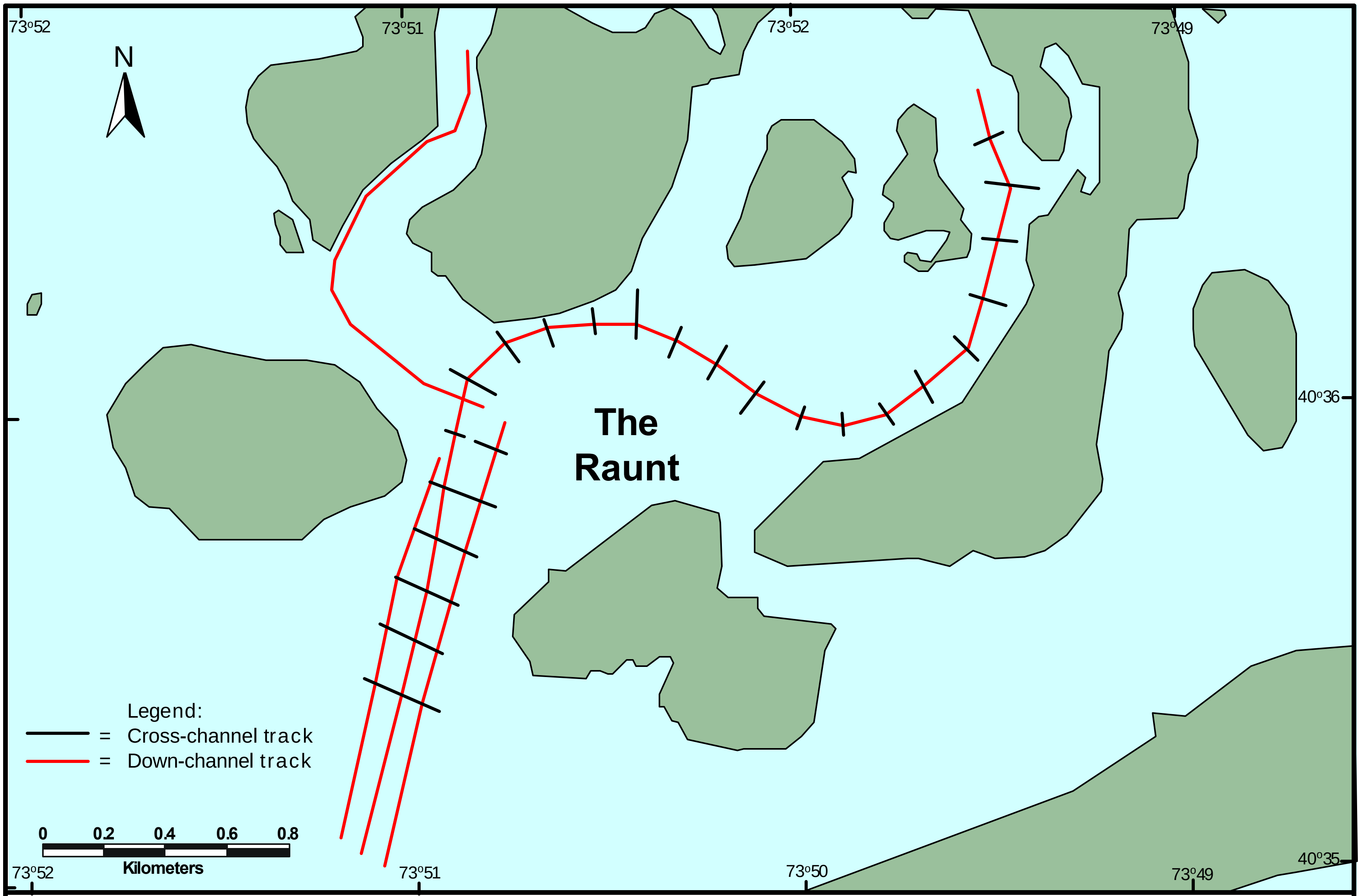

Figure 2-5. Planned Acoustic Doppler Current Profiler survey lines in The Raunt.

