NOAA Technical Report NOS CO-OPS 043

Ocean Systems Test and Evaluation Program

Test, Evaluation, and Implementation of Current Measurement Systems on Aids-To-Navigation

Silver Spring, Maryland
May, 2005

noaa National Oceanic and Atmospheric Administration

U.S. DEPARTMENT OF COMMERCE
National Ocean Service
Center for Operational Oceanographic Products and Services

Center for Operational Oceanographic Products and Services
(CO-OPS)
National Ocean Service (NOS)
National Oceanic and Atmospheric Administration (NOAA)
U.S. Department of Commerce

The CO-OPS mission is to deliver the operational environmental products and services necessary to support NOAA's Environmental Stewardship and Environmental Assessment and Prediction Missions. CO-OPS provides the focus for operationally sound observation and monitoring capability coupled with environmental predictions to provide the quality data and information needed to support the cross-cutting NOS Primary Goals of Navigation, Coastal Communities, Habitat, and Coastal Hazards.

Ocean Systems Test & Evaluation Program

The CO-OPS Ocean Systems Test and Evaluation Program (OSTEP) facilitates the transition of new technology to an operational status, selecting newly developed sensors or systems from the research and development community and bringing them to a monitoring setting. OSTEP provides quantifiable and defensible justifications for the use of existing sensors and methods for selecting new systems. The program establishes and maintains field reference facilities where, in cooperation with other agencies facing similar challenges, devices are examined in a non-operational field setting. Through OSTEP, sensors are evaluated, quality control procedures developed, and maintenance routines generated. The quality of the reference systems used in the field is assured by both rigorous traceable calibrations and redundant sensors.

The Ocean Systems Test & Evaluation Advisory Board consists of:

NOAA Technical Report NOS CO-OPS 043

Ocean Systems Test and Evaluation Program

Test, Evaluation, and Implementation of Current Measurement Systems on Aids-To-Navigation

Kathryn Thompson Bosley, PhD
Chris McGrath
Jennifer P. Dussault
Mark Bushnell
Michael J. Evans
Geoffrey W. French
Karen Earwaker

May 2005

noaa National Oceanic and Atmospheric Administration

U.S. DEPARTMENT OF COMMERCE
Carlos M. Gutierrez, Secretary

National Oceanic and Atmospheric Administration
Vice Admiral Conrad C. Lautenbacher, Jr., U.S. Navy (Ret.)
Undersecretary of Commerce for Oceans and
Atmosphere and NOAA Administrator

National Ocean Service
Dr. Richard W. Spinrad, Assistant Administrator of the National Oceanic and Atmospheric Administration (NOAA) Ocean Services and Coastal Zone Management

Center for Operational Oceanographic Products and Services
Michael Szabados, Director

NOTICE

CO-OPS STATEMENT OF ACCEPTANCE

CO-OPS management personnel have reviewed this document and concur that the evaluated sensor/system, when deployed and implemented as described herein, meets the defined requirements and is suitable for operational use. While additional testing may lead to superior performance or more economical operation, the existing sensor/system configuration is sufficient as described.

Kathryn T. Bosley 5/18/05
OSTEP Project Leader

Mark Bushnell 5/18/05
OSTEP Program Manager

Thomas N. Mero 5/16/05
Chief, Requirements & Development Division

Leonard Hickman 5/16/05
Chief, Products & Services Division

Chief, Field Operations Division

Chief, Information Systems Division

Michael Szabados
Director, CO-OPS

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Ocean Systems Test and Evaluation Program

Test, Evaluation, and Implementation of Current Measurement Systems on Aids-To-Navigation

EXECUTIVE SUMMARY

The Physical Oceanographic Real-Time System (PORTS®) is a program of the National Ocean Service's Center for Operational Oceanographic Products and Services (NOS/CO-OPS). PORTS® provides real-time marine environmental information to support safe and efficient maritime commerce and informed coastal resource management. In response to user requests for water current information near navigation channels, CO-OPS entered into a partnership with the U.S. Coast Guard (USCG) to place current measurement systems on existing USCG aids-to-navigation (ATON) buoys.

This document describes measurement and communication technologies employed, the design considerations which ensure that the PORTS® payload does not interfere with the primary mission of the buoys, the system test and evaluation undertaken, the field procedures for installation, repair and maintenance of the systems, the data flow configuration, data quality control procedures, and finally, the products generated and disseminated to the public from these current measurement systems.

The system, developed from commercial off-the-shelf (COTS) technology, consists of a "clamparatus" (produced by the Oceanscience Group) that secures a current profiler (manufactured by Nortek) and electronics box to the buoy. The entire package weighs ~200 pounds and is easily deployed using a small boat and a block and tackle. Data are sent to shore via spread spectrum radios. Deployments of up to seven months have been achieved thanks to the low power consumption of both the profiler and radios. This system satisfies the maritime community's requirements for current information within navigation channels, while removing the restraints of previous current meter placements, which were limited by cable length and the need to stay out of the channel. Underwater cable to shore has long been a PORTS® operations weak link because cables are often snagged and broken.

The ATON-mounted system complies with all USCG requirements. The most important concern is ensuring that the system does not interfere with ATON utility or maintenance. Other USCG requirements include: a completely battery powered system; the ability to deploy and recover with the buoy on station; the ability to remove the entire package prior to ATON servicing; the use of all

similar metals and coloration; and minimal alteration of buoy profile and characteristics.

NOS/CO-OPS uses the David Taylor Model Basin to evaluate all acoustic Doppler current profilers (ADCPs). Current profilers are mounted to a carriage that travels through the tank at precise speeds; the current speed recorded by the profiler is then compared to the carriage speed. CO-OPS policy requires that all Nortek current profilers used in ATON current measurement system be tow-tested at David Taylor before operational use. The David Taylor tests showed a mean speed difference of between one centimeter per second (cm/s) and five cm/s, depending on the carriage speed and Nortek bin sampled. These results are completely in line with current profilers of other manufacturers used by CO-OPS.

CO-OPS performed a field intercomparison in the Potomac River in about 60 feet of water. A bottom-mounted RD Instruments 600 kilohertz (KHz) Workhorse ADCP configured with one-meter bins was located approximately 250 meters north of the Nortek one-megahertz (MHz) Aquadopp current profiler mounted on Buoy B at Piney Point. The Nortek was also configured with one-meter bins. Performance was evaluated by comparing the differences in current speed and direction. The speeds compare very well, within the anticipated error of individual instruments. There was no obvious bias in the ATON, with the mean difference being ~ 3 cm/s equals 0.06 knots. The results of comparisons with current directions from bottom-mounted current profilers show agreement to within +/-21° (standard deviation of 26°) when all data are included. The difference improves to 12° when speeds less than one-quarter knot are omitted. These results are encouraging, considering three general categories of source of differences between the two direction measurements: 1) the error in bottom mount direction; 2) the error in ATON direction; and 3) the real environmental differences between the respective volumes of water.

CO-OPS performed another intercomparison at the mouth of the Freeport River, Texas, in about 11 meters of water. Data from a bottom-mounted ADCP located about 70 meters from an ATON-mounted profiler were analyzed. As in the Piney Point comparison, an RD Instruments 600 KHz Workhorse ADCP configured with one-meter bins was deployed in a bottom mount to evaluate the Nortek one-MHz Aquadopp profiler mounted on Buoy 6, which was also configured to sample one-meter bins. The mean speed difference was ~3 cm/s with no bias observed. The Freeport River empties into the Gulf of Mexico and, although the flow in the region is not tidally dominated, the rapid reversals in the alongshore current are evident in both records of direction. In spite of large directional differences at times of current reversal, the mean direction difference was ~15° and ~12° when only times with speeds greater than one-quarter knot are considered.

The general navigation requirements are for reported current speeds to be accurate to within +/- 0.10 knot and direction accurate to within +/- 15° in order to aid in the maneuvering of large vessels. The ATON-mounted current measurement system, as designed and deployed with the recommended procedures, meets these speed and direction requirements. The authors recommend that CO-OPS senior management approve the ATON current measurement system for use in PORTS® and begin the operational dissemination of the data via the web, phone and text pages (CO-OPS homepage). Additional system testing (outlined in Section 8.0) is recommended. As presented in this report, the ATON current measurement system provides the navigation community with important data in those areas where it is impracticable to use either the traditional bottom-mounted or side-looking current profilers.

CO-OPS management personnel have reviewed this document and concur that the evaluated sensor/system, when deployed and implemented as described, meets the defined requirements and is suitable for operational use. While additional testing may lead to superior performance or more economical operation, the existing sensor/system configuration is sufficient as described.

1.0 INTRODUCTION

1.1 Requirements

CO-OPS developed a real-time current measurement system for placement on USCG Aids-To-Navigation (ATON) as an enhancement to the PORTS® Program. The requirement for this system came from user requests for current information at navigation channels in locations that are either too far from shore for the use of a bottom-mounted current profiler system with armored cable or are in danger of being dredged up. Users, marine pilots in particular, often require current information at the confluence of two navigation channels or in areas where a tight turn is needed to stay inside the dredged channel. Through communication with local pilots, CO-OPS understands that the basic requirement for current information useful to navigators is to know the vertical structure of the current speed and direction to within ± 0.10 knot and ± 15° in order to aid in the maneuvering of large vessels.

Implementation of ATON current profilers is an important step forward for CO-OPS for two reasons. First, and most important, buoy-mounted current profilers allow the measurement of currents at the navigational channels in the exact positions that are of most interest to the professional mariner. Before this PORTS® enhancement became a reality, the need to limit cable length and to stay safely outside of the navigation channel determined the location of a bottom-mounted current profiler as much as did the users' request for current information. Second, there is significant improvement in the availability of current data compared to conventional bottom-mounted current measurement systems, which have been plagued by underwater cable problems, platform movement, and silting. Because divers and underwater cables are not needed, installation and operations and maintenance (O&M) costs are reduced considerably. The ATON-mounted current profiler systems are a more robust way of delivering critical data every six minutes.

Open-water current information has a variety of uses, in addition to the traditional PORTS® objectives of promoting navigation safety and increasing the efficiency of maritime commerce. Knowledge of the currents is helpful for search and rescue efforts, mitigation of hazardous material (HAZMAT) events, maritime accident investigation, planning and implementing dredging, conducting environmental impact studies, and engineering design work.

1.2 Acknowledgments

Thanking key people is traditionally reserved for the end of a document; however, in this project, external support was so crucial that it merits a more prominent position. This project would not have been possible without the flexibility and cooperation of the USCG Fifth District Aids-to-Navigation and Waterways Management Branch, particularly John Walters and Chief Warrant Officer (CWO) David Merrill, Commanding Officer of the buoy tender ***Frank Drew***. Ron George of the Oceanscience Group and Dr. Lee Gordon, formerly of Nortek USA, not only developed the system, but handled CO-OPS' changing requirements in the early phases of the project.

1.3 Purpose and Organization of This Report

This report satisfies the CO-OPS programmatic requirement for documentation of new measurement or data collection systems which have been put into operational use. The document first describes the basic features and capabilities of the ATON current profiler systems, including the measurement and communication technologies employed to meet the users' basic requirements, as well as the design considerations which ensure that the PORTS® payload does not interfere with the primary mission of the buoys (Section 2.0). A description of the evolution of the Ocean Systems Test and Evaluation Program (OSTEP) test plan for ATON acoustic Doppler current profilers (ADCPs) is provided, followed by a description of the results of a variety of tests (Section 3.0). The final five sections of this report document are:

- field procedures for installation, repair and maintenance of the system (Section 4.0);
- the data flow configuration (Section 5.0);
- data quality control procedures (Section 6.0);
- the products generated and disseminated to the public from these current measurement systems (Section 7.0);
- recommendations (Section 8.0).

2.0 DEVELOPMENT OF THE ATON CURRENT MEASUREMENT SYSTEM

CO-OPS used commercial off-the-shelf (COTS) hardware and commercial buoy-mounted meter expertise through contracts with the Oceanscience Group and Nortek to integrate this existing technology into a complete instrument package. The Oceanscience Group and Nortek were selected because of their success in California (*Sea Technology*, 2000). The Oceanscience Group produced a "clamparatus" to secure the sensor and electronics box to the navigation buoy. Nortek manufactured the current profiler and also interfaced the data stream to a spread spectrum radio.

2.1 The ATON Mount

Under a contract with CO-OPS, the Oceanscience Group designed and built the "clamparatus" mounting device, which provides for easy installation and maintenance, while not interfering with the ATON's primary mission of ensuring safe navigation (Figures 1 and 2).

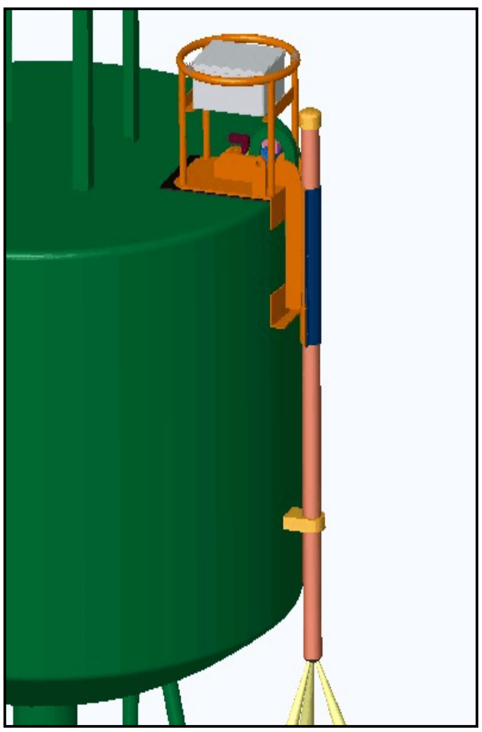

Figure 1. Design concept for the clamparatus— the mount to attach the current profiler system to an ATON

Figure 2. The prototype clamparatus deployed on Buoy 2C at the mouth of the Chesapeake Bay

Most of the clamparatus is aluminum, providing strength without excess weight. The tube, which holds the current profiler and protects the profiler's power/communications cable, is made of fiberglass reinforced with additional poured resin. The self-contained, watertight electronics box contains the radio modem, circuitry, and enough batteries to allow for six- to eight-month service intervals (Figures 3 and 4). Nortek, manufacturer of the current profiler, also designed and built the circuit board.

Figure 3. The ATON topside electronics box

Figure 4. Close-up of the circuit board in the electronics box

The radio is a MaxStream X-stream PGK 900 MHz spread spectrum transceiver, which was also chosen for power considerations. The sensor and communications are completely powered by two 12-volt (V) D-cell battery packs placed in parallel. At present power consumption rates, CO-OPS estimates that more than six months of six-minute current profile sampling and data transmission are possible before battery replacement is necessary.

2.2 The Nortek Acoustic Doppler Profiler

The current meter is a Nortek Aquadopp profiler (current profiler), selected for compact size and low power consumption (Figure 5). The Aquadopp profiler measures the current profile in water using acoustic Doppler technology. The current profiler uses three acoustic beams slanted at 25° to measure the current profile in a user-selectable number of cells. Generally, CO-OPS uses one-meter bins and collects as many bins as a station's water depth allows. The current profiler has internal tilt and compass sensors and a high-resolution pressure sensor (See Appendix A - Aquadopp Specifications).

Figure 5. The Nortek Aquadopp

2.3 On-Buoy Power Budget

PROFILER. The current buoy systems are deployed for a period of six months with a profiler interval of six minutes and an averaging interval of five minutes. The profiler will take 43,200 measurements, and each profile will consist of 149 bytes. The estimated energy used by the profiler for this duration is 369.9 watt-hours (WH).

MODEM. The 9XStream modem on the buoy is set with a baud rate of 2400 bits per second (bps) and has an average transmit time of 0.66 second for a profile consisting of 149 bytes. During a transmission the modem draws a current of 150 milliamps (mA). The modem will be in sleep mode for an estimated 336.8 seconds per six-minute profiler interval and will draw a current of one mA while in this mode. The estimated energy used by the modem for these profiler settings is 303.9 WH. The total energy used by the buoy system for a six-month time period with the settings outlined above will be 673.8 WH.

2.4 The Shoreside Station

2.4.1 Data Collection Platform (DCP)

The data collection platform (DCP) used with the ATON ADCP is manufactured by Sutron Corporation and is part of the Xpert family of DCPs. The model 9210 is based on the Intel 486 microprocessor using the Microsoft Windows CE operating system. The unit has integrated analog and digital input-output (I/O) modules, three RS-232 serial ports, an SDI-12 port and an I2C port for additional I/O modules. The unit is packaged in a small aluminum case 11" by 6" by 3".

The DCP performs a number of self-tests on its internal systems while powering up; any errors are displayed on the front panel Liquid Crystal Display (LCD) and recorded in the system logs. After the self-tests, the system reads the setup file implementing the AquaPro.sll (Sutron Dynamic Linked Library), the software which performs the following:

- Sets the recording options, (daily, weekly recent, and/or time sync)
- Sets COM ports and baud rates
- Wakes up the MaxStream radio on the buoy
- Establishes communications with the profiler
- Sets the profiler time and date
- Sets the profiler parameters (these settings are taken from the buoy.cfg file on the DCP)
- Starts the profiler
- Establishes the following files on the DCP storage card:
  - MMDDYYYYHHMMSS.hdr - American Standard Code for Information Interchange (ASCII) text file based on the Buoy.cfg file that lists the profiler’s parameters
  - MMDDYYYYHHMMSS.cfg - a copy of the Buoy.cfg file
  - MMDDYYYYHHMMSS.prf - raw profiler data
- Starts polling the radio serial port every three seconds. Every six minutes the profiler sends the raw data to the DCP. When the DCP receives the data the following actions are taken:

Received message length is compared to the expected message length.

If the message is complete:

- The raw message is copied to the MMDDYYYYHHMMSS.prf file.
- The raw message is converted to ASCII.
- A copy of the raw ASCII data is placed in the Recent.dat file.
- The raw ASCII data are appended to the MMDDYYYY.dat file.

If the message length is not complete:

- The raw message is appended to the BadData.dat file.
- The time the data were received, the message length, and an error flag are written to the BadTime.dat file.

If a message is not received within a given time frame:

- The time and date are taken from the DCP, and an ASCII file is written with that time and date and copied to the Recent.dat file.
- All data fields in the file are set to zero.
- The file is also to the appended to the MMDDYYYY.dat file.

2.4.2 Communications

Shore Station to Buoy. The shore stations use 9XStream, 24XStream, or the X-Tend radio modems from MaxStream to communicate with the buoy-mount systems. The 9XStream radio modems operate between 902 and 928 MHz, implementing a frequency-hopping spread spectrum modulation technique with a maximum transmit power of 140 milliwatts (mW). The 24XStream radio modems operate between 2.4 and 2.4835 gigahertz (GHz), also implementing a frequency-hopping spread spectrum modulation technique with a maximum transmit power of 50 mW. The 9XStream and 24XStream modems operate at a baud rate of 2400 bps, with four retries to provide reliable communication over the distance required. The X-Tend radio modems operate between 902 and 928 MHz implementing a frequency-hopping spread spectrum modulation technique and have a maximum transmit power of 1W.

Data Collection. Every six minutes the DCP at the shore station is polled for a copy of the Recent.dat file through either a Raven Code Division Multiple Access (CDMA) Internet Protocol (IP) modem from AirLink Communications or an Xpert voice modem from Sutron. In the future, if a phone connection is unavailable, Geostationary Operational Environmental Satellite (GOES) communications will be used as the primary pathway for data collection with the IP modem as a backup. The Raven CDMA modems have an assigned static IP address, which can be polled through the public CDMA/1XRTT (radio transmission technology) network. They support dual band operation for both 800 MHz cellular and 1.9 GHz PCS (personal communication system) bands. The CDMA modems are connected to the 9210s through an RS232 DB-9F interface and operate at a baud rate of 115200 bps.

2.4.3 Power

The 9210 and the radio frequency (RF) radio run off a 12V 38 ampere-hours (ah) battery, which is charged by a 30W solar panel through a 12V, eight ah solid state photovoltaic (PV) charge controller. The Raven CDMA runs off of a 12V 38ah battery, which is charged by a 30W solar panel through a 12V, eight ah solid state PV charge controller.

2.5 US Coast Guard Approval

CO-OPS is committed to ensuring that the primary mission of the USCG buoys is not impeded in any way by ATON utility and/or maintenance. The importance of this cannot be overstated. To that end, many steps were taken, including:

- building a package that could be deployed and recovered while the buoy is on station so that the entire package can (and will) be removed prior to servicing the buoy;
- isolating dissimilar metals and matching coloration; and
- designing for minimal alteration of the buoy profile and characteristics.

The total package weighs approximately 200 pounds, therefore it should have negligible effect when deployed on a 12,000 -plus pound, 8' by 26' navigation buoy. Other precautions include: 1) the buoy optics are lowered by only 0.1 inch, and 2) the buoy tilt is increased by only one-half degree.

Figure 6. Chief Warrant Officer David Merrill of the buoy tender *Frank Drew* gives approval to the clamparatus

CO-OPS met with the USCG Fifth District Aids-to-Navigation and Waterways Management Branch several times during this project. Initial meetings were briefings in order to obtain USCG approval to proceed. After the prototype system was built, CO-OPS installed it on an 8' x 26' ATON at the Portsmouth, Virginia USCG buoy yard, giving all USCG ATON Branch personnel an opportunity to inspect and comment on the system (Figure 6).