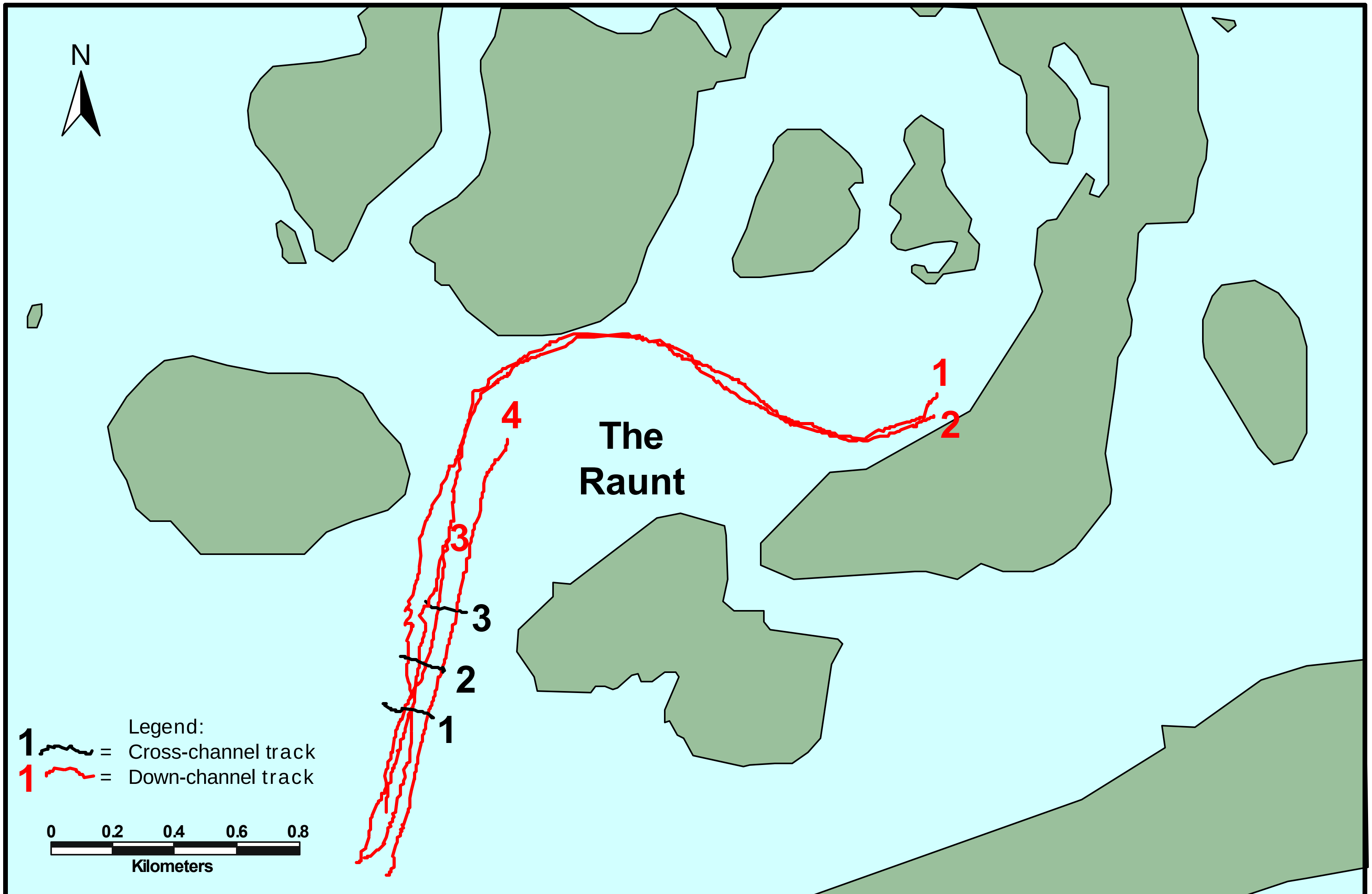

Figure 2-6. Actual Acoustic Doppler Current Profiler survey lines in The Raunt.

the helm to display the active waypoints and survey track in real time. This allowed the Captain to pilot the vessel and maintain its position along the planned trackline as closely as possible. However, tide, wind, and trackline position relative to the channel configuration precluded following the planned trackline exactly. After completing the surveys, post-plots of each trackline were prepared by importing the GPS fixes (point data) into ArcView® and creating line files from the points.

2.2.3 Acoustic Doppler Current Profiler

An RD Instruments (San Diego, California) Workhorse® 600 ADCP with bottom-tracking features (RD Instruments, 1998a) was used in the survey. The unit was a 600-MHz instrument suitable for the range in water depths expected during the survey. Although a 300-MHz instrument would have been adequate for most water depths encountered in the study area, the deeper pits required a higher frequency transducer, e.g., 600-MHz. The ADCP was mounted mid-ship on a retractable aluminum bracket and pole on the portside so that the ADCP transducer faces were 0.5 m below the water surface. The pole was secured to a steel sleeve fixed to the side of the vessel. External DC power was supplied to the ADCP during data collection mode. The ADCP was retracted when the vessel was underway to protect the instrument. The ADCP was connected by communication cables to a computer set up in a weatherproof cabin on the survey vessel.

Internal software tracked the instrument's movement and present water movement data relative to the bottom (RD Instruments, 1998b). RD Instruments WinRiver® software running on a Pentium® III computer was used during data collection and for display. Data was collected and displayed in real-time. A unique serial file name was created by the WinRiver® software for each transect data stream. After completion of the survey, the files were copied and the copies renamed to reflect the transect line number selected for each line in a study area because the original filenames did not necessarily agree with the selected numbering scheme.

Prior to data collection, a configuration file was prepared that set the data collection and recording parameters for the ADCP. Data are collected and stored as "ensembles" of current speed and direction at discrete levels (bin size was set at 50 cm) through the water column. The data stream from the RDI ADCP is stored in a proprietary format that minimizes file sizes and facilitates efficient data access, display, and extraction to other formats. Using WinRiver® software, current velocity and direction may be displayed from the data files for each transect completed in the survey. Data also may be extracted as text files for summary and plotting in other software applications.

The ADCP has four transducer faces each of which transmits a sound pulse and receives the echo. An internal flux gate compass allows the instrument to correct the ADCP current velocity and direction relative to earth coordinates, regardless of vessel orientation, track, and speed. Internal software also corrects for vessel pitch and roll.

Depending on a number of factors, the survey vessel proceeded at 0.5 to 2.5 knots. Vessel speed was reduced when the survey lines were short especially on narrow channels, when the water was very shallow, and when the end of the line was near. Higher vessel speeds were possible when surveying in deep channel with long tracklines. Some transects were truncated if depths shallower than the draft of the vessel was encountered. Some transects also could not be run true or straight due to of obstructions or tidal or wind conditions.

When the survey line was completed, the data file was closed and saved on the hard drive of the field computer. For data security, a copy of the ADCP files was saved on a 100 MB Zipdisk® at least once for each hour of data collection. Upon returning from the field, all ADCP files and associated navigation data was backed up on magneto-optical media and all original data archived on CD-ROM for data security. A profile of velocity magnitude and velocity direction was prepared for each completed transect using the WinRiver® software.

To standardize the data displays and assist in interpretation, cross-channel profiles were generated with data displayed left to right on a figure as cross-sections facing in the upstream direction (away from the inlet/mouth of the estuary or the ocean). In down-channel transects, profiles were displayed left to right depicting data from the lower reaches to upper reaches of the channel or embayment regardless of the actual direction the transect was run in the field.

2.3 SCHEDULE

To facilitate the ADCP survey which was conducted using the R/V WALFORD, the survey was scheduled to coincide with the highest spring tides of the year. The survey vessel was engaged for the week of 25 September and was to be used by other researchers before and after the ADCP survey.

Survey equipment was shipped from CSA in Jupiter, Florida on 22 September 2000 and delivered at the Seaway Marina office in Rockaway, New York on 25 September 2000. CSA personnel arrived on site on 25 September. Field mobilization began when the R/V WALFORD became available for the ADCP survey after returning from a fish survey at 9:30 a.m. on 26 September. Mobilization and survey equipment inventory at the Seaway Marina was completed by mid-afternoon and the R/V WALFORD left the dock at 4:55 p.m. to begin surveying in Grass Hassock Channel. ADCP surveys in Norton Basin, Grass Hassock Channel, and The Raunt continued through/28 September.

All planned ADCP survey lines were completed with the exception of a single down-channel line and the majority of the cross-channel lines in The Raunt. Low water did not allow surveys in the upper reaches of the channel in The Raunt because of the draft of the R/V WALFORD. Surveys were conducted in Norton Basin and Little Bay only during high tides because of the shallow areas at the mouth of the Norton Basin.

The R/V WALFORD entered Norton Basin at high tide during the morning of 27 September to survey the basin. Little Bay was surveyed at high tide the next day. The R/V WALFORD left Norton Basin before the ebbing tide trapped it inside the sill at the mouth of Norton Basin. Surveys in The Raunt were conducted during an ebbing tide after surveys in Little Bay and Norton Basin were completed. Surveys were conducted in Grass Hassock Channel during low tide where the channel was relatively deep. The times and heights of high and low tides during the survey period are shown on **Table 2-1**.

Table 2-1. Times and heights of high and low tides at Norton Point, Head of Bay, Jamaica Bay, New York during survey period from Tides and Currents® tidal predictions based on National Oceanic and Atmospheric Administration tide station in Sandy Hook, New Jersey.