2.6 The Prototype Installation

The requirement for easy deployment/recovery resulted in the decision to assemble all pieces of the system shoreside to eliminate the possibility of water damage caused by opening the electronics box while on the buoy. The maiden deployment of the entire package took five people one hour on a rather windy day in December 2002 (Figure 7). Chesapeake Channel Lighted Bell Buoy 2C (LBB 2C) at the mouth of the Bay was chosen for the prototype installation due to its proximity to the CO-OPS Facility in Chesapeake, Virginia and availability of shore communications. Additionally, since this is the most open water of all the Chesapeake Bay sites, the prototype will likely face a full range of deployment challenges at this location.

Figure 7. 17 December 2002 deployment of the prototype clamparatus and profile on buoy 2C

2.7 Compass Performance

In order to assess the system's performance, one-month of current data (17 October – 21 November 2003) was compared to NOS harmonic tidal current predictions from a station 0.75 mile away. A calibration accuracy issue with the compass became obvious immediately because, at any given time, the current direction from predictions and that observed by the ATON system could be ±180° different (Figure 8). Even considering the natural differences between predictions and observations, which include the effect of wind and runoff, the strong (non-linear) magnetic effect of the buoy's steel hull was clear.

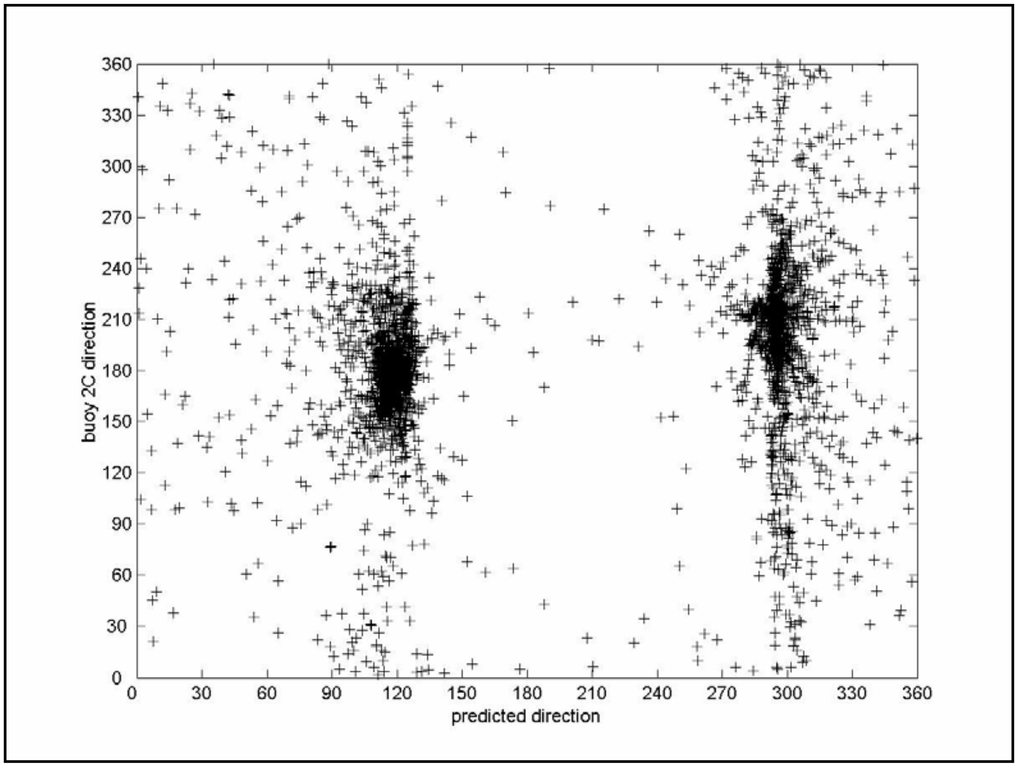

Figure 8. Comparison of current directions from the ATON profiler and predictions based on NOS-accepted harmonic constituents

In response to CO-OPS' concerns, Nortek designed and installed a current profiler firmware enhancement, which enabled CO-OPS to perform compass calibrations. CO-OPS began assessing the capability of this calibration by studying the effect of a large steel pipe placed in the field of the Nortek current profiler (Figure 9). Preliminary in-lab experiments were very promising (Figure 10), since much of the magnetic deviation was removed by running the calibration procedure.

Figure 9. Calibration table with current profiler and steel pipe used to simulate the ATON's magnetic effect

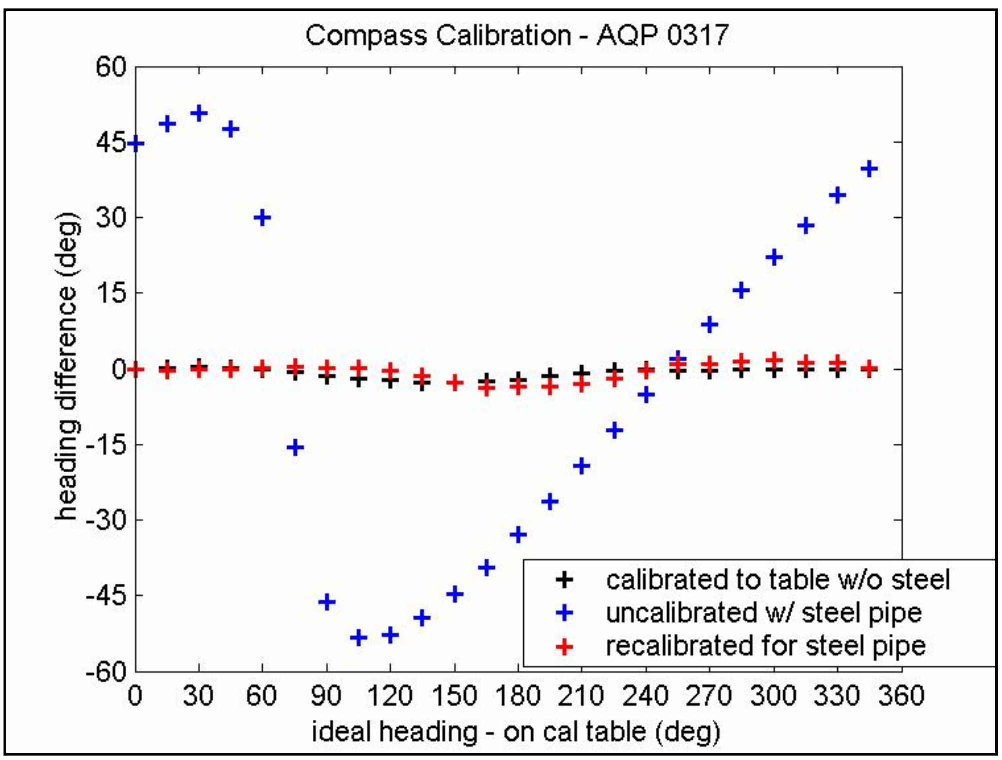

Figure 10. Results of running compass calibration software

Nortek Compass Calibration Firmware. Originally there was no way to calibrate the Aquadopp's compass in order to remove the effect of nearby magnetic objects. In response to CO-OPS' findings, Nortek provided revised firmware. The "compass" in the Nortek Aquadopp is actually a three-dimensional (3D) magnetometer plus a tilt sensor. Thus, there are two transformations performed. The first is a one-time magnetometer correction. The routine performed by the magnetometer correction firmware can be expressed as:

$$[M_x', M_y', M_z'] = [M_{xo}, M_{yo}, M_{zo}] + T \times [M_x, M_y, M_z]$$

where the $[M_x, M_y, M_z]$ is the internal 3D magnetometer reading at any given point and $[M_x',M_y',M_z']$ are the readings after correction. The matrix T is determined at the Nortek factory during a routine magnetometer calibration, which is designed to ensure that all components are properly scaled and cross-coupling between the components is removed. The offsets $[M_{xo}, M_{yo}, M_{zo}]$ are determined during the in-situ compass calibration, in which the entire ATON with the current profiler attached is rotated through 360° several times (Figure 11). The purpose is to remove the effect of "hard iron" (i.e. magnetic fields) in the mounting structure.

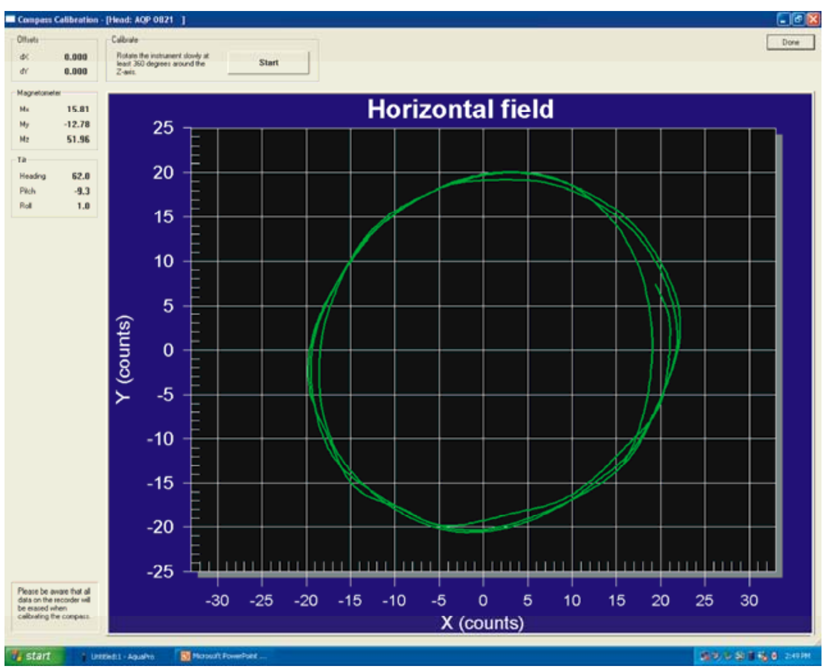

Figure 11. Compass calibration software

The second transformation occurs on a sample-by-sample basis. To calculate the compass direction from the magnetometer and tilt sensor readings, the following relationship is used:

$$[M_{hx}, M_{hy}, M_x] = G\ (\text{pitch, roll}) \times [M_x', M_y', M_z'] \ \Rightarrow\ H = \text{atan}\ (M_{hy}, M_{hx})$$

The magnetometer readings are first transformed into an earth-referenced system using the pitch and roll sensor. Then the heading is calculated from M_{hx} and M_{hy}, which are magnetometer components perpendicular to the gravity vector. This calculation assumes that the ATON was perfectly "flat" (zero pitch and roll) during the compass calibration spin, which may be the source of some residual error. CO-OPS continues to work with Nortek to determine the magnitude of this compass calibration error.

CO-OPS and Nortek also continue to explore the collection of a GPS compass reading during the calibration spin to build a correction table, since a GPS compass does not use the relationship to the Earth's magnetic field. Work must be done to transform such an externally-generated correction table into the correction terms used when measuring the current profile.

2.8 Version 2 Clamparatus and Nortek Firmware

CO-OPS began working with Oceanscience Group to improve the prototype clamparatus when the current direction accuracy became suspect, and in response to the "ease of deployment" issues of the prototype. First, the fiberglass tube that holds the Nortek current profiler was extended by two feet in order to move the sensor's compass farther away from the ATON's steel hull. The method of attaching the tube was changed dramatically. Initially the tube was secured with 12 bolts holding a curved plate over the tube at the approximate water line (Figure 12).

Figure 12. Prototype tube attachment mechanism

The new clamparatus uses three large U-bolts isolated in rubber bushings (Figure 13). The additional length makes deployment and recovery slightly more cumbersome, but does not change the package's weight significantly, partially because of the removal of the heavy tube clamping mechanism.

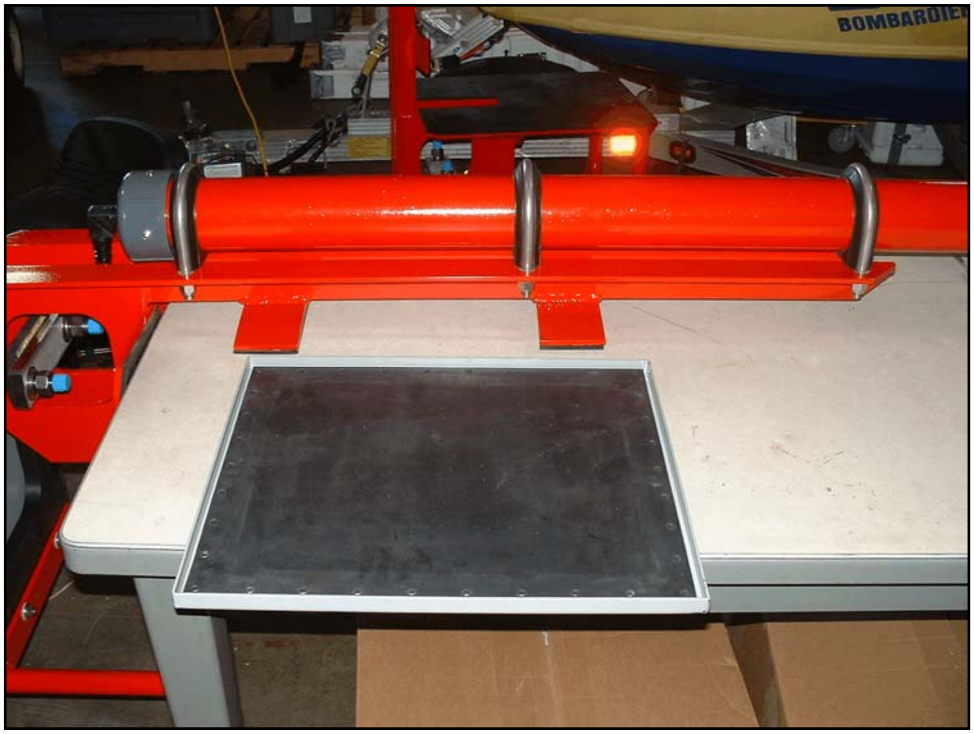

Figure 13. Mark II tube attachment (the electronics box lid is in the foreground)

The use of a simpler and more watertight electronics box and the increase in battery capacity that the new box allowed resulted in a significant increase in weight (150 pounds [lbs] to 200 lbs).

Another improvement between the prototype and the production clamparatus is the use of a simpler clamping mechanism. The prototype clamp block had several moving parts which could be easily dropped in the water. Additionally, the original clamp block required the use of shims to fill the variable space inside an ATON lifting eye, which was inconvenient and time-consuming (Figure 14). The new mechanism is adjusted by tightening three stainless steel bolts (Figure 15).

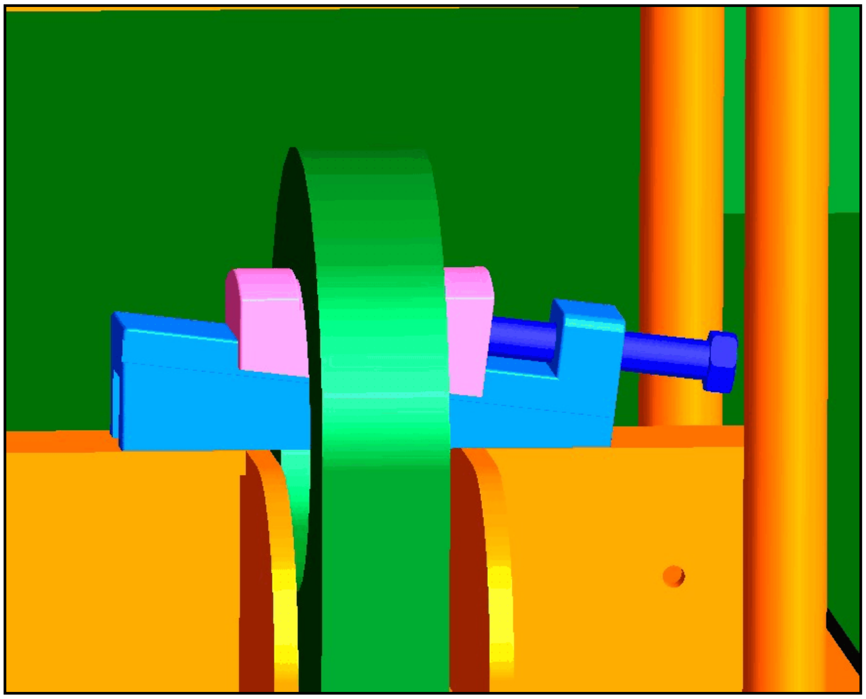

Figure 14. Prototype clamp block

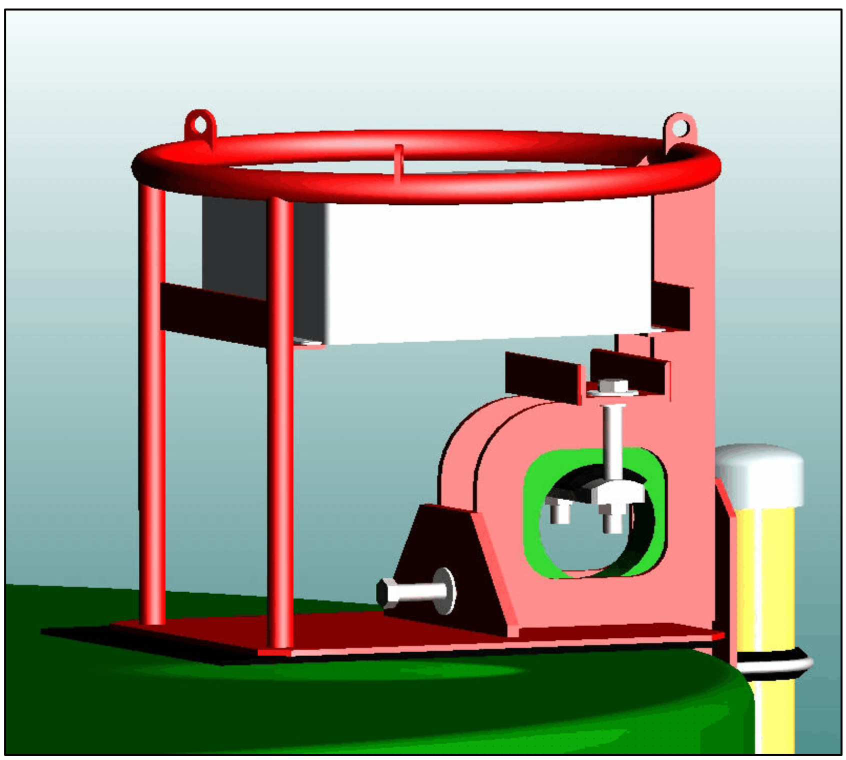

Figure 15. Mark II (simplified) clamp block

3.0 TEST AND EVALUATION

3.1 Test & Evaluation Plan Evolution

Initially, the development of the ATON ADCP was neither a directed CO-OPS effort nor a PORTS® partner-requested capability. Rather, OSTEP identified it as a potentially rewarding technology, first described by Nortek and Oceanscience Group in the October 2001 issue of the journal *Sea Technology*. The Maryland Port Authority (MPA) accepted the developmental cost and the associated risk, without the requirement of a fully-developed test plan. Additionally, the USCG had the option of declining support if the ATON ADCP was found to hinder the primary ATON purpose of safe navigation. CO-OPS is grateful to the MPA for such earnest interest and for assuming this risk.

Acceptance of a sensor for OSTEP testing requires that three fundamental conditions are met:

- **Need**. There must be a requirement within CO-OPS for the sensor/system.
- **Funding**. Funds supporting the project must be in place.
- **Sufficient human resources**. CO-OPS staff must have adequate time to conduct test and evaluation.

These conditions were satisfied for the test and evaluation of the ATON ADCP.

Within OSTEP, certain testing precepts have been established:

- Testing by external partners with OSTEP guidance and input is highly desirable. Many institutions have expertise and similar interests in sensor/system evaluation. It is cost effective and strengthens the overall findings when partnership synergies are exploited.
- Review of OSTEP test plans and results by external partners is also highly desirable, for the same reasons.
- Tests results provided to OSTEP by the manufacturer of the sensor/system being tested are desired, but they are not sufficient to justify acceptance for operational purposes.

After receiving MPA support for the ATON ADCP concept, CO-OPS planned the testing to ensure that the following requirements were met:

- Field references comprised of existing operational current measurement technologies must be established at a variety of locations.
- Reported current velocities must be sufficient to meet navigational requirements. Accuracies must be similar to bottom-mounted ADCP accuracies, with an understanding that they would likely be less accurate.
- Maintenance cycles must be required at six-month intervals or greater.
- Hardware installation must be a safe and simple, small boat, fair weather operation.

- Installation and maintenance costs must be acceptable to CO-OPS and PORTS® partners.
- Overall data distribution reliability must be as good or better than cabled deployments (in the long term). Valued data at locations beyond cabled ranges must have a favorable cost/benefit ratio.
- Hardware life expectancies in the harsh marine environment must meet operational requirements and must survive most episodes of corrosion, storms, vandalism, etc.
- The vendors must be reliable to the extent that anticipated product delivery is a probable outcome. There is no joy in unsupported hardware.

Planned testing followed decades of acceptance testing for a variety of ADCPs from several manufacturers. Well-defined acceptance tests were conducted at the Naval Surface Warfare Command (NSWC), Carderock Division (David Taylor) and in the field. Standardized quality control/quality assurance (QA/QC) evaluation by the NOS/CO-OPS National Current Observation Program (NCOP) was planned and executed. Operational QA/QC criteria and procedures for the Continuous Operational Real-time Monitoring System (CORMS) were developed using the standards set for existing PORTS® current observation stations. In summary, CO-OPS has evaluated this current measurement technology as rigorously as it has all previous NCOP current observation technologies.

Test plans were intentionally flexible, given the unique deployment of COTS sensors. As with many OSTEP projects, reactive testing based upon previous results was envisioned in order to maximize strained resources.

3.2 Nortek ADP Tests at David Taylor Tow Tank

The David Taylor Model Basin consists of several hydraulic facilities, including two towing basins and a circulating water channel. NOS uses the towing basins to test its current profilers. The current meters are mounted to a carriage that travels the tank at a precise speed—the current speed is then compared to the carriage speed.

CO-OPS policy dictates that all current profilers must be towed at David Taylor before operational use; therefore all Nortek Aquadopps are tow tested at David Taylor. The following results are from two AQP (S/N 1084 and 1093) that were towed on 10 July 2003. They are indicative of the results from all the other AQP tows.

The carriage and Aquadopp speed measurements were compared using Aquadopp bins one through four. For S/N 1084 the mean speed difference of bin two was -0.17 cm/s at a nominal carriage speed of 40 cm/s and 1.45 cm/s when the carriage was traveling 80 cm/s (Figure 16). For S/N 1092 the mean speed difference of bin four was -1.23 cm/s at a nominal carriage speed of 40 cm/s and -2.28 cm/s when the carriage was traveling 80 cm/s (Figure 17). These differences are completely in line with differences observed during David Taylor tow tests of both RDI and SonTek current profilers (Dr. Eddie Shih, personal communication).

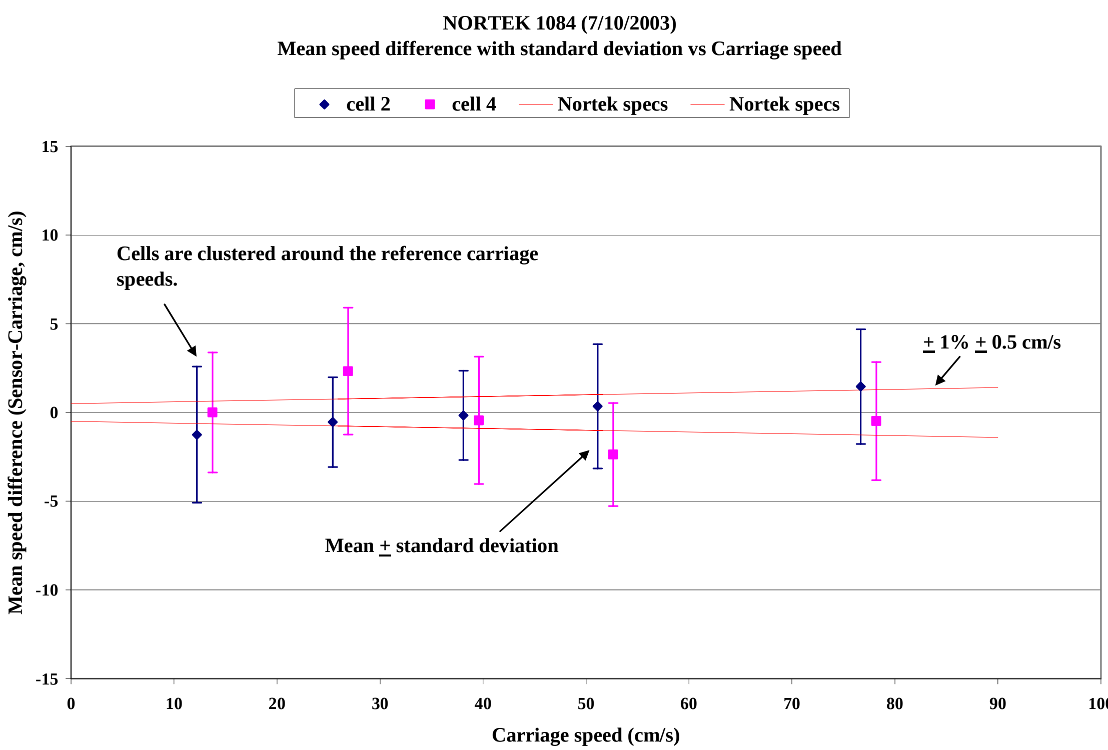

Figure 16. Carriage speed transitions help to identify a timing difference between the current profiler and the carriage

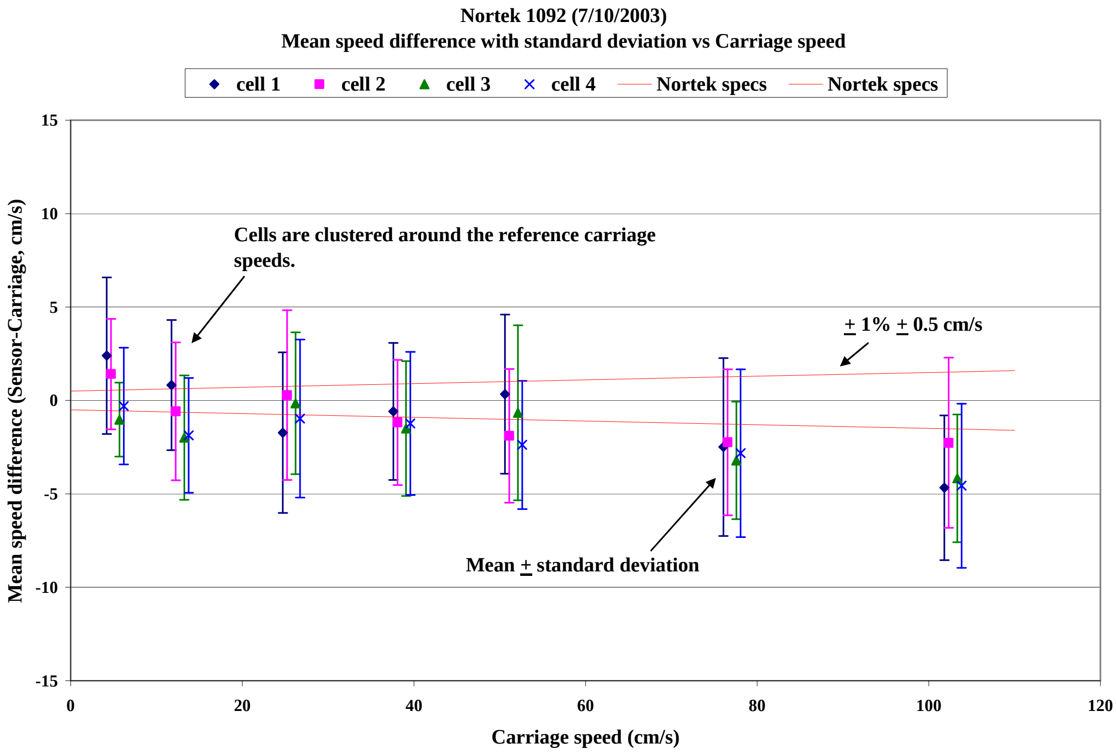

Figure 17. Difference between the reference carriage speed and the speed recorded in bins two and four of the current profiler

It should be noted that large difference spikes during carriage reversal occurred in some of the early tows. These data points were removed before calculating the mean differences shown in Figure 17. The spikes can be explained by the fact that the carriage is on a track above the water and the current profiler is submerged in the tow tank. This characteristic is seen with all current profilers tested at this facility. The carriage can stop and have a speed of exactly 0 m/s whereas the water will always be moving, even when the carriage has stopped. This results in a carriage speed of exactly 0 m/s at times, while the Nortek speed does not go to 0 m/s.

Analysis of the current profiler data using Nortek's display software reveals a need for refinement of the Aquadopp mounting system. The current profiler must not have been totally secure during the early test, since heading, pitch, and roll all vary during the tow test (Figure 18).

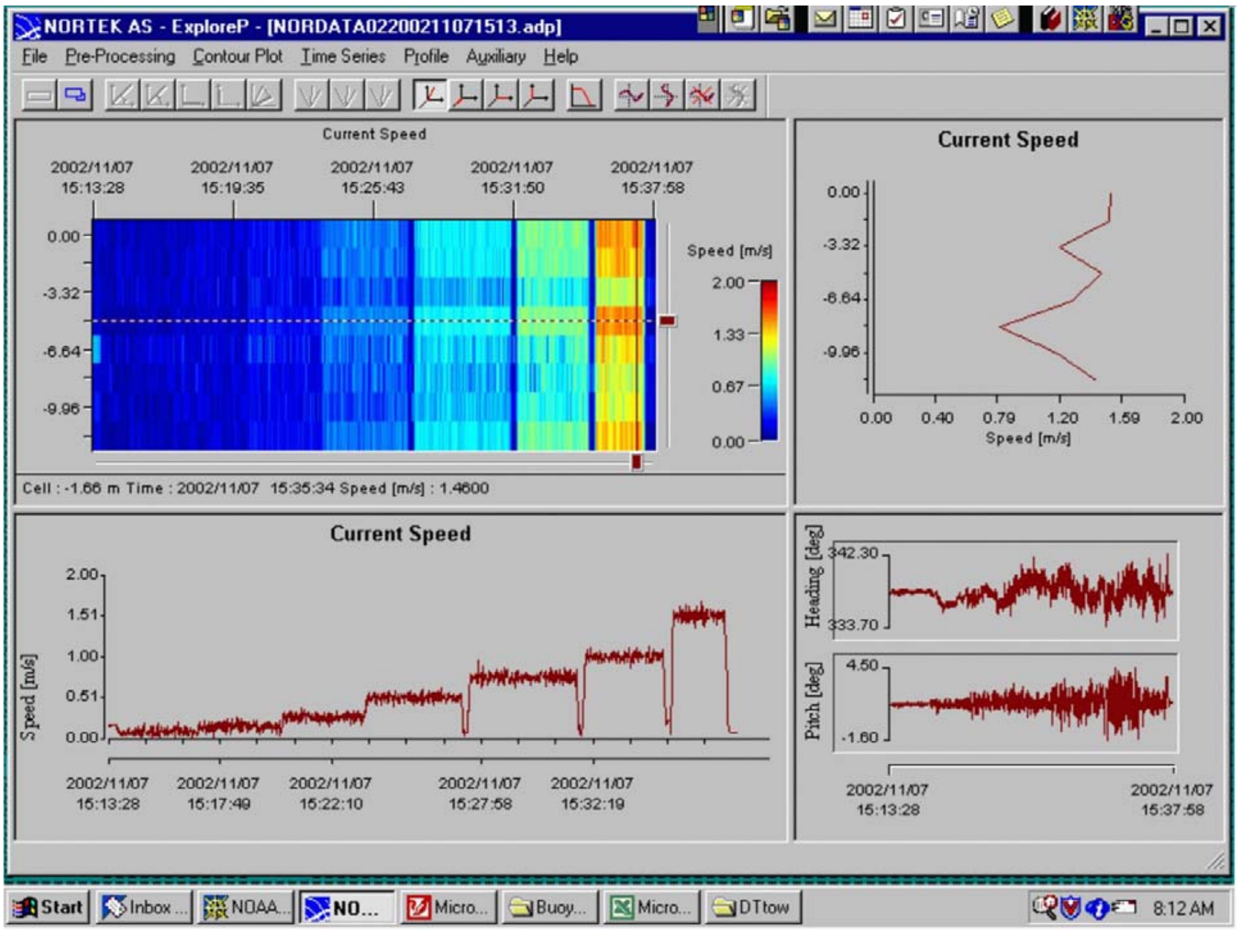

Figure 18. Tow test data from the current profiler visualized using the Nortek display software. Note the variation of heading and pitch, indicating that the current profiler was not stiffly affixed to the carriage.

3.3 A 31-Day Comparison of Buoy "2C" Currents with NOS

The NOS Predictions. In 1999 CO-OPS performed a current survey in the Lower Chesapeake Bay. The harmonic predictions used for this comparison are from a station located 0.76 nautical mile (nm) from Buoy "2C" (Figure 19). The 1999 station was a bottom-mounted RDI Workhorse. It is important to notice that, although the stations are relatively close, the 1999 station is closer to the dredged channel, which likely restricts the flow on ebb.

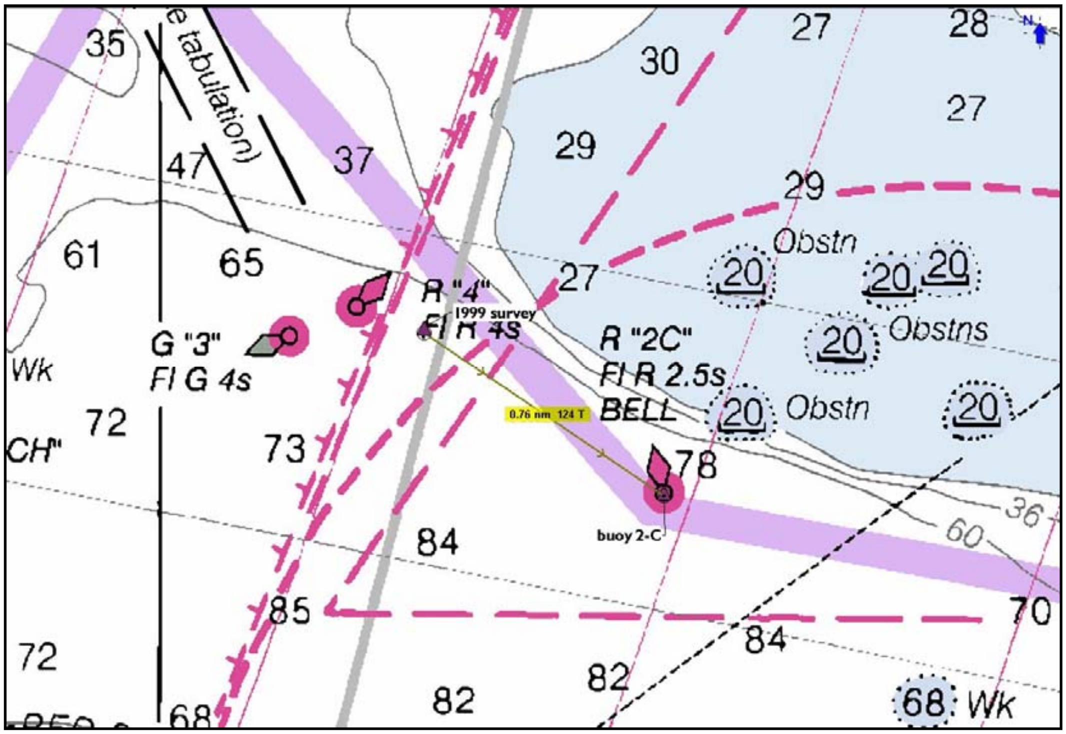

Figure 19. Location of ATON 2C and the 1999 NOS current survey station used to make comparison predictions

The Nortek Data. On 16 October 2003, with Brad Wynn at the helm of the NOAA *Bay Tide*, a crew consisting of John Abbitt, Kate Bosley, Steve O'Malley, and John Stepnowski installed the latest version of Oceanscience Group's clamparatus on Buoy "2C" (Figure 20). On 21 November Kate Bosley, Dave Hatcher, and Brad Wynn returned to the buoy to retrieve data stored in the current profiler. This step was necessary because shoreside problems had produced data gaps, and because the radios did not have enough bandwidth to transfer large data files. Three data files were linked together to produce a 31-day time series of current profiles. Midway in the deployment the clock was reset to Greenwich Mean Time (GMT).

Figure 20. Deployment of clamparatus on 2C

Results. The five-day period shown in Figures 21-23 was chosen as a representative comparison of the month-long series at 2C. There are clear times of tidally dominated flow (e.g. day 308) and other times when wind-driven events dominate (e.g. day 309.5). The largest directional differences occur at slack tide, which is to be expected since the flow is weak and variable. The directional differences during peak flood and ebb warrant further investigation.

The mean of the absolute value of the difference between the predicted direction and the Nortek-observed direction is 50.2° for the 31-day deployment (Figure 23). Although the differences do cluster around ± 30°, there is considerable scatter in the differences (standard deviation [s.d.] is 66.1°) (Figures 24 and 25).

Again it is important to note that these comparisons use astronomical predictions as the standard of comparison. Concurrent observations from two different current measurement systems are needed to fully investigate the ATON system.

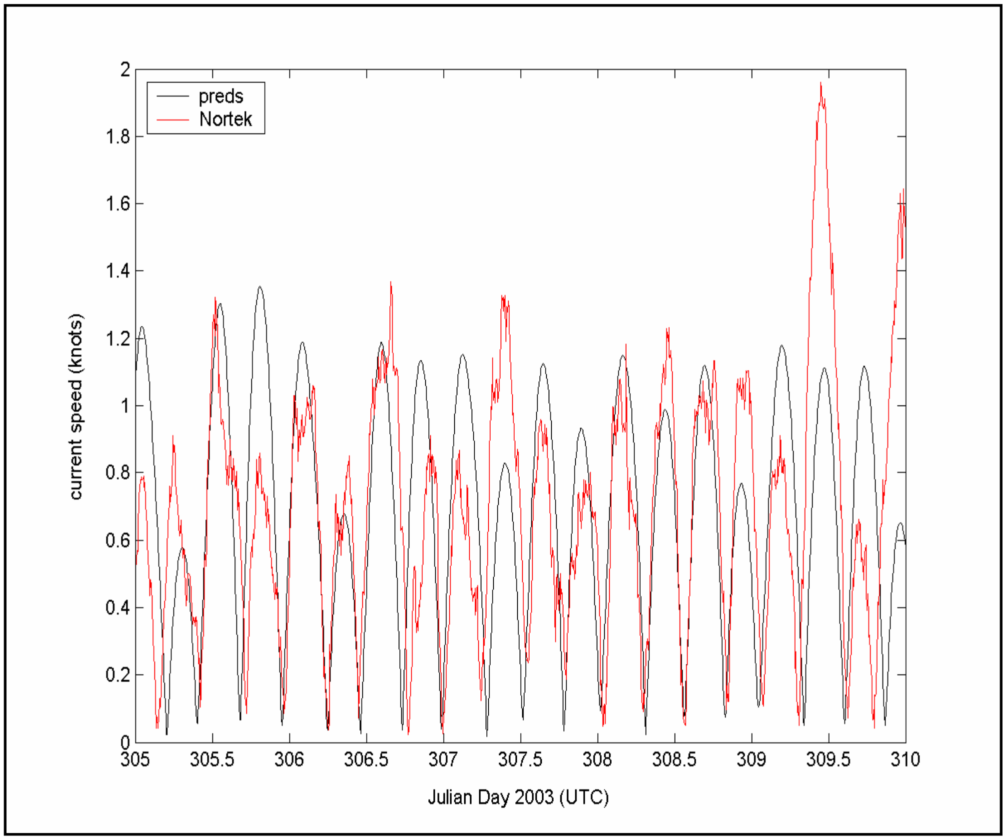

Figure 21. Time-series of Aquadopp-measured current speed and predicted current speed

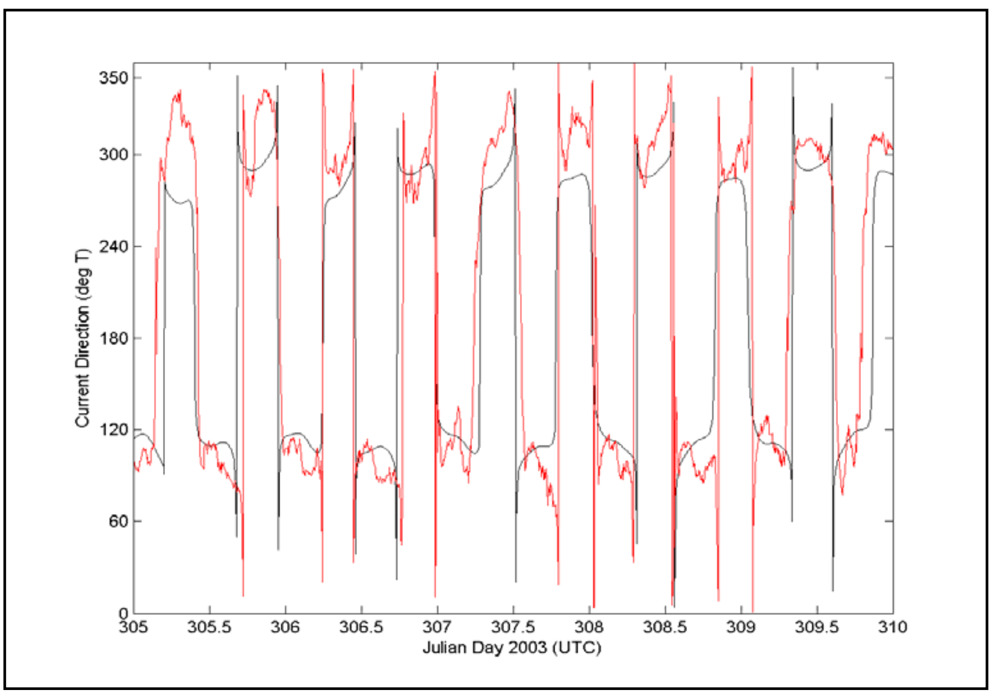

Figure 22. Time-series of Aquadopp-measured current direction and predicted current direction