DAY	LOW TIDE	HIGH TIDE	LOW TIDE	HIGH TIDE
26 Sep	2:00 a.m., -0.5 ft	7:56 a.m., 6.5 ft	2:14 p.m., -0.4 ft	8:13 p.m., 6.9 ft
27 Sep	2:48 a.m., -0.7 ft	8:44 a.m., 6.8 ft	3:06 p.m., -0.5 ft	9:01 p.m., 6.9 ft
28 Sep	3:34 a.m., -0.7 ft	9:30 a.m., 7.0 ft	3:55 p.m., -0.5 ft	9:46 p.m., 6.7 ft

Surveys were completed by mid-afternoon of 28 September. Demobilization of the R/V WALFORD was completed after equipment was prepared for shipment back to Jupiter, Florida the next day.

3.0 RESULTS AND DISCUSSION

ADCPs are used widely by oceanographers to measure currents in the deep-sea environment. ADCP technology has been adapted to the riverine and estuarine environment and has revolutionized the way tidal and streamflow measurements are made. The ADCP measures water motion by transmitting sound at a fixed frequency. The instrument then measures the Doppler-shifted echoes backscattered from scatterers (e.g., plankton and sediment) in the water and converts the echoes to along (acoustic) beam velocity components. An internal flux gate compass also allows the instrument keep track of it's position relative to the earth's magnetic field and software then reduces the along beam velocities to north/south, east/west, and vertical velocity components. The velocity profiles are determined by range-gating the echoes so that velocities are determined at pre-set intervals along the acoustic path (called bins). Vessel-mounted RD Instruments, Inc (RDI) ADCPs may be set up with bottom-tracking to correct the ADCP data relative to vessel motion. Software then allows a user to examine the ADCP data in multiple display modes, including vertical profiles of current velocity and direction along the survey track.

The primary advantage of ADCPs compared with point-current meters lies in the shorter time required to complete a measurement and its ability to make multiple measurements of velocity and direction simultaneously. Measurement time is reduced and data can be collected throughout the water column and as a cross-section of the channel rather than at discrete points. When making measurements across an open channel, taglines or other stationing devices are unnecessary because the instrument keeps track of distance traveled, provided the bed is stable. The instrument can be boat-mounted, towed, bottom moored, or surface moored.

The primary disadvantages of ADCPs compared with a standard current meter are its high initial cost, its inability to function in shallow water, and its complexity. This requires an in-depth understanding of the physics, electronics, and software of the ADCP system prior to use. The frequent revisions to hardware, firmware, and software due to the relative newness of the technology also requires attention.

ADCP data are presented as current velocity magnitude and direction profiles for each cross-channel and down-channel transect completed by study area. Data from the primary study areas (Norton Basin and Little Bay) are presented first, followed by data from the reference areas (Grass Hassock Channel and The Raunt). Current velocity magnitude and direction are presented for each transect completed in sequence, with any repeat transects included with each corresponding primary transect. Data from cross-channel transects are presented first followed by down-channel transects for each area surveyed.

Each ADCP figure (velocity magnitude and direction) is presented with depth in meters (m) on the y-axis set to 20 m on all figures (0 m is the water surface) and length or distance along the transect on the x-axis with the start of the transect set at 0 m. The extent (maximum value) of the x-axis is dependent on the actual length of the transect. The hypsography (bottom profile) along the transect is displayed as a dark line. The reader should note that the transects were not run straight and true due to various factors (e.g., currents, wind). The ADCP data are displayed as length or distance along the transect traversed. Vessel speed also varied along the transects due to various factors (e.g., depth, currents). In certain cases, data collection continued even when the vessel deviated from the planned track due to shallow depth or obstructions.

Velocity magnitude in meters per second (m/s) relative to the bottom of the channel is presented in the upper panel of each figure, while the velocity direction in degrees relative to the compass (0 or 360 is North, 90 is East, 180 is South, 270 is West) in the lower panel. The magnitude and direction displays are color coded with a corresponding legend for each panel.

Because the transducer was located 0.5 m below the water surface and the blanking distance of the instrument, data on currents within 1 m of the water surface are not available. Near bottom data usually are not available because the software rejects values that fall outside of quality control (QC) parameters. Blanks in the profile also may occur when the data are rejected due to QC parameters. Large masses of macroalgae (*Ulva*) floating in the water column were noted during the survey. These may have been the cause of the blank areas in some of the ADCP profiles.