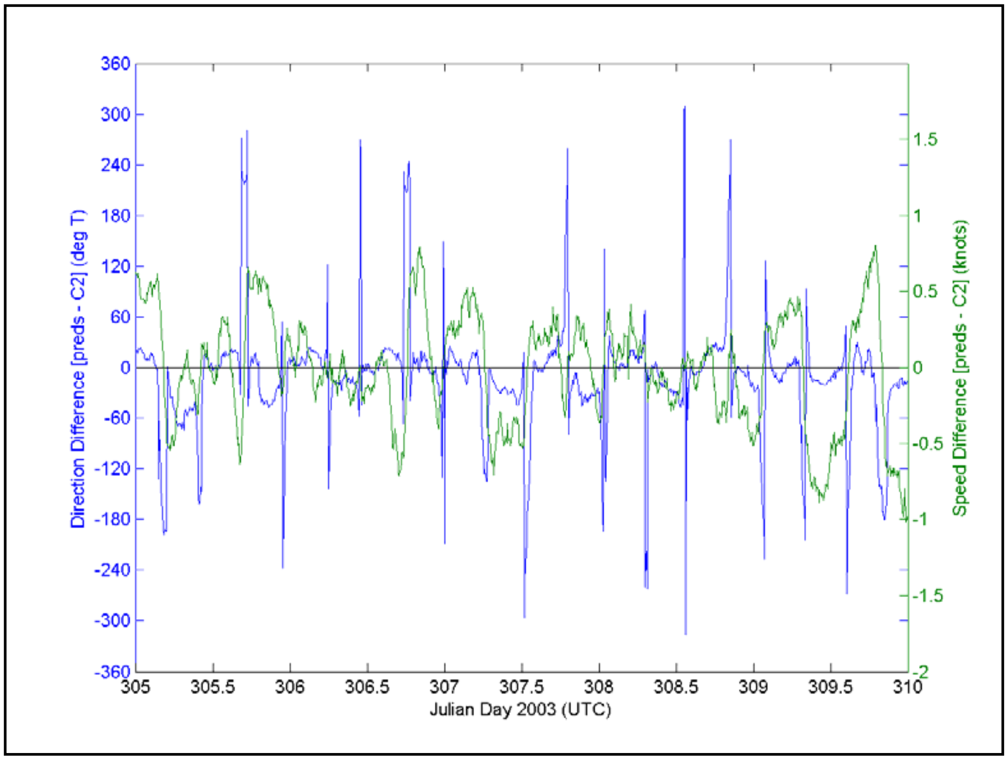

Figure 23. Predictions – ATON direction and speed differences

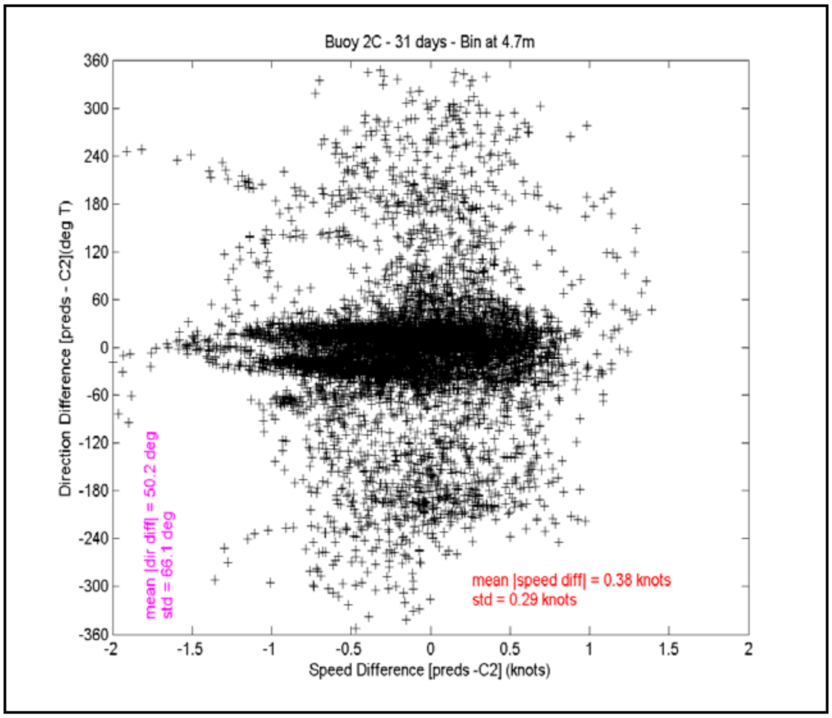

Figure 24. Scatter plot of speed and direction differences between the ATON-mounted observations and astronomical predictions derived from a nearby station

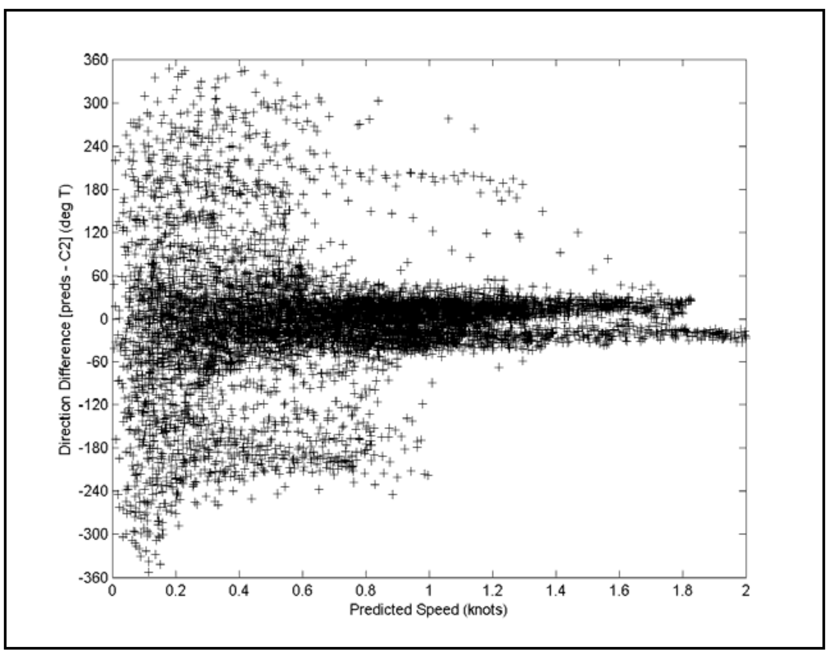

Figure 25. Relationship between the predicted speed and the difference in direction. Notice that the direction becomes more accurate as the speed increases.

3.4 Piney Point – A 19-Day Comparison of Currents from ATON "B" and a Bottom Mount

CO-OPS performed an intercomparison of ATON- and bottom-mounted current profilers in the first quarter of 2004, because concurrent observations from two different measurement systems are needed to fully evaluate the ATON system. The Chesapeake Bay test site selected was ATON B in the Potomac River. The station was selected because it is a reasonable depth for a bottom mount, the flow is assumed to be nearly rectilinear, and the ATON is less than a mile from the shore station, potentially providing a good radio link.

The Bottom-Mounted Current Profiler. CO-OPS' Coastal and Estuarine Current Analysis Team (CECAT) deployed a 600- KHz RDI Workhorse in a trawl-resistant platform. The current profiler was placed ~ 250 yards to the north and outside the watch circle of the ATON (Figure 26 and 27). The Workhorse was set to report a value every six minutes in one-meter bins throughout the water column.

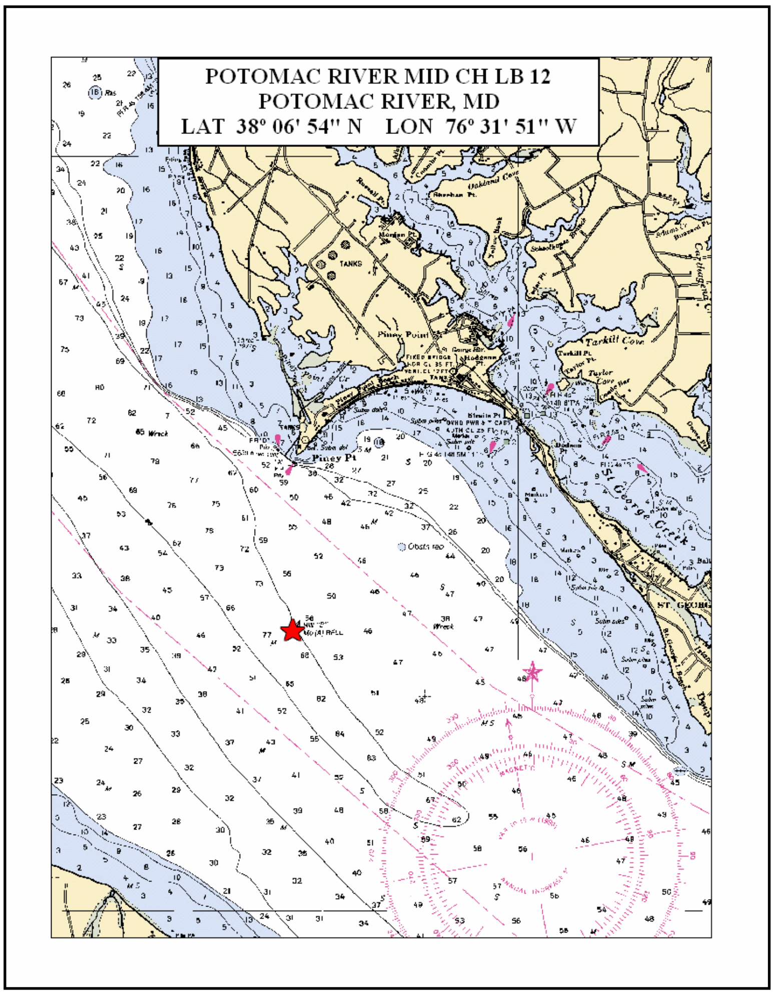

Figure 26. The Potomac River location of the subject intercomparison

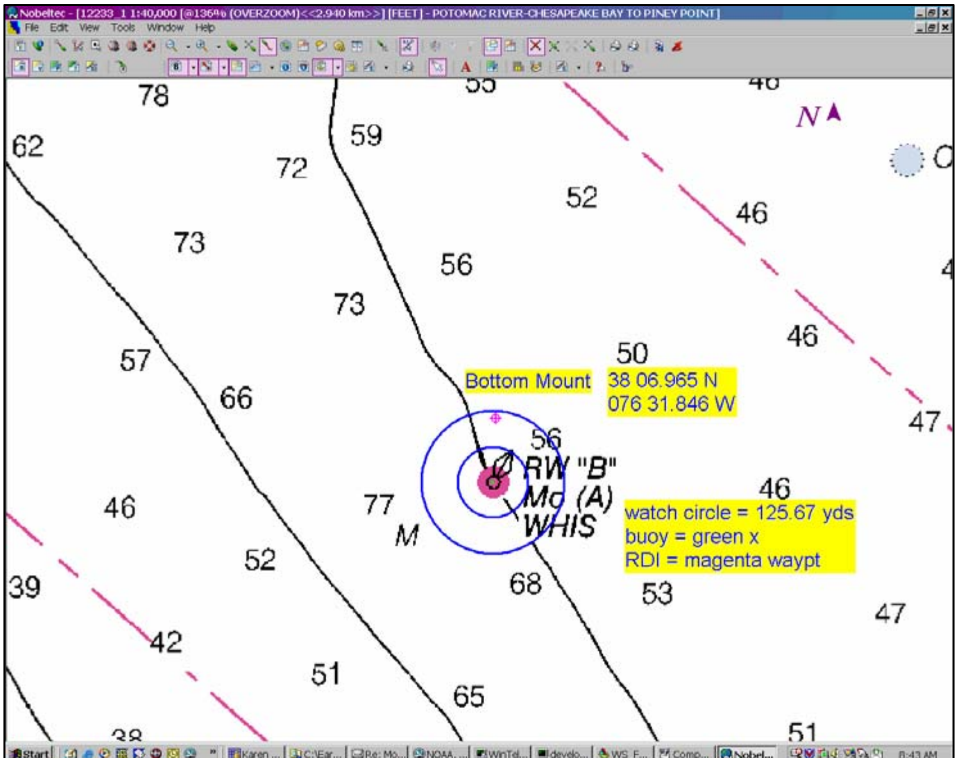

Figure 27. The bottom-mounted current profiler platform was placed to the north of the ATON's watch circle in approximately the same depth of water

Figure 28. Bottom-mount for ADCP with pop-up buoy for recovery

The ATON Current Profiler. On 17 March 2004 a clamparatus and Nortek current profiler were installed on ATON B just off Piney Point in the Potomac River (Figure 29). The one-MHz profiler was set to average 180 seconds out of the 360-second sampling interval. For consistency with the bottom mount, the bin length was set at one meter. Approximately 20 days later, data were downloaded directly from the current profiler, which was sitting on the ATON. This step was necessary because shoreside problems had produced data gaps, and because the radios had insufficient bandwidth to transfer large data files.

Figure 29. ATON LWB B in the Potomac River

Results. CO-OPS began with a comparison of three bins: the shallowest Nortek (3.5 m [11.5']), mid-depth (9.5 m [31.2']), and the deepest RDI (15.5 m [44.3']). At these three depths the speeds compare very well, within anticipated error of individual instruments (Figure 30). There was no obvious bias in ATON current speeds. The mean of the absolute value of the speed differences were all ~ 3 cm/s = 0.06 knot.

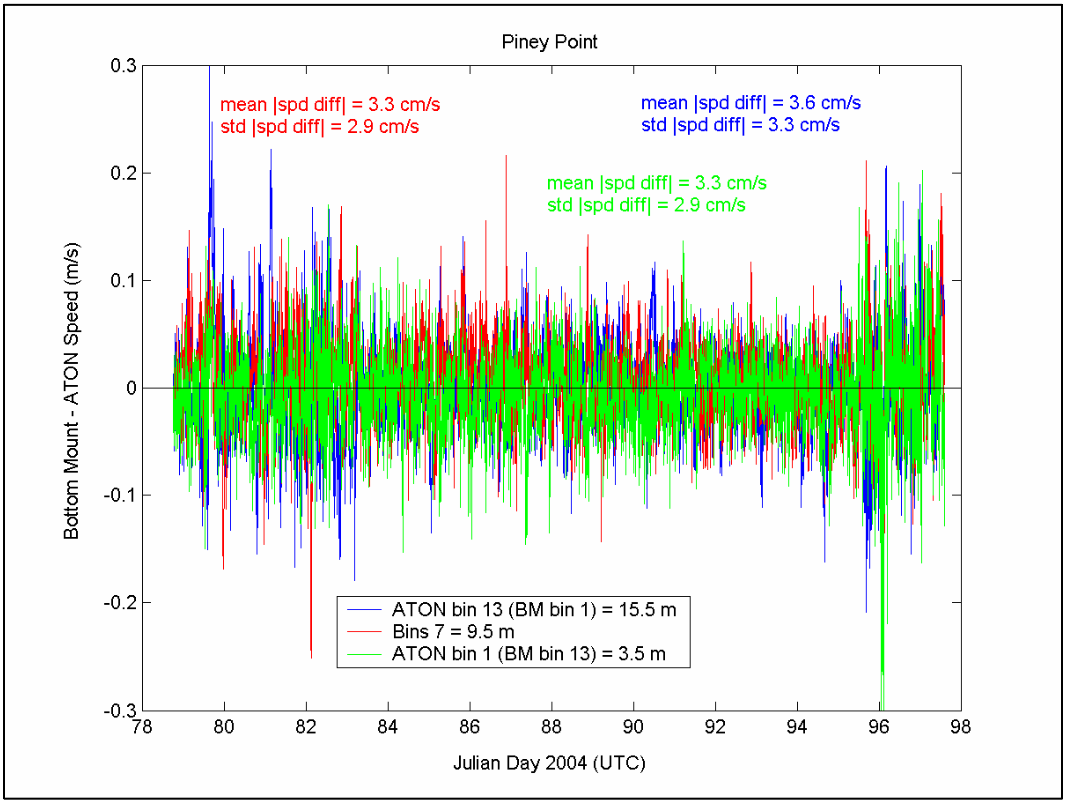

Figure 30. Time-series of the difference between the speeds recorded by the bottom-mounted current profiler and the ATON current profiler at three depths

As expected, the ATON current measurements were noisier at all levels because of ATON motion. Also, the ATON currents exhibited vertical velocities approximately ten times greater than those of the bottom mount (Figure 31).

The current direction measurements from the ATON-mounted system are the focus of this comparison. CO-OPS must determine whether the ATON system can provide current measurements that meet the requirements of the navigation community. The current directions from both the bottom- and ATON-mounted measurements were corrected for local variation to degrees true north by subtracting 10.92 from the instruments readings. These two five-day segments are representative of the maximum differences observed during the time-series (Figures 32 and 33).

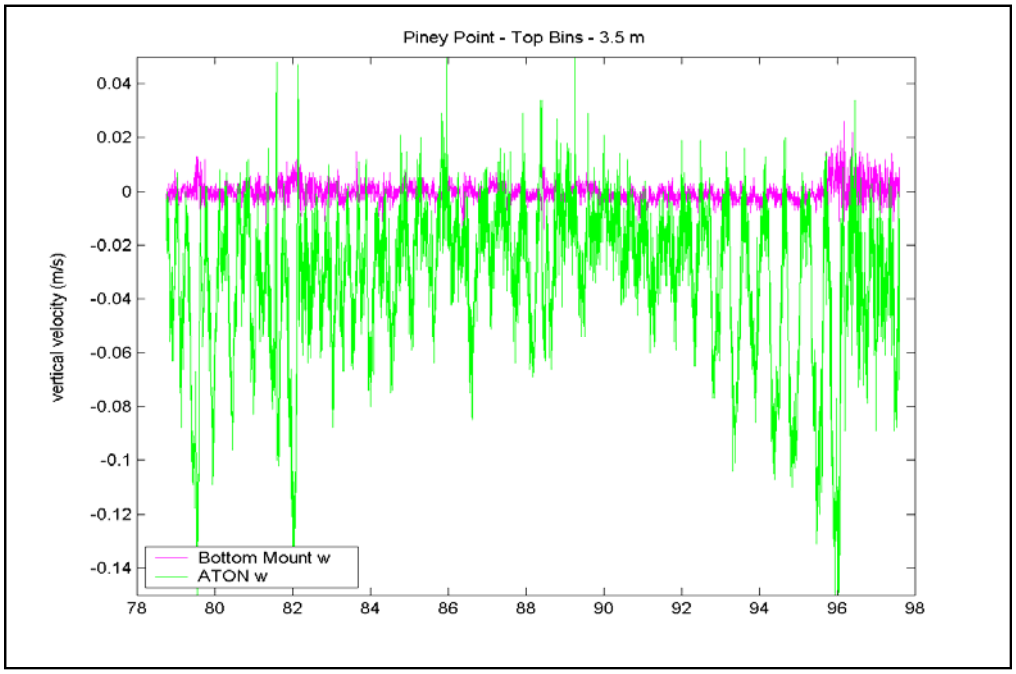

Figure 31. Vertical velocity measured by the ATON- and bottom-mounted current profilers

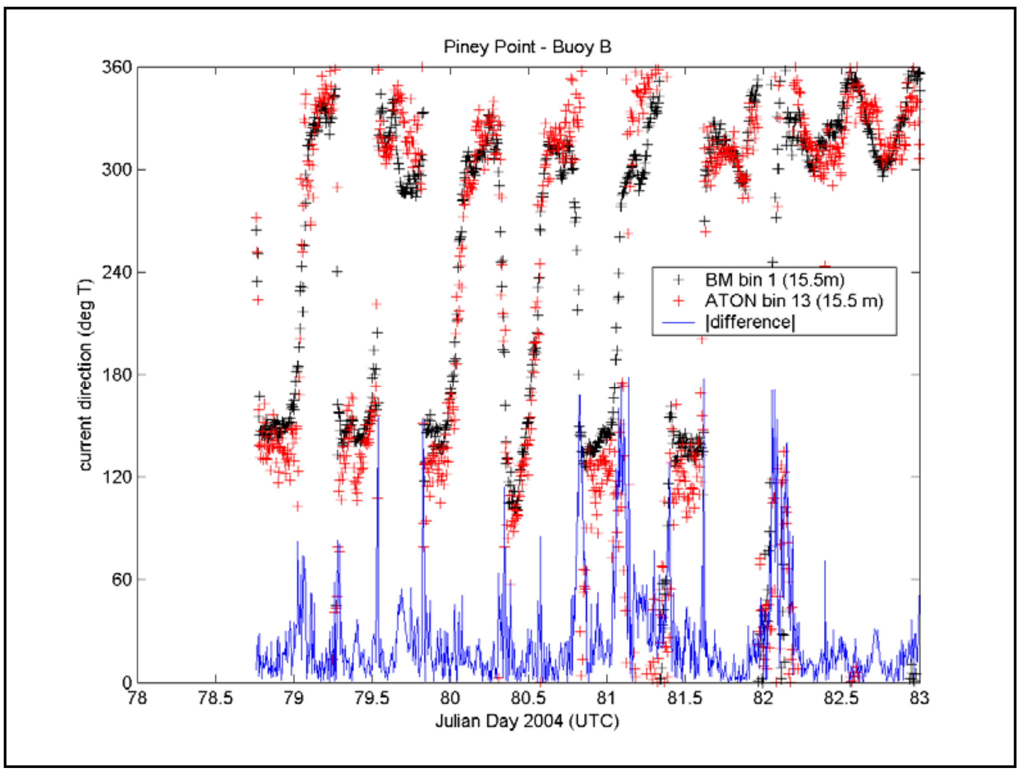

Figure 32. Time-series comparison of directions observed by the bottom and ATON mount (JD 78-83)

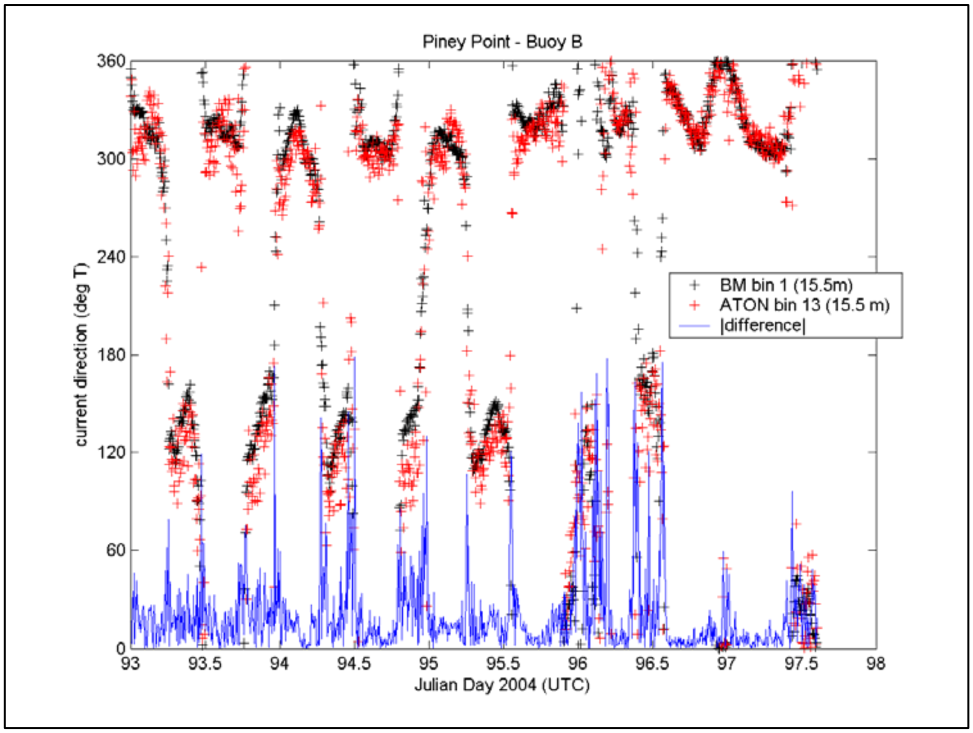

Figure 33. Time-series comparison of directions observed by the bottom and ATON mount (JD 93-98)

A comparison of the directions measured by the two systems is encouraging because they flood and ebb together, with similar time/direction characteristics, and because largest differences occur at the change of tide, when the currents are weak and variable. There is, however, no clear pattern (i.e. the ATON direction is not always higher/lower on flood/ebb).

CO-OPS explored several other relationships in search of a parameter that correlated well with the difference in direction between the bottom mount and ATON (Figure 34). The mean of the absolute value of the difference between the bottom- and ATON-mounted observed directions was 21.2° for the 20-day series when all points were considered (s.d. is 26.1°). Analyzing only the points when the observed speed is greater than 0.25 knots reduced the mean difference to 12.3°. There was considerable scatter in the differences (s.d. is 16.3°).

A plot of the data in velocity space revealed that a higher difference was associated with east-west velocity (Figure 35). This may be a result of the predominate wind (and therefore) wave direction being along the ~ east/west axis of the Potomac River. Waves cause more vertical motion of the buoy and may therefore introduce more velocity error. CO-OPS will explore this possibility further using recently collected wave and current data from Cape Henry Light Wreck Buoy "2CH".

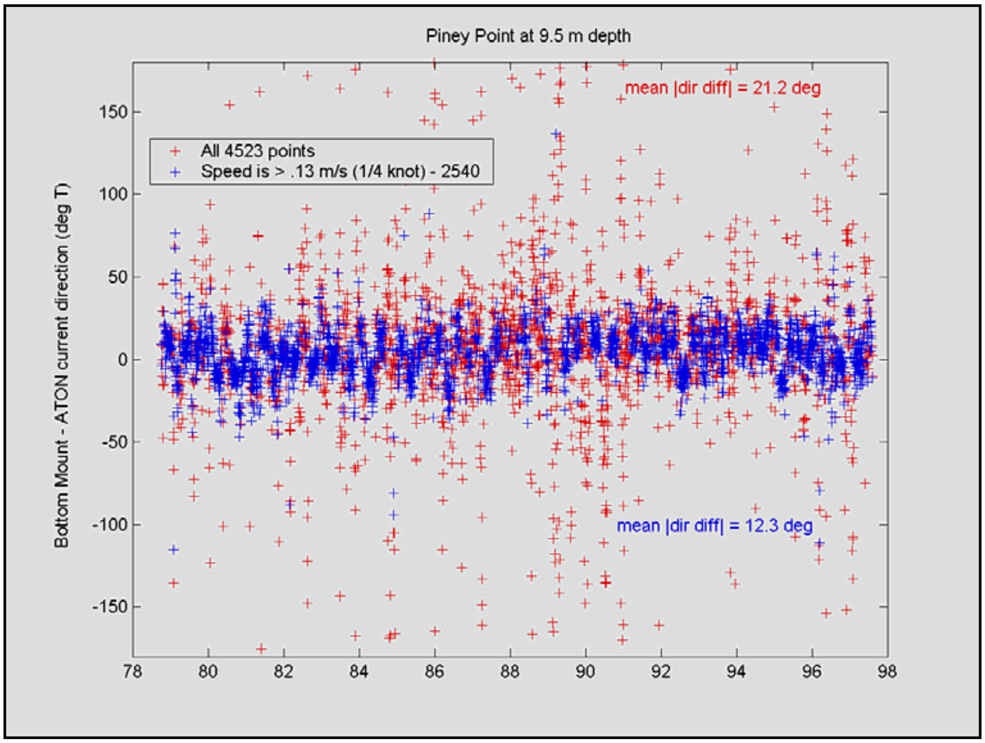

Figure 34. Time-series of the difference in direction between the two current profiler systems. The mean of the absolute value of the difference decreases significantly when only higher speed values are considered.

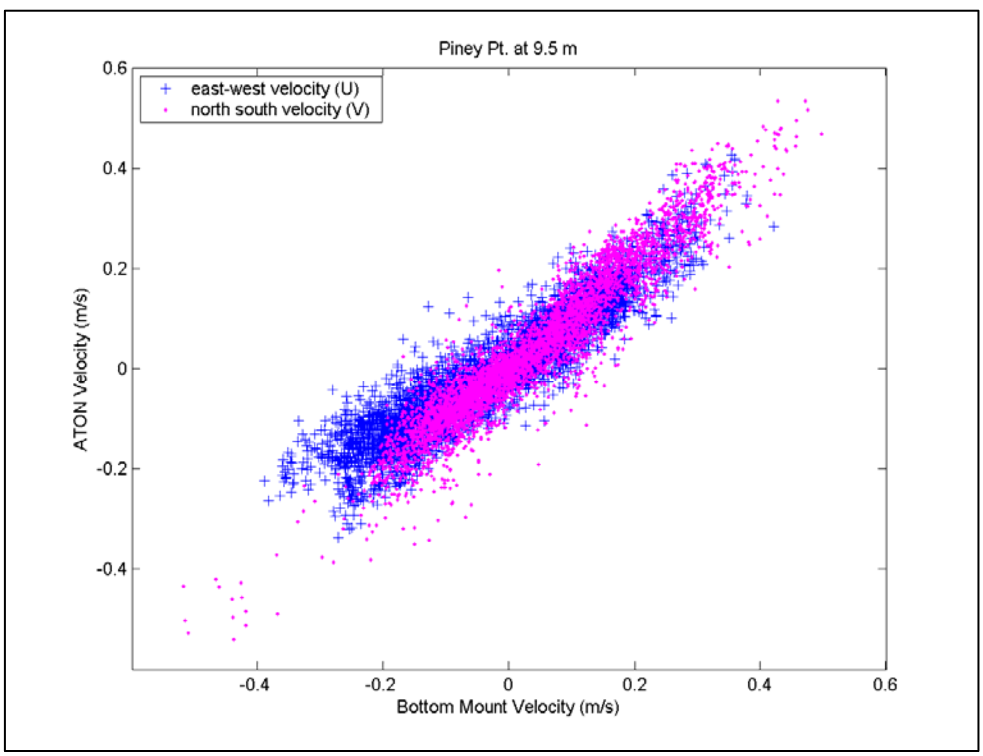

Figure 35. Mid-depth (9.5 m) current components measured by both mounting

The difference isn't just related to the direction the buoy is pointed, although there are more negative differences when the heading is between 50° and 150° and more positive differences when the heading is between 150° and 360° (Figure 36). This hints that having the mass of the ATON upstream or downstream of the current profiler may have some effect. However, the orientation of the ATON, which is directly driven by flood and ebb, doesn't appear to be related to the direction differences (Figure 37).

Suspecting that the degree of tilt of the ATON may be a primary indicator of data quality, CO-OPS explored the relationship between pitch and error in direction (Figure 38). The only thing that becomes obvious from this exercise is that the ATON has a semi-permanent 5°+ tilt.

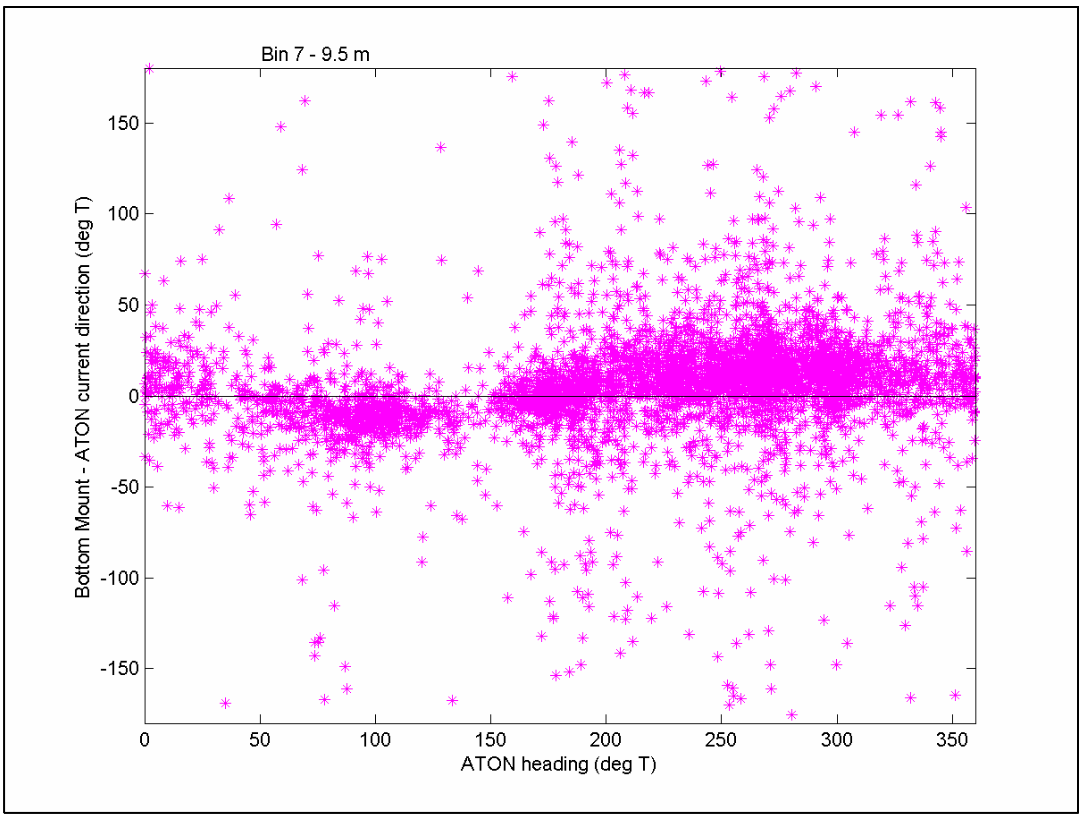

Figure 36. A weak relationship is seen between differences in direction and the ATON-mounted current profiler heading

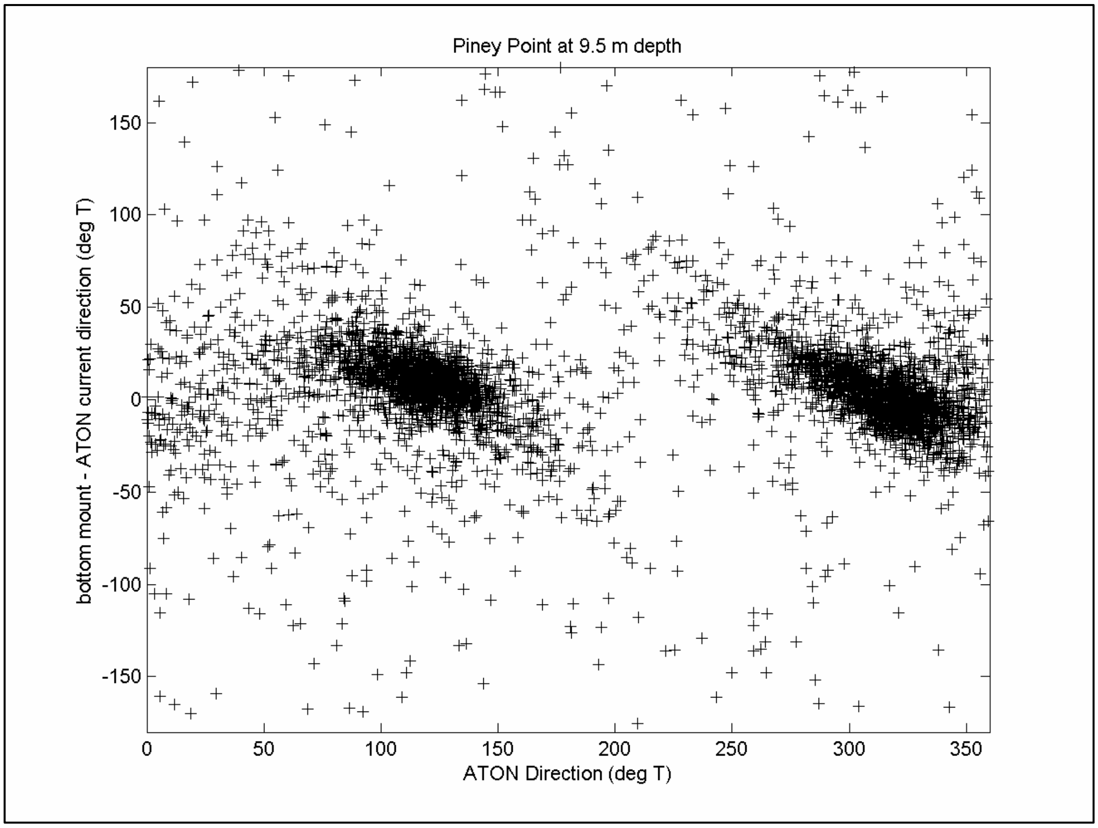

Figure 37. Flood and ebb, ATON direction versus current direction difference

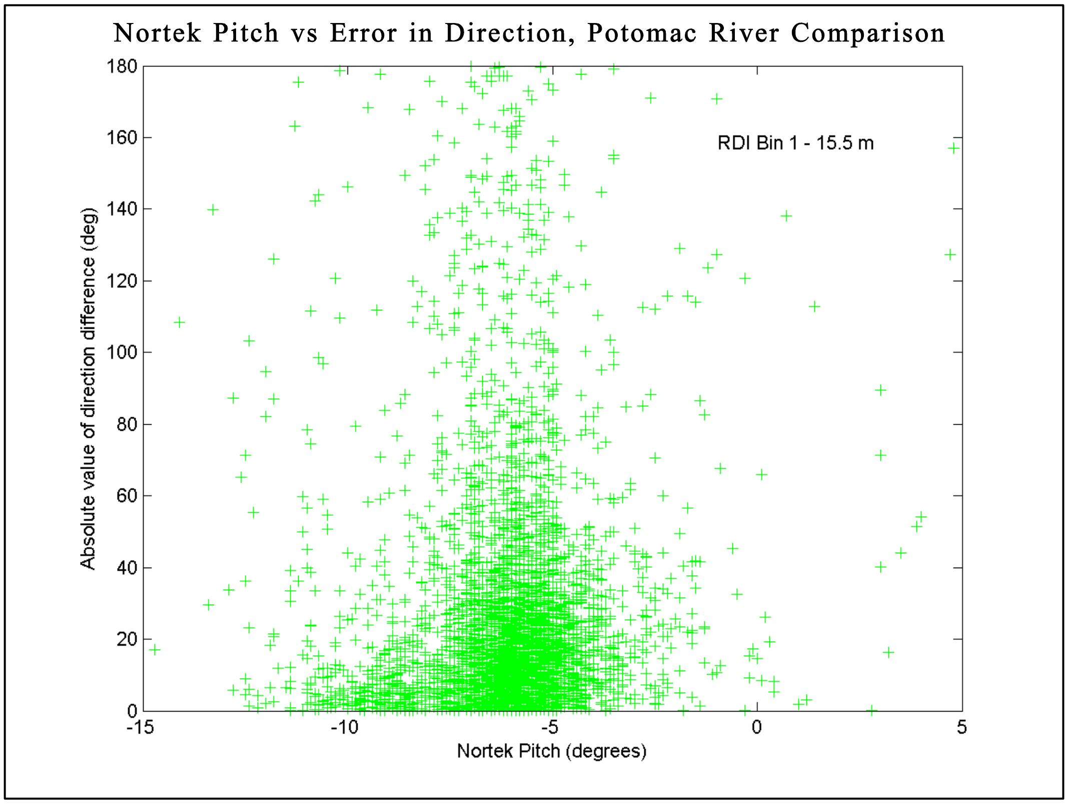

Figure 38. Pitch of the Nortek Aquadopp versus the difference in direction

Piney Point Summary. The result of this current profiler mounting system comparison is that at speeds greater than 0.25 knot, the average difference between the current direction measured by a bottom-mounted system and an ATON-mounted system is ~ 12°. It is important to note that there are errors in the directions observed by both the bottom- and ATON-mounted current profilers, as well as real directional differences caused by horizontal shear in the current field. At first look, no clear linear relationship can be identified between the direction difference and heading, pitch, or current direction.

3.5 Freeport - A Comparison of Current Measurements Taken by a System Mounted on a USCG ATON and in a Bottom Platform

Project Background. CO-OPS partnered with Fugro GEOS to compare two current profiler mounting systems near the Freeport Entrance Channel in Texas. This project leveraged one of Fugro GEOS's contracts, Freeport Liquid Natural Gas Development, L.P. (who commissioned Fugro GEOS to install an RDI Workhorse ADCP in a seabed mooring in self-contained mode) in order to obtain profiles of current speed and direction during a six-month period from November 2003 to April 2004 (Figure 39). CO-OPS evaluated the direction data from the Nortek profiler and the effectiveness of the calibration procedure by comparing them to the direction data from the seabed-mounted Workhorse ADCP.

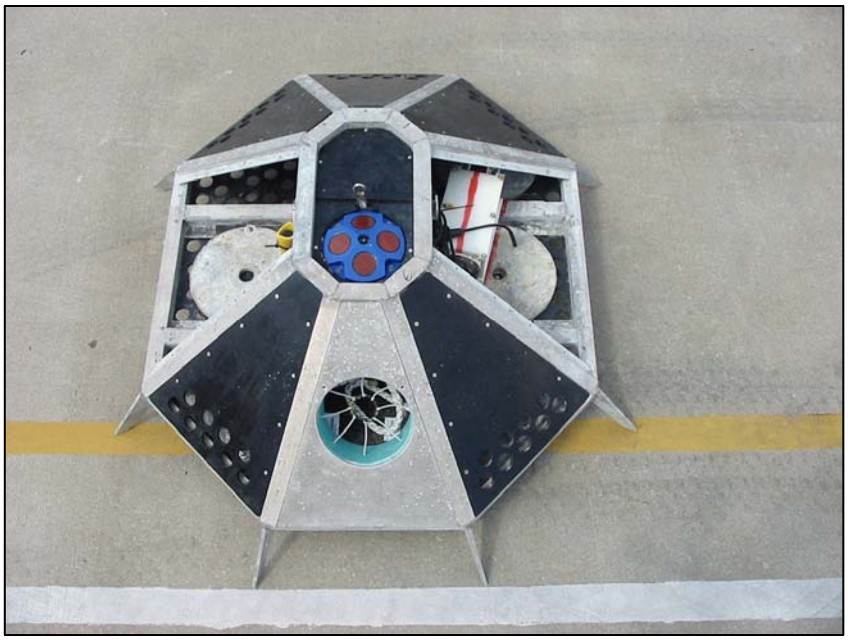

Figure 39. Seabed mooring with RDI ADCP

Comparison Configuration. In January 2004 Fugro GEOS and CO-OPS successfully installed a clamparatus system on Navigation Buoy 6 at the Freeport Entrance Channel (Figure 40). This ATON is approximately 70 meters away from the bottom-mounted current profiler, in a water depth of about 11 meters.