To avoid confusion and facilitate interpretation of the ADCP figures, data have been presented in a standard manner in addition to the format described above. For the cross-channel displays, the profiles are presented as a cross-section of the channel when facing in an upstream direction. Data from the left bank of the channel are shown on the left side of the display (and data from the right bank are on the right side). For the down-channel transects, data are presented in an upstream direction from left to right on the display. Therefore, data from the lower reaches of the channel are on the left side of each figure, while data from the upper reaches are on the right side of each figure. Data are presented in this manner regardless of the actual direction of travel (left bank to right bank or upstream to downstream) during the survey. In cases where the actual direction of travel was opposite of the display format described above (e.g., the transect was run from the right bank to the left bank of a channel or from upstream to the downstream end or reach of a channel or embayment), the x-axis was “flipped” so that the zero value (start of transect) is on the right side of the figure. For the long down-channel transects (e.g., Grass Hassock Channel), averages of 10 ensembles were used to simplify the data display. Each figure is accompanied by a note indicating whether the data are displayed as they were collected or modified to maintain consistency in points of reference. The caption for each figure indicates the time the transect was started, as well as the next or closest low or high tide.

General observations on currents for each area are provided. Detailed discussions of current patterns are not provided.

3.1 NORTON BASIN

Figures 3-1 to **3-24** show the ADCP data from 18 cross-channel transects in Norton Basin done on 27 September during various stages of the tide (flooding, slack, and ebbing). Surveys for Cross-channel Lines 1, 14, 15, 16, 17, and 18 were repeated on 28 September. Data from the four down-channel transects done on 27 September and two repeat transects done on 28 September in Norton Basin are shown in **Figures 3-25** to **3-30**.

3.1.1 Cross-Channel Transects

The data from 18 cross-channel transects show that current velocities in Norton Basin are relatively low within a few hours of high tide. Most of the velocities recorded along the transects were close to zero although some approached 0.5 m/s. Similar observations were made in the transects that were repeated (Lines 1, 14 through 18). Consistent flow patterns also were not evident in most of the velocity direction displays from the cross-channel transects. In a few cases (e.g., Lines 14, 15, and 16), a southerly flow on the bottom and northerly flow near the surface is suggested (**Figures 3-15**, **3-17,** and **3-19**).

3.1.2 Down-Channel Transects

Low current velocities also were evident in Down-Channel Lines 1, 2, and 3 in Norton Basin, extended out of the mouth of Norton Basin into Grass Hassock Channel (left side of **Figures 3-25** to **3-28**). Down-Channel Line 4 that was located within the upper reaches of Norton Basin, also shows low current velocities and no evident flow pattern (right side of **Figures 3-29** and **3-30**).

Compared to the upper reaches of Norton Basin (right side of **Figures 3-25** to **3-28**), increased current velocities were observed in Grass Hassock Channel (left side of **Figures 3-25** to **3-28**) and along the sill at the mouth of Norton Basin. Down-Channel Line 3 (**Figure 3-28**) was done later in the day (10:34 a.m.) than Down-Channel Lines 1 (7:40 a.m.) and 2 (9:42 a.m.). Line 3 shows increased current velocities in the upper part of the water column of Grass Hassock Channel (left side of **Figure 3-28**), while velocity remains at zero in the upper reaches of Norton Basin (right side of **Figure 3-28**).

When comparing Down-Channel Lines 1, 2, and 3, an increase in current velocity also is apparent also in the entrance channel from Grass Hassock Channel into Norton Basin (sill area). Current velocity was greater in Lines 2 and 3 (**Figures 3-26** and **3-28**) compared to Line 1 (**Figure 3-25**). While current velocity is near zero in the entrance channel into Norton Basin in Line 1, in Lines 2 and 3, done later in the day during an ebbing tide, current velocity increased to near 0.5 m/s.

The increase in current velocity in the sill area between Lines 1, 2, and 3 was accompanied by a change in current direction. In Line 1, a southerly flow (flooding tide into Norton Basin) occurred, while in Lines 2 and 3 during an ebbing tide, the current direction was northerly (lower panels in **Figures 3-25**, **3-26**, and **3-28**).

A northerly or northwesterly flow on the surface and southerly flow on the bottom within Norton Basin also is suggested by the velocity direction displays in Down-Channel Lines 1, 2, and 3 (lower panels in **Figures 3-25**, **3-26**, and **3-28**).

The repeat survey of Norton Basin Down-Channel Line 2 (Line 2B) is shown in **Figure 3-27** with the original ensembles to illustrate the great detail possible and volume of data involved with long transects. Line 2B was done on 28 September during slack tide and shows the low current velocities and lack of a definitive flow pattern within Norton Basin. Line 2B also shows increased current velocity in near surface waters on the right side of Grass Hassock Channel.