The data from the seabed- and the ATON-mounted current profilers were compared over a four-month period, between January and April 2004. A service visit was conducted mid-way to change the batteries in the seabed-mounted current profiler and to download data from both instruments. Both current profilers were configured to record current data in one meter bins over six-minute ensembles.

The Workhorse ADCP was also configured to measure waves. This allowed the performance of the ATON-mounted Nortek profiler to be evaluated in higher sea states, when the buoy is tilted more. A further benefit of the comparison at this location is the ability to evaluate system performance in an offshore environment, rather than in a protected bay where tidal currents are the dominant feature.

Figure 40. ATON LBB 6 at the mouth of the Freeport River

Preliminary Results. Data from the first two months of the survey are presented here. Generally, there is agreement between the current measurements from the two different mounting systems. The major shifts in current direction are observed in both data sets, as well as major current events (Figures 41-44). As expected, the agreement breaks down during weak currents, as well as during periods with relatively high waves due to current variability. Unlike the comparison that CO-OPS has performed in the Potomac River of the Chesapeake Bay, currents at the mouth of the Freeport River are not predominately tidal. The largest signal in current direction results from changes in the offshore current regime.

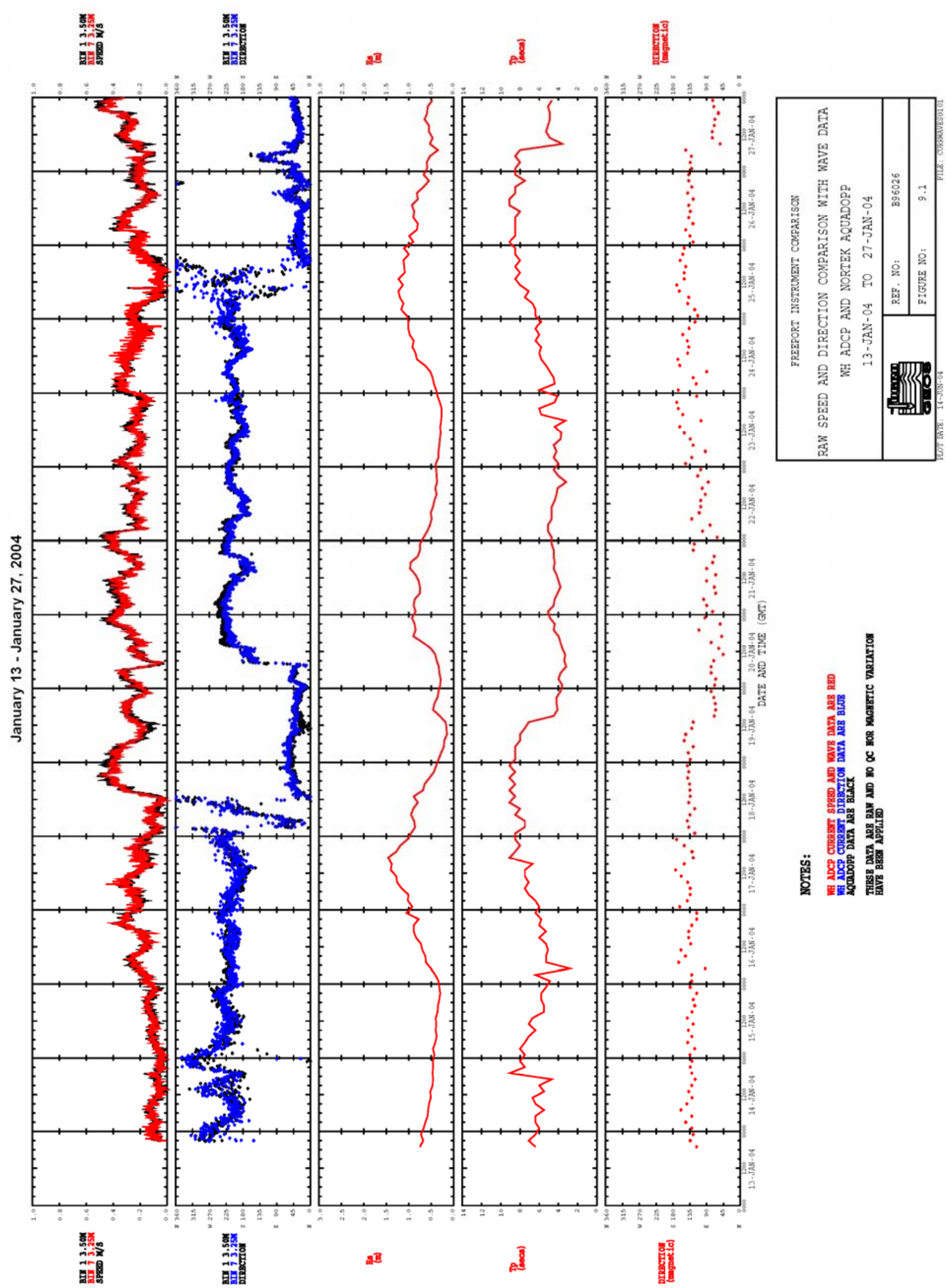

Figure 41. Time-series of current speed and direction from both measurement systems and waves measured by the bottom mount

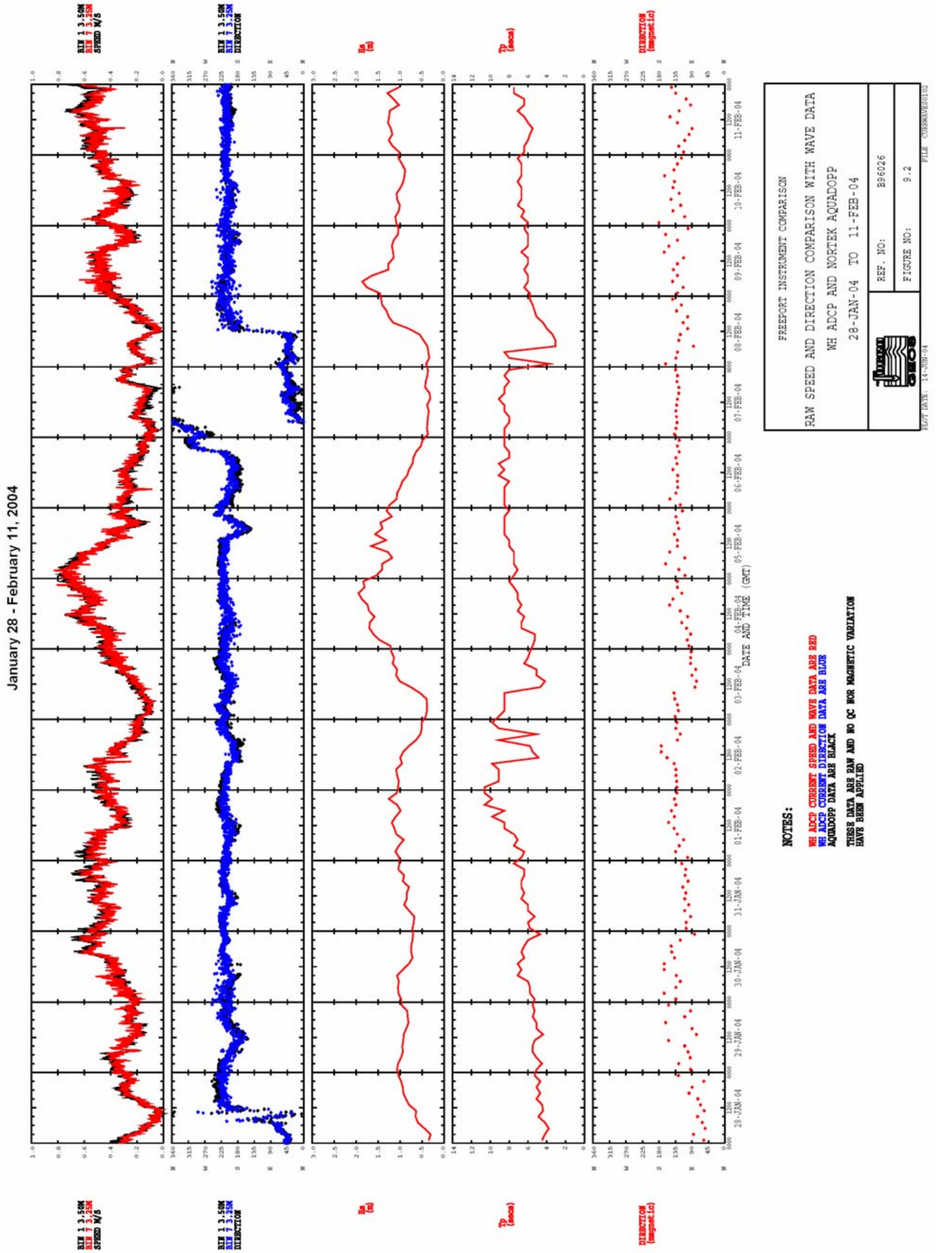

Figure 42. Time-series of current speed and direction from both measurement systems and wave height, period, and direction from the bottom mount

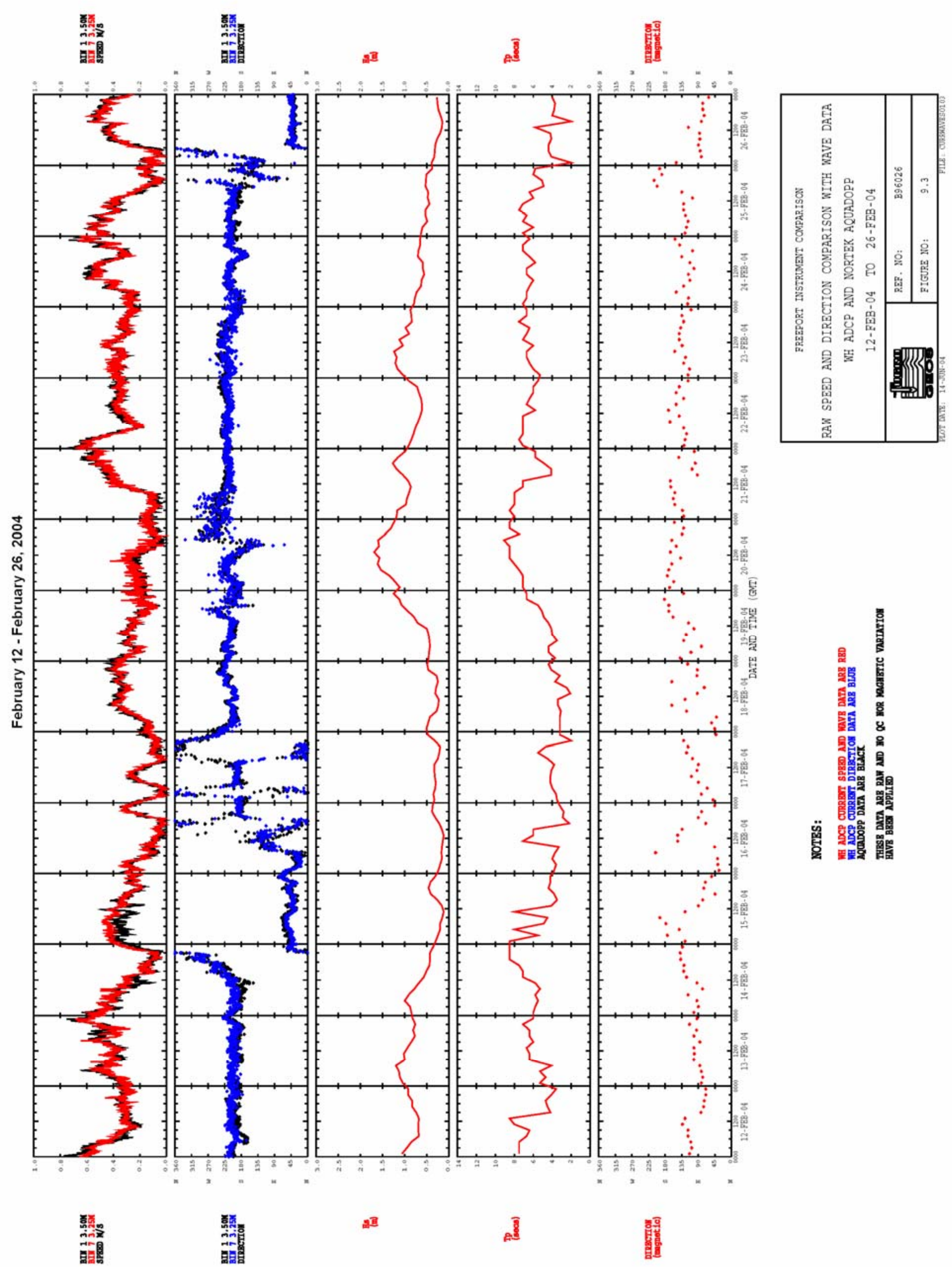

Figure 43. Time-series of current speed and direction from both measurement systems and wave height, period, and direction measured by the bottom mount

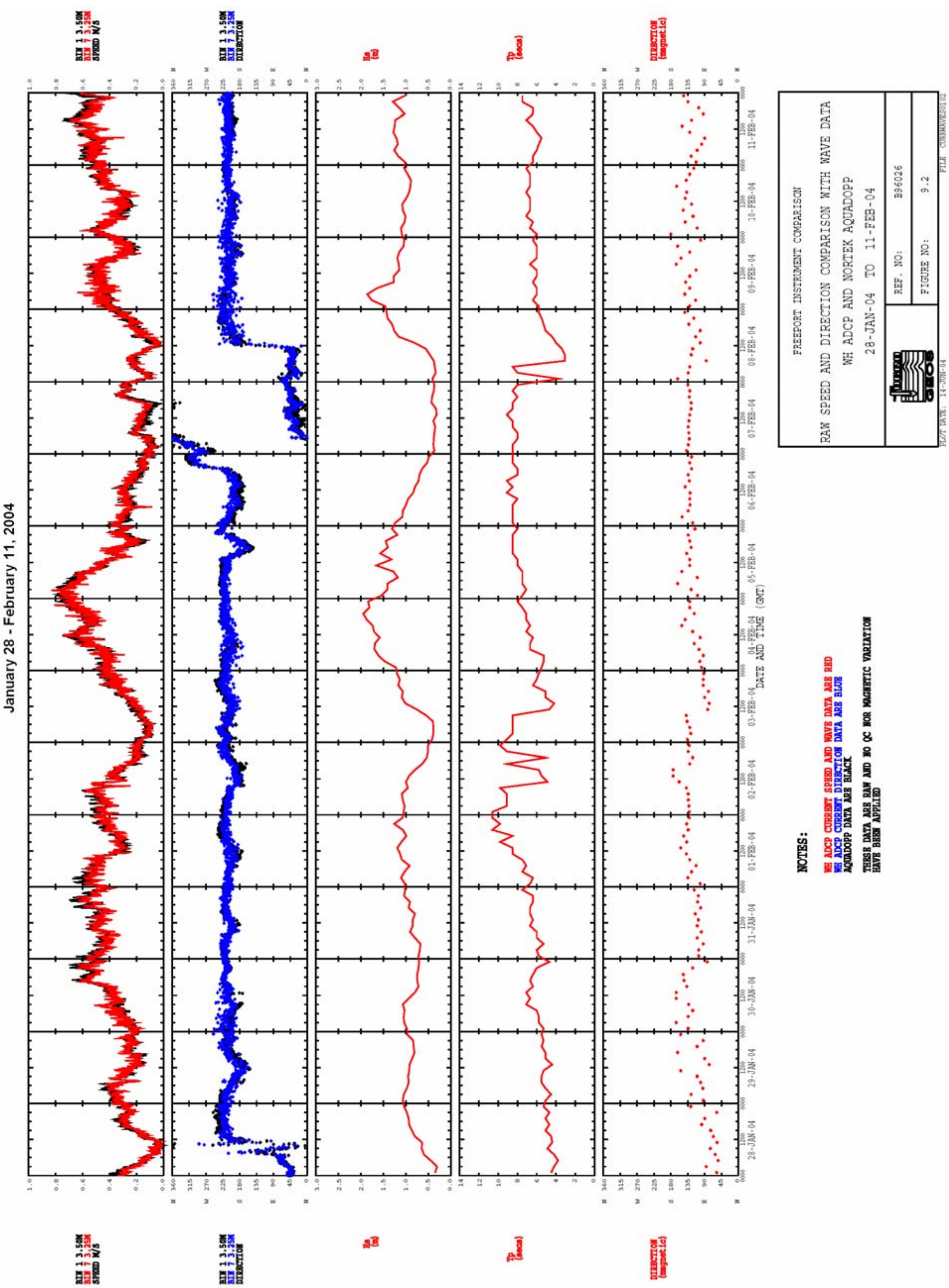

Figure 44. Time-series of current speed and direction from both measurement systems and wave height, period and direction measured by the bottom mount

Focusing first on the observed current speed, CO-OPS found that the mean speed difference for the top usable ATON bin (3.5 m) is 3.1 (cm/s) with a 2.9 cm/s s.d. There is small bin-to-bin variation in the speed differences, with the middle depth bin showing the least difference between the bottom mount and ATON (Figure 45), where both sensors are most likely to be measuring the same physical volume. The speed differences are nearly evenly distributed about zero, thus no large bias exists in either of the current profiler speed measurements (Figure 46).

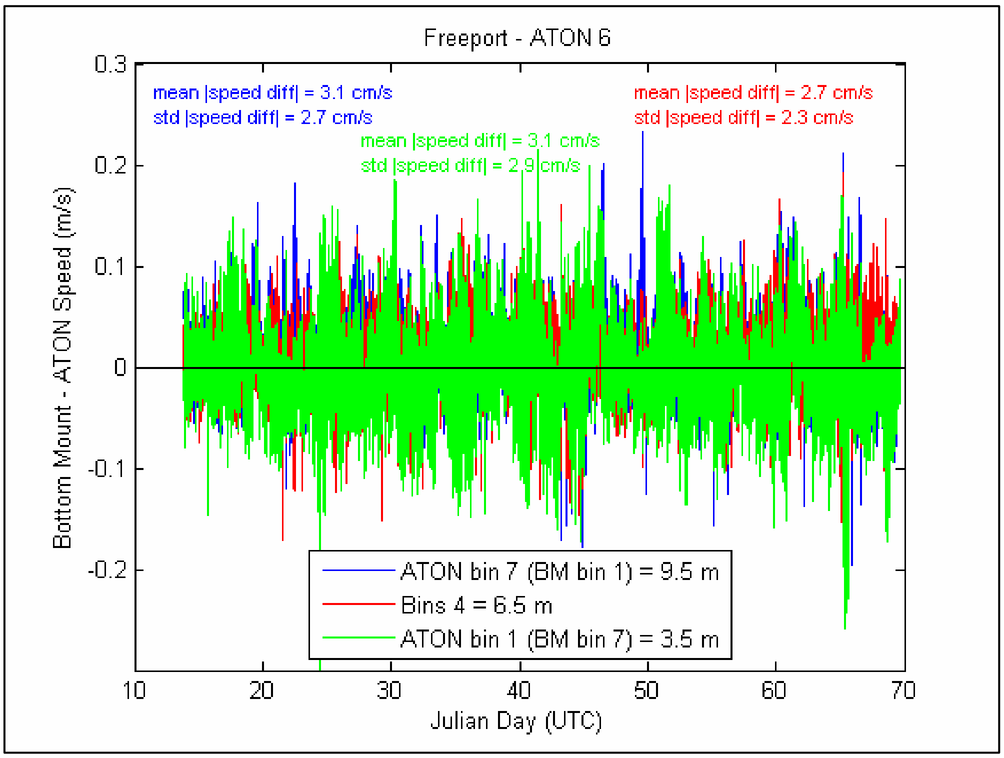

Figure 45. Time-series of differences between the current speed measured by the bottom-mounted current profiler and the current speed from the ATON-mounted sensor

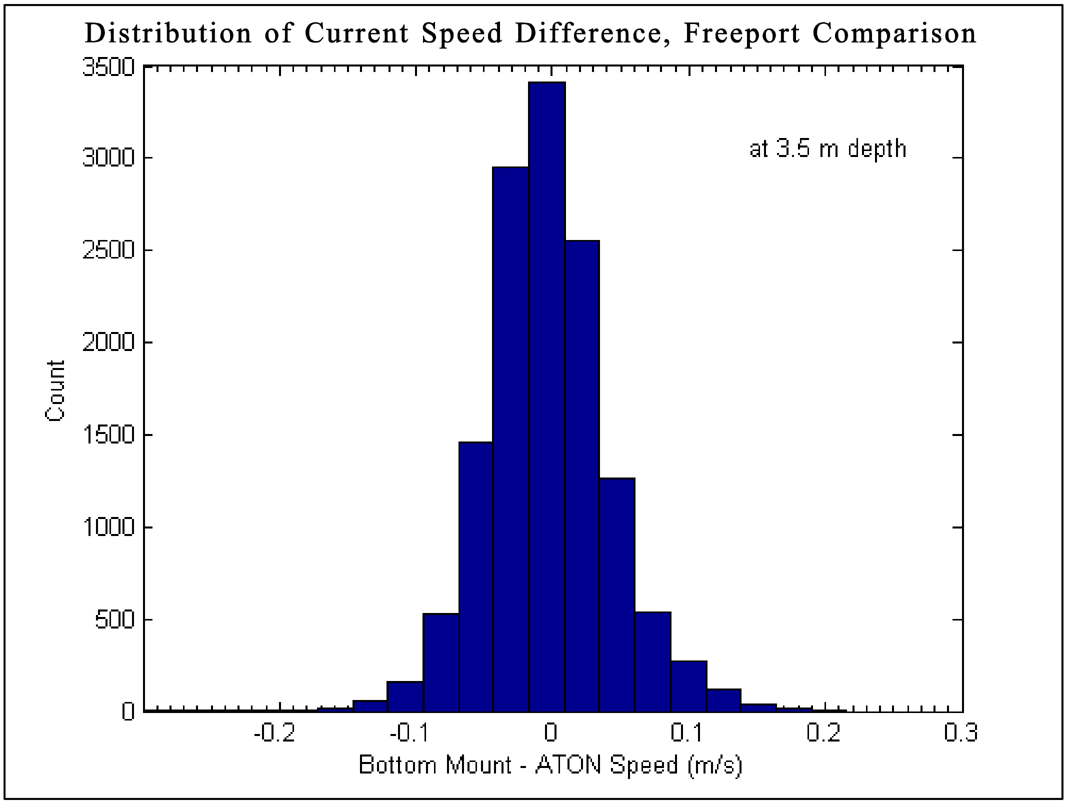

Figure 46. Distribution of the current speed differences

As with previous studies, the most concern is about the agreement between the current direction measured by the sensors on the two different mounting systems. Similar general current patterns are observed by both measurement systems (Figures 47-50). The data show that the difference between the directions increases at low speeds (Figure 51). For the 3.5 m bin, the mean of the absolute value of the difference in six-minute directions is 13.4° (s.d. = 15.1°) when all 60 days are considered, and 11.5° (s.d. drops to 10.1°) when only points with speeds greater than 0.25 knot are tabulated (Figure 52).

Although the asymmetry around zero was slightly more for the directional differences than seen in the current speed difference, a large bias was not evident in either of the current direction measurements (Figure 53). The distribution showed that 69% of the directional differences were within +/- 10° of zero and 89% of the differences were less than or equal to +/- 15°. No single predictor of directional difference was found.

ATON heading, observed current direction, and pitch were all investigated, but none had a useful regression relationship that could be used to adjust the ATON current direction prior to data dissemination (Figures 54-56).

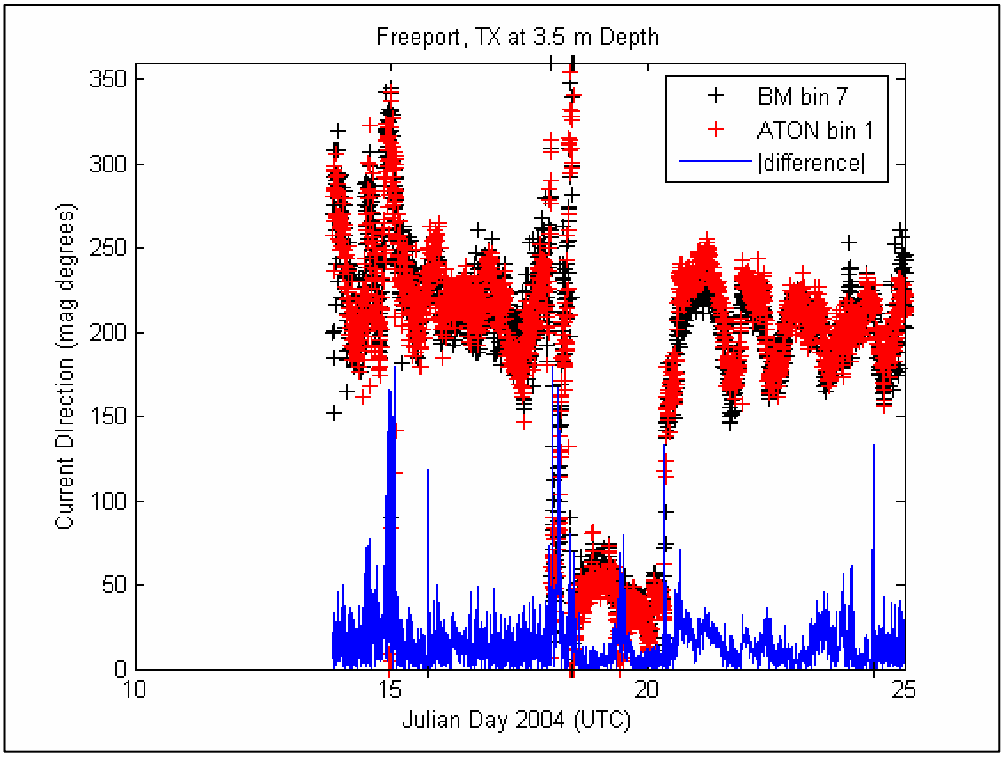

Figure 47. Time-series of current direction difference at Freeport, Texas, 10-25 January 2004

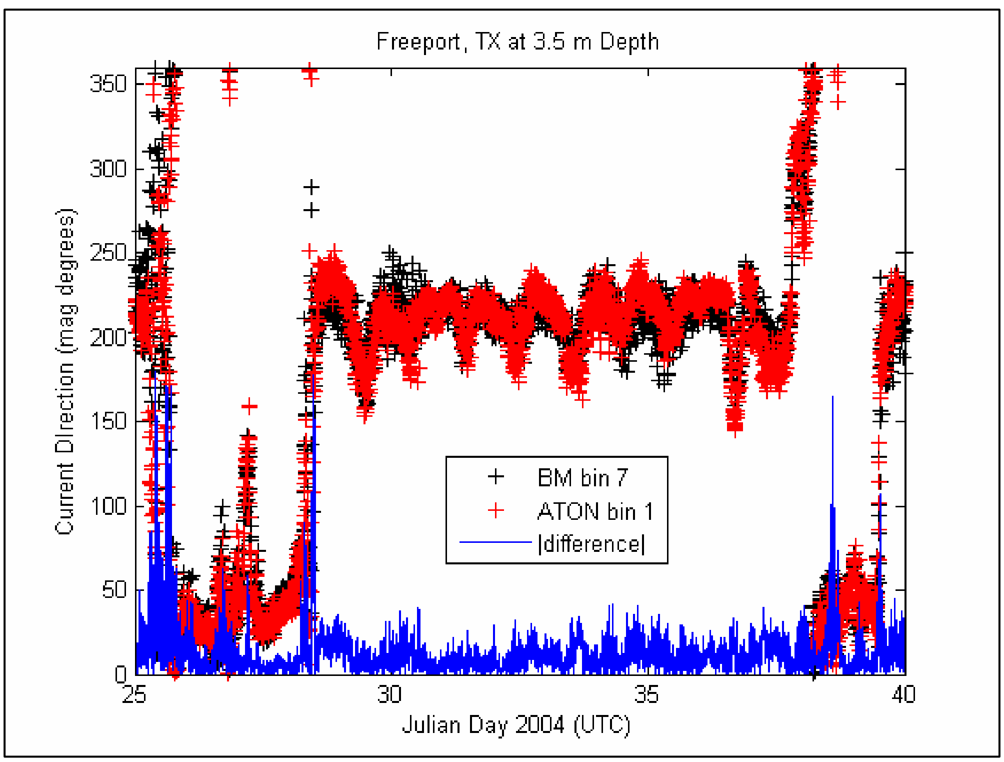

Figure 48. Time-series of current direction and direction difference, Freeport, Texas, 25 January-9 February 2004

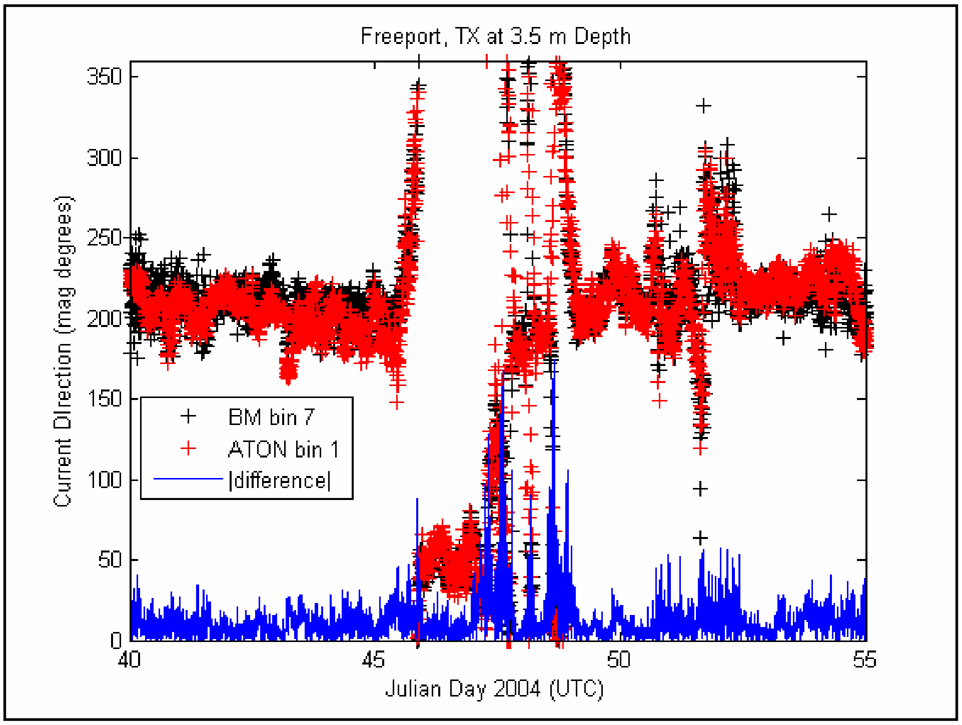

Figure 49. Time-series of current direction and direction difference, Freeport, Texas, 10-24 February 2004

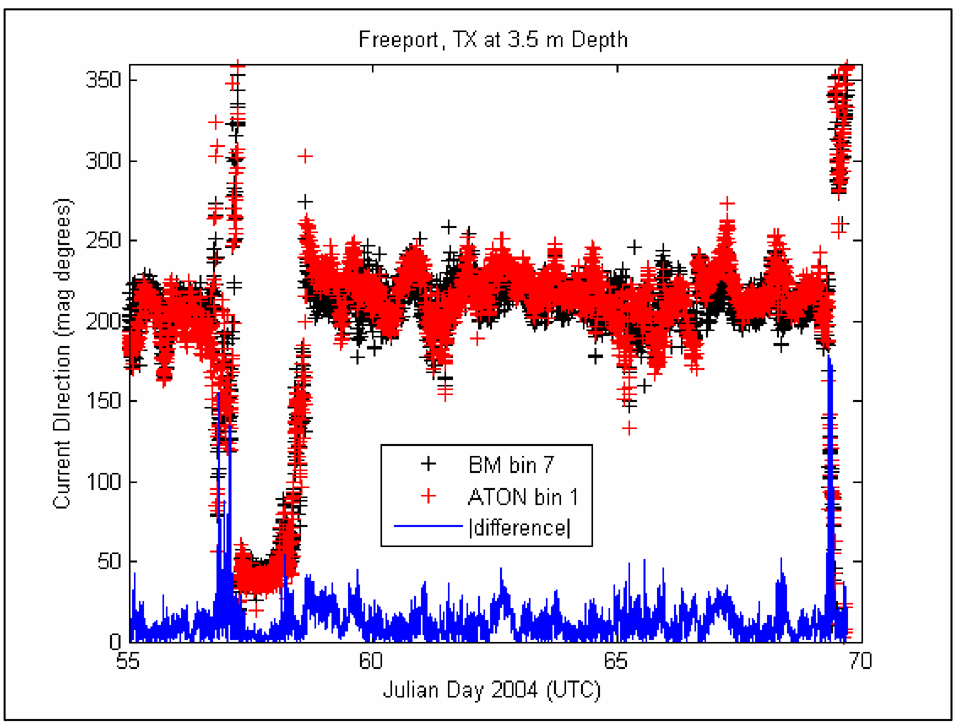

Figure 50. Time-series of current direction and direction difference, Freeport, Texas, 25 February – 10 March 2004

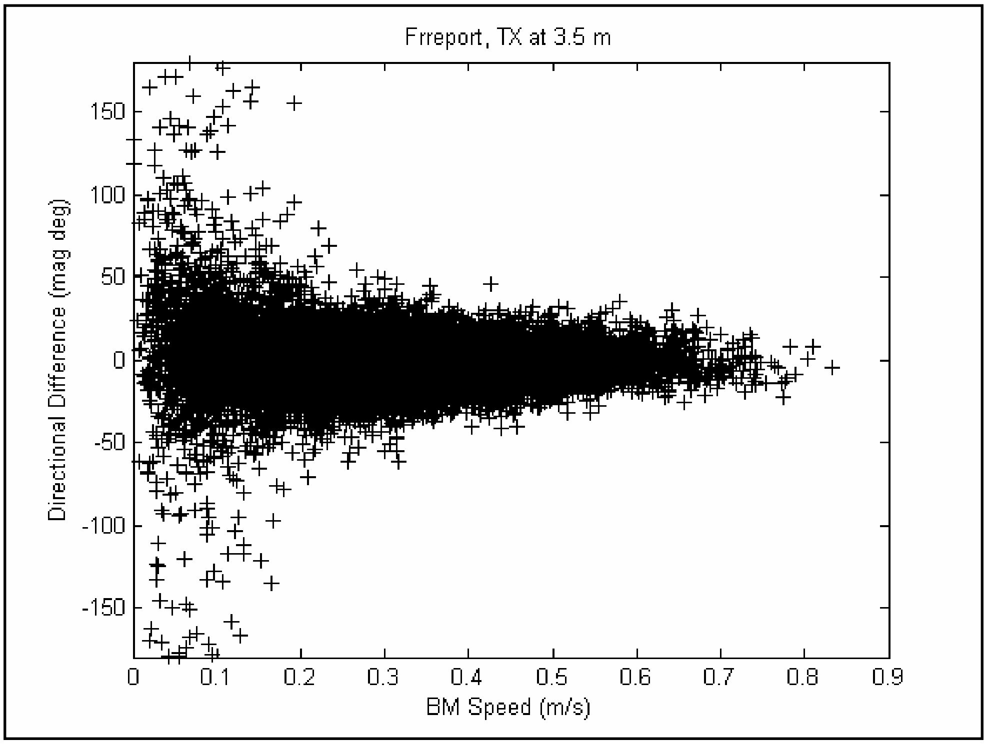

Figure 51. Current direction difference versus current speed, Freeport, Texas

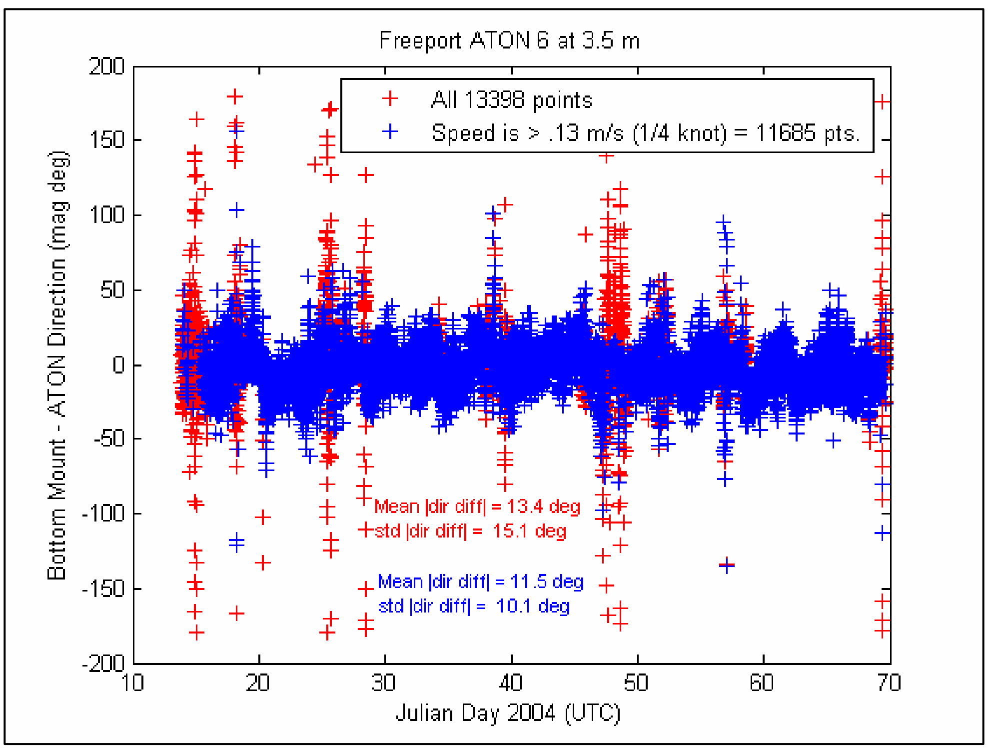

Figure 52. Time-series of the difference between the current direction observed by the bottom- and ATON-mounted systems. The red + indicate all points, the blue + are from times when the current speed is above one-quarter knot.

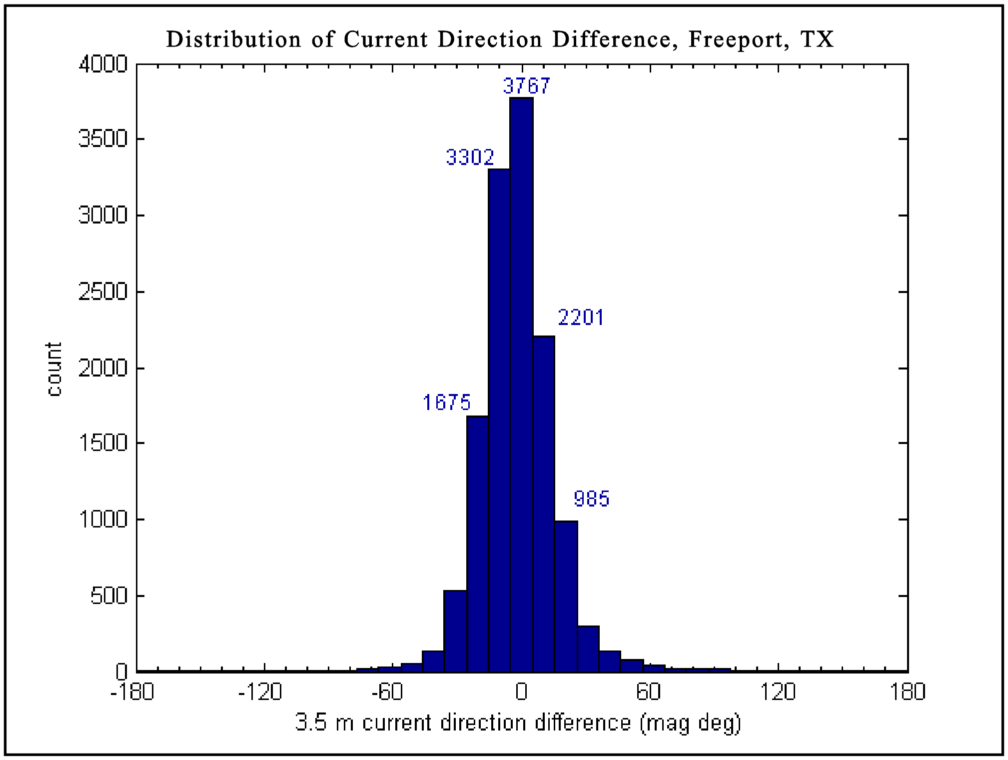

Figure 53. Current direction difference distribution, Freeport, Texas

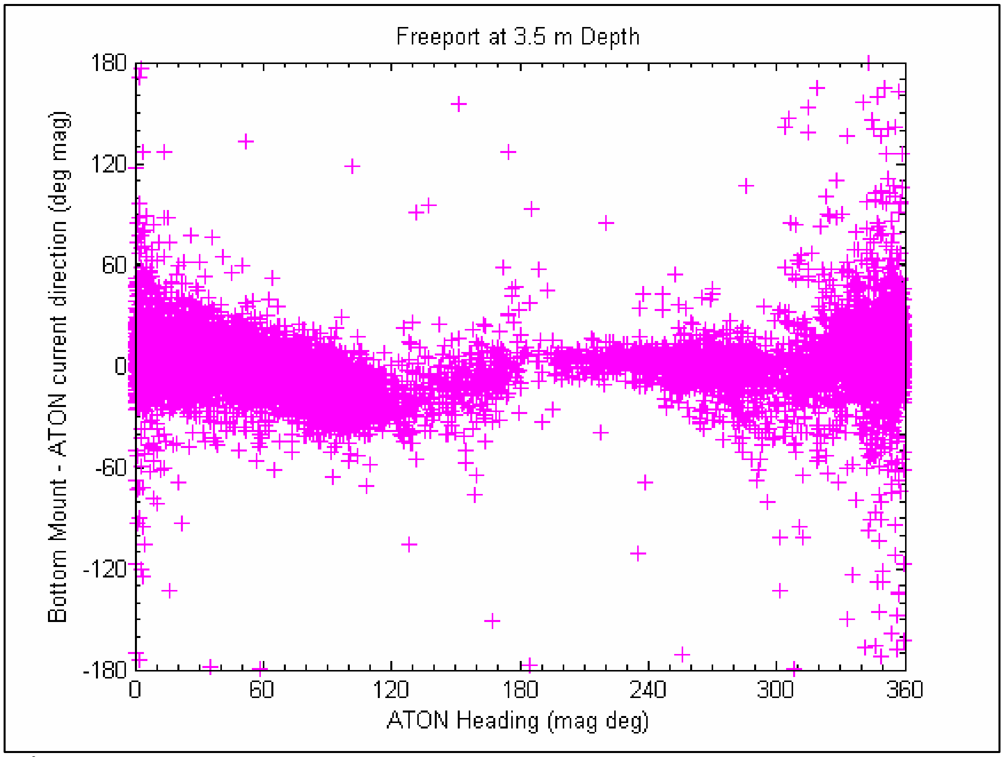

Figure 54. Nortek Aquadopp heading versus current direction difference, Freeport, Texas