A shift in the current direction within Grass Hassock Channel also is evident between Norton Basin Down-Channel Lines 1, 2, and 3 (left side of lower panels in

Figures 3-25, **3-26**, and **3-28**) that were done successively later in the ebbing tide. While a northerly and easterly flow was observed in Line 1, which started at 7:40 a.m. (**Figure 3-25**) during a flooding tide, the current direction shifted to a southerly and westerly flow later during the ebbing tide in Line 2 which started at 9:42 a.m. and Line 3 which started at 10:34 a.m. (**Figures 3-26** and **3-27**).

3.2 LITTLE BAY

ADCP data from cross-channel transects in Little Bay are shown in **Figures 3-31** to **3-37**, while **Figures 3-38** and **3-39** show data from down-channel transects in Little Bay. The survey in Little Bay was done on 28 September during a flooding and then slack tide. There were no repeat surveys done in Little Bay.

3.2.1 Cross-Channel Transects

Like Norton Basin, current velocities were low or near zero in Little Bay within a few hours of high tide, as observed in all the cross-channel transects. There were no definitive flow patterns evident in the displays of velocity direction (**Figures 3-31** to **3-37**).

3.2.2 Down-Channel Transects

Low current velocities and the lack of definitive flow patterns in Little Bay were observed also in the down-channel transects (**Figures 3-38** and **3-39)**. The profiles suggest that there may be a southerly flowing bottom current in the entrance channel into Little Bay. This would be consistent with the flooding tide occurring during the survey. Geomorphology and restricted circulation at the mouth of Norton Basin may explain the observed lack of currents in Little Bay, in addition to the time the survey was done relative to tides.

3.3 GRASS HASSOCK CHANNEL

Figures 3-40 to **3-59** show ADCP data from 20 cross-channel transects surveyed in Grass Hassock Channel on 27 September during a flooding tide. **Figures 3-60** to **3-63** show data from four down-channel transects surveyed on 26 and 27 September during a flooding tide. Transects were surveyed beginning at the upper reach of Grass Hassock Channel. There were no repeat surveys done in Grass Hassock Channel.

3.3.1 Cross-Channel Transects

Current velocities were significantly higher in Grass Hassock Channel than those observed in Norton Basin and Little Bay. Higher current velocities in the cross-channel transects in the lower reaches (Lines 1 to 8 in **Figures 3-40** to **3-47**) of Grass Hassock Channel were observed compared to the upper reaches (Lines 9 to 20 in **Figures 3-48** to **3-59**). Velocities of 0.7 to 1.0 m/s were present through the water column in Lines 1 to 8, while velocities dropped to less than 0.5 m/s in succeeding transects (Lines 9 to 20). The high current velocities (greater than 0.5 m/s) observed in transects from the lower reaches of Grass Hassock Channel were present through the breadth of the channels with the exception of certain transects. Reduced current velocities were present on the right side of the channel on Line 2 (**Figure 3-41**), the left side of the channel in Line 4 (**Figure 3-43**, the right side of the channel on Line 6 (**Figure 3-45**), and the left half of Line 7 (**Figure 3-46**). Line 7 (**Figure 3-46**) was truncated because of shallow areas in the middle of the channel so the transect is only about 110 m in length. Higher current velocity is evident toward the center of the channel at Line 7. This difference in current velocity between the main axis of the channel and the sides also can be observed in Line 8.

At Line 8 (**Figure 3-47**) the current velocity for most of the channel dropped to less than 0.5 m/s except for an area near the water surface on the left side of the channel. At Line 10 and above (**Figures 3-49** to **3-59**), current velocities were mostly less than 0.5 m/sec and generally similar through the water column and across the breadth of the channel. A current running more than 0.5 m/s is evident on the right side of the upper reaches of Grass Hassock Channel at Lines 18 to 20 (**Figures 3-57** to **3-59**). The possible source of this flow is discussed below.

Differences in current velocities between the lower and upper reaches of Grass Hassock Channel can be expected due to the channel morphology. The lower reach of Grass Hassock Channel is narrower and shallower than the middle and upper reaches. Water flow in a channel would increase in areas of restricted passage.

Current directions in the lower reaches where velocity is higher also were more consistent than in the middle and upper reaches of Grass Hassock Channel. Current direction at Line 1 was easterly and shifted northerly at Line 2 before returning to an easterly direction in Lines 3 to 8 (**Figures 3-42** to **3-47**). This shift in flow reflects the turn in the channel. An easterly direction of flow would occur during a flood tide in Grass Hassock Channel. A northerly flow on the left side of Line 4 (**Figure 3-43**) is due to Winhole Channel that is oriented North-South where the western end (left side of profile) of Line 4 is located.

Above Line 8 in Grass Hassock Channel (**Figures 3-48** to **3-59**) where current flow dropped to less than 0.5 m/s, current directions are no longer consistent through most of the water column and across the breadth of the channel. In the upper reaches of Grass Hassock Channel where Lines 18 to 20 are located, a westerly flow direction is evident on the right side of the channel (**Figures 3-57** to **3-59**). This may be due to flow from the "Head of Bay" and Motts Basin into Grass Hassock Channel (**Figure 1-1**). Lines 18 to 20 were surveyed before low tide (3:06 p.m.). Lines 18, 19, and 20 were started at 1:45 p.m., 1:31 p.m., and 1:23 p.m., respectively.

3.3.2 Down-Channel Transects

Current velocities and patterns of flow also were observed in the down-channel transects done in Grass Hassock Channel that supported observations made among the cross-channel transects. In Down-Channel Lines 1, 2, and 3 (**Figures 3-60** to **62** higher current velocities (above 0.5 m/s) are evident in the lower reaches of Grass Hassock Channel (left side of the figure) particularly in the shallower and narrower part of the channel corresponding to the segment from about 300 m to 1,480 m on Line 1.

In the middle and upper reaches of Grass Hassock Channel velocities were under 0.5 m/s generally. Parts of the water column exhibited slightly higher velocities (about 0.5 m/s) in the upper reaches of Grass Hassock Channel, e.g., at the middle of the water column (midwater) in Line 1 (**Figure 3-60**), at midwater in Line 2 (**Figure 3-61**) extending downstream to the middle reaches, and within 5 m of the surface in Line 3 (**Figure 3-62**) for most of the middle and upper reaches. Line 4 that ran from the middle to the upper reaches of Grass Hassock Channel (**Figure 3-63**) also showed slow currents in most of the water column except for slightly higher velocities near the water surface near the middle and upper segments.

Down-Channel Lines 1 and 2 (**Figures 3-60** and **3-61**) were done on 26 September during a flooding tide while Lines 3 and 4 (**Figures 3-62** and **3-63**) were done on 27 September during an ebbing tide. Current directions correspond to the differences in tides between the pairs of surveys. A flooding tide showed a predominantly easterly or northerly direction (Lines 1 and 2) while an ebbing tide showed westerly or southerly flow (Lines 3 and 4). Current direction was predominantly in a northeasterly direction in the sections of Line 1 (**Figure 3-60**) where the channel was shallow and narrow (restricted) and velocity was high. A similar pattern in current direction can be observed in the same sections of Line 2 (**Figure 3-61**). In Lines 3 and 4 (**Figures 3-62** and **3-63**) current direction was predominantly southwesterly in the corresponding narrow sections of Grass Hassock Channel during an ebbing tide.

3.4 THE RAUNT

ADCP data from three cross-channel transects in The Raunt are shown in **Figures 3-64** to **3-66**. **Figures 3-67** to **3-70** show ADCP data from four down-channel transects. All transects were completed on 28 September during an ebbing tide. There were no repeat surveys done in The Raunt. The observed patterns in current velocity and direction in The Raunt are readily explained by the tidal conditions and morphology of the channel.

3.4.1 Cross-Channel Transects

Current velocities at about 0.5 to 0.7 m/s were very similar among the three cross-channel lines while current directions were mainly southerly and westerly (**Figures 3-64** to **3-66**). Higher current velocities can be expected in the area compared to Norton Basin and Little Bay because The Raunt is located at the confluence of several tidal channels. The close similarities in the velocity magnitude and direction profiles of the three cross-channel lines can be expected because they were completed within an hour of each other and all three were located in the lower reaches of The Raunt.

3.4.2 Down-Channel Transects

The patterns of current velocity along the down-channel lines can be explained by tidal conditions and channel morphology. Current velocity was about 0.5 to 0.7 m/s along the lower to middle reaches of Down-Channel Lines 1 and 2 (**Figures 3-67** and **3-68**). In the upper reaches of The Raunt along Lines 1 and 2, current velocity was lower (less than 0.5 m/s). Lower current velocities at the upper reaches of a tidal channel can be expected especially at the later part of an ebbing tide. Similar current velocities were observed in Down-Channel Lines 3 and 4 (**Figures 3-69** and **3-70**) that ran along the lower reaches of The Raunt compared to the lower segments of Lines 1 and 2. The points along Line 3 showing the bottom coming up to the water surface are where the survey vessel touched the bottom on shoal areas in The Raunt.

Figures 3-69 and **3-70** depicting data from Down-Channel Lines 3 and 4 also show differences in current velocity between the main channels leading to Rockaway Inlet (Runway and Beach Channels) and The Raunt where an area of lower current velocity is evident in between. A strong southerly current from an ebbing tide in The Raunt would slow down as when it gets to the main channel. This pattern also may be discerned in Lines 1 and 2 (**Figures 3-67** and **3-68**).

The patterns in current direction among the four down-channel lines are explained by the geomorphology of the area. As shown in **Figure 2-6**, the orientation of the channel in The Raunt changes markedly between the lower and upper reaches of the channel. The lower part of the down-channel transect (**Figure 3-68**) actually occurs in the main channel leading to Rockaway Inlet. Data from Lines 3 and 4 also show the shift in current direction between the main channel leading to Rockaway Inlet and The Raunt (**Figures 3-69** and **3-70**). During an ebbing tide, a westerly current would occur in the main channel. Further upstream along the transect, within the channel of The Raunt, the channel runs in a North-South, an ebbing tide would run southerly as observed in **Figures 3-67** and **3-68**. Continuing upstream, the channel turns to the east so an ebbing tide would run westerly as indicated in **Figures 3-67** and **3-68**. The channel then turns to the southeast and then towards the east and northeast, and a corresponding change in the current direction is evident in the ADCP velocity direction data from the down-channel transects.

4.0 SUMMARY

A survey of current velocity and direction using an ADCP was conducted in Norton Basin and Little Bay as primary study areas and in Grass Hassock Channel and The Raunt as reference areas in Jamaica Bay on 26 through 28 September 2000. The survey was conducted to assess the feasibility of using a vessel-mounted ADCP within the Jamaica Bay environment (particularly in Norton Basin and Little Bay where both very shallow areas and deep pits are located) and to collect profiles of current velocity and direction along selected transects in primary and reference study areas. The primary purpose of this ADCP survey (and future ADCP surveys) is to support the interpretation of the fish bioacoustic survey for the Norton Basin Baseline Study. The fish bioacoustic study will be conducted by USACE WES. The ADCP survey lines were based on the proposed fish bioacoustic survey lines to be done by WES.

The study documents the successful application of a vessel-mounted ADCP for most of the Jamaica Bay study areas except for the upper reaches of The Raunt. Profiles of current velocity and direction in the water column along cross-channel and down-channel surveys in Norton Basin, Little Bay, Grass Hassock Channel, and the lower reaches of The Raunt were obtained successfully. Vessel-mounted ADCP can be used to support interpretation of fish bioacoustic data from Jamaica Bay.

All planned ADCP survey lines were completed with the exception of a single down-channel line and the majority of the cross-channel lines in The Raunt. A total of 70 ADCP transects were completed. In Norton Basin, 24 cross-channel lines and 6 down-channel lines were completed including repeat lines. In Little Bay, 7 cross-channel lines and 2 down-channel lines were completed. In Grass Hassock Channel, 20 cross-channel lines and 4 down-channel lines were completed while 3 cross-channel lines and 4 down-channel lines were completed in The Raunt.

Low water did not allow surveys in the upper reaches of the channel in The Raunt. Due to shallow areas at the entrance channel to Norton Basin, surveys could be conducted in Norton Basin and Little Bay during high tides only. Future surveys should consider using a survey vessel with a shallower draft to allow more flexibility in scheduling surveys within Norton Basin and Little Bay.

Low current velocities of mostly near zero or less than 0.5 m/s were measured in ADCP transects done in Norton Basin and Little Bay during the survey. There were no definitive flow patterns that could be discerned based on current directions in the upper reaches of Norton Basin and Little Bay although interesting flow patterns could be observed in the entrance channels to these embayments. In contrast, significant current velocities of 0.5 to 1 m/s or more and tidally driven changes in current directions were documented in the transects located in references areas in Grass Hassock Channel and The Raunt. The observed patterns in current velocity and direction in Grass Hassock Channel and The Raunt are explained by tidal conditions and morphology of the channels.

5.0 REFERENCES

RD Instruments. 1998a. Workhorse Acoustic Doppler Current Profiler Technical Manual. RD Instruments, Inc. San Diego, California.

RD Instruments. 1998b. Bottom-Tracking Addendum. RD Instruments, Inc. San Diego, California.