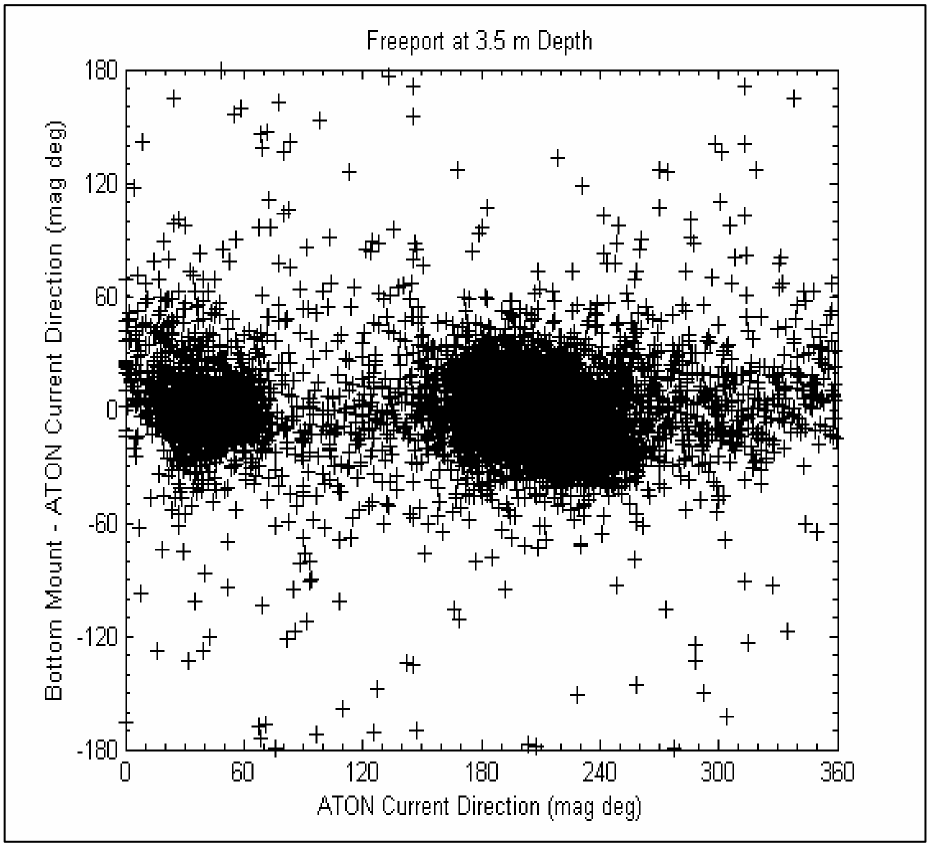

Figure 55. Nortek Aquadopp current direction versus direction difference, Freeport, Texas

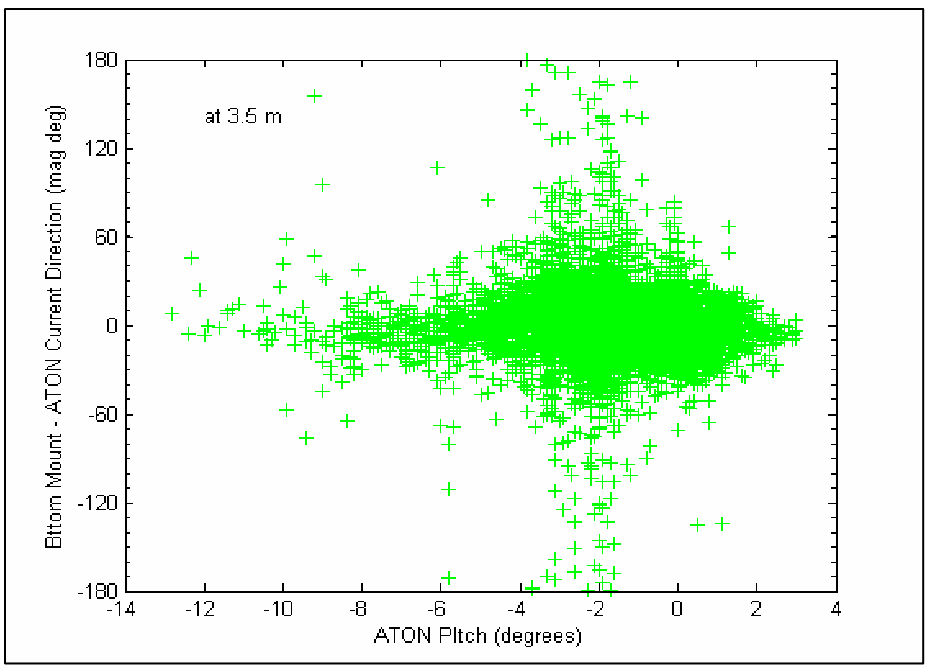

Figure 56. Nortek Aquadopp pitch versus direction difference, Freeport, TX. There is no increase in direction difference for increased pitch of the Aquadopp.

3.6 A Tidal Cycle Comparison of ATON- and Ship-Mounted Current Measurements Near the Mouth of the Chesapeake Bay

Project Background. CO-OPS conducted an experiment using a ship hull-mounted current profiler, in addition to two intercomparisons with bottom-mounted current profilers. CO-OPS purchased ship time on the Old Dominion University (ODU) research vessel the *R/V Fay Slover* (Figure 57). ODU's Center for Coastal Physical Oceanography scientists obtained profiles of current speed and direction during a complete tidal cycle near spring tide in May 2004. Data from a hull-mounted RD Instruments Workhorse ADCP were used to evaluate the direction data from the ATON system and the effectiveness of the compass calibration procedure.

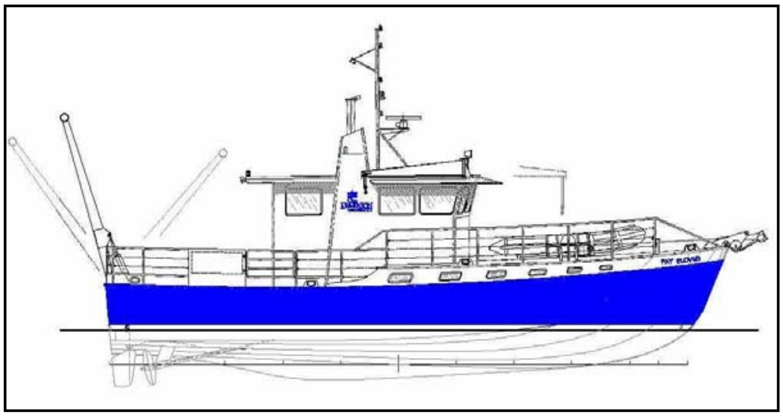

Figure 57. Old Dominion University's research vessel the *R/V Fay Slover*

Comparison Configuration. CO-OPS installed a clamparatus system on the Cape Henry Wreck Lighted Buoy 2CH at the Chesapeake Bay entrance (Figure 58). This ATON is at approximately 36.9592° north (N), 76.0128° west (W) in about 13 m of water. On 17-18 May 2004 the *R/V Fay Slover* moored near 36.9596° N, 76.0129° W, just to the NW of LB 2CH and collected 24 hours of continuous current profiles. A 600-KHz RDI Workhorse ADCP mounted in the hull of the *R/V Fay Slover* was used to obtain the current profiles. Both current profilers were configured to record current data in one meter bins over six-minute ensembles.

This experiment was planned to catch the spring tidal currents for this area, which were predicted for 17-18 May 2004. The winds at the Chesapeake Bay Bridge Tunnel (CBBT) were five m/s from the SW (Figure 59). The winds died down early in the study period and changed to easterly, but then slowly increased in speed and rotated to southwesterly.

Figure 58. Calibrating the compass of the ATON current measurement system on LB 2CH

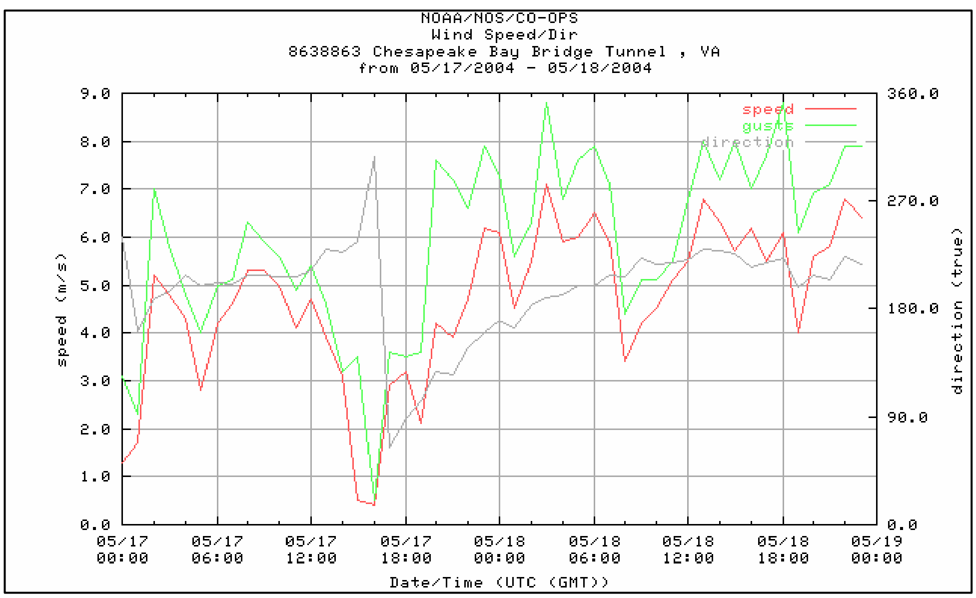

Figure 59. Wind speed, direction, and gust during the experiment observed at the Chesapeake Bay Bridge Tunnel NOS station

Study Results. Data from the 24-hour survey are presented here. Generally, there is agreement between the current measurements from the two systems. The major shifts in current direction (flood to ebb) are observed in both data sets, as well as the relative differences in the strength of flood and ebb (Figures 60-62). Agreement is best in the near-bottom bins, particularly in the east/west component of the current. In other intercomparisons performed by CO-OPS (one in the Potomac River and one in the Gulf of Mexico), the agreement decreased at times when the current was changing direction (i.e. when the currents were weak and variable). These data do not show this pattern—the timing of the change from the southeast to the northwest is nearly simultaneous in the bottom-mounted and ATON record, with the slight exception of some phase difference in the near-surface (bin one).

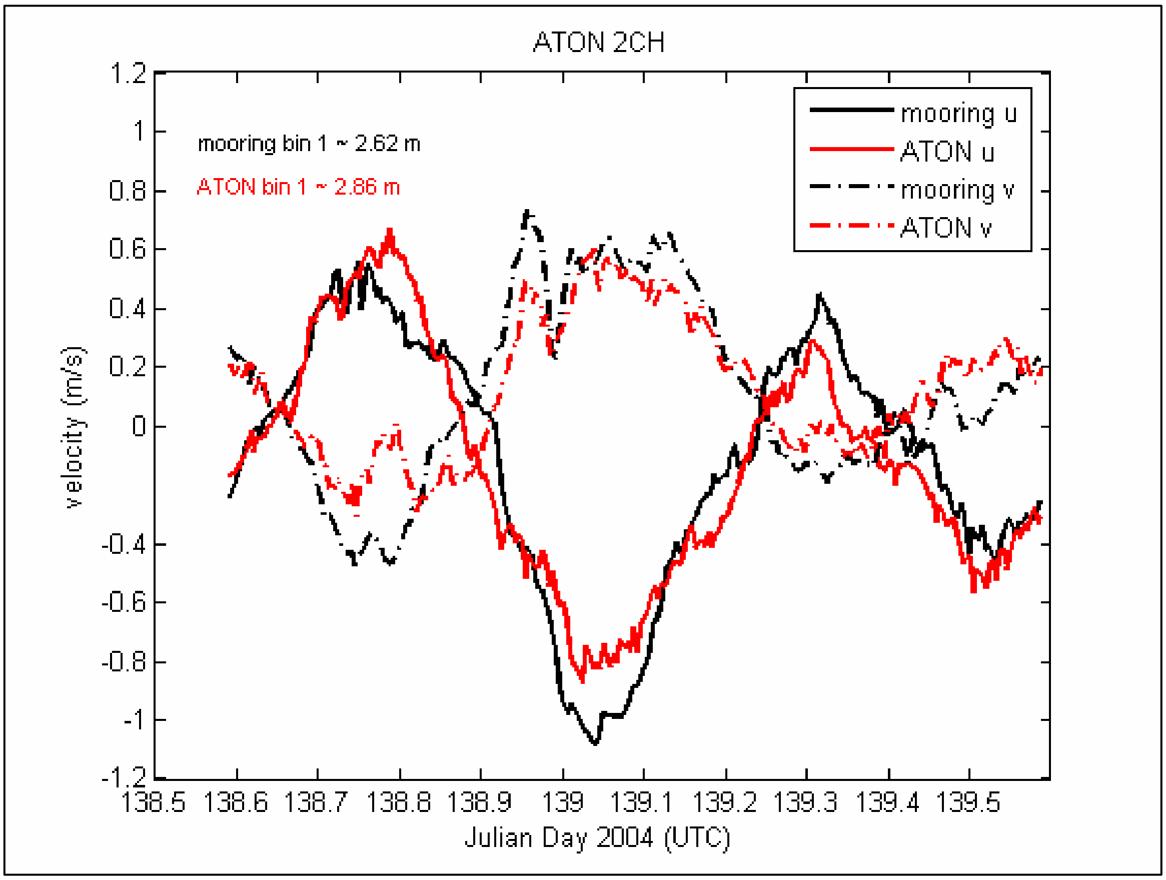

Figure 60. Near surface eastward and northward current velocities observed by the hull-mounted ADCP (black) compared to those observed by ATON-mounted system (red)

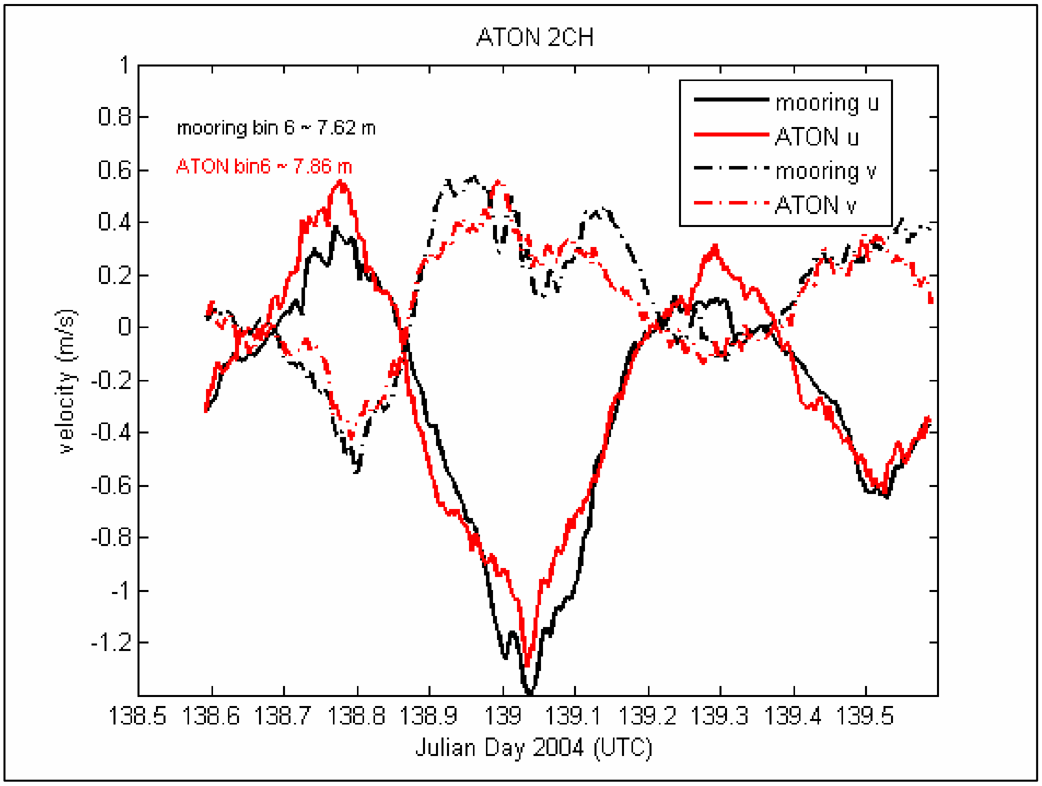

Figure 61. Mid-depth eastward and northward current velocities observed y the hull-mounted ADCP (black) compared to those observed by ATON-mounted system (red)

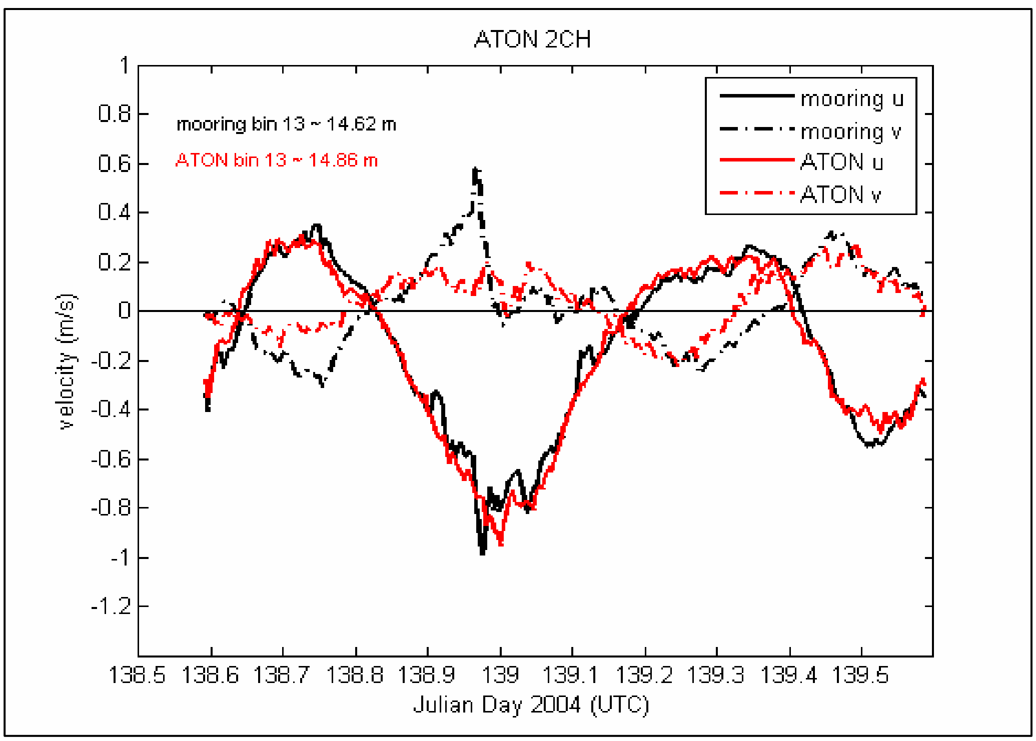

Figure 62. Near-bottom eastward and northward current velocities observed by the hull-mounted ADCP (black) compared to those observed by ATON-mounted system (red)

Focusing first on the observed current speed, CO-OPS found that the mean speed difference for the top usable bin (2.62 m) was 10.7 cm/s with an s.d. of 7.3 cm/s (Figure 63). The agreement increases with depth, with the bottom bin showing the least difference between the ship and ATON (Figure 64). The speed differences are considerably higher than those observed in other CO-OPS intercomparisons. During both the Freeport, Texas and Potomac River comparisons the mean speed differences (and s.d. about those means) were only 3 cm/s at all depths. CO-OPS investigated possible explanations for these higher speed differences. Sample size is an important factor. Here only one day of data is compared, while during the Freeport and Potomac experiments, the data sets were 60 and 30 days respectively. The ATON-mounted pitch and roll values are of the same order of magnitude as the Freeport and Potomac River comparisons (Figure 65).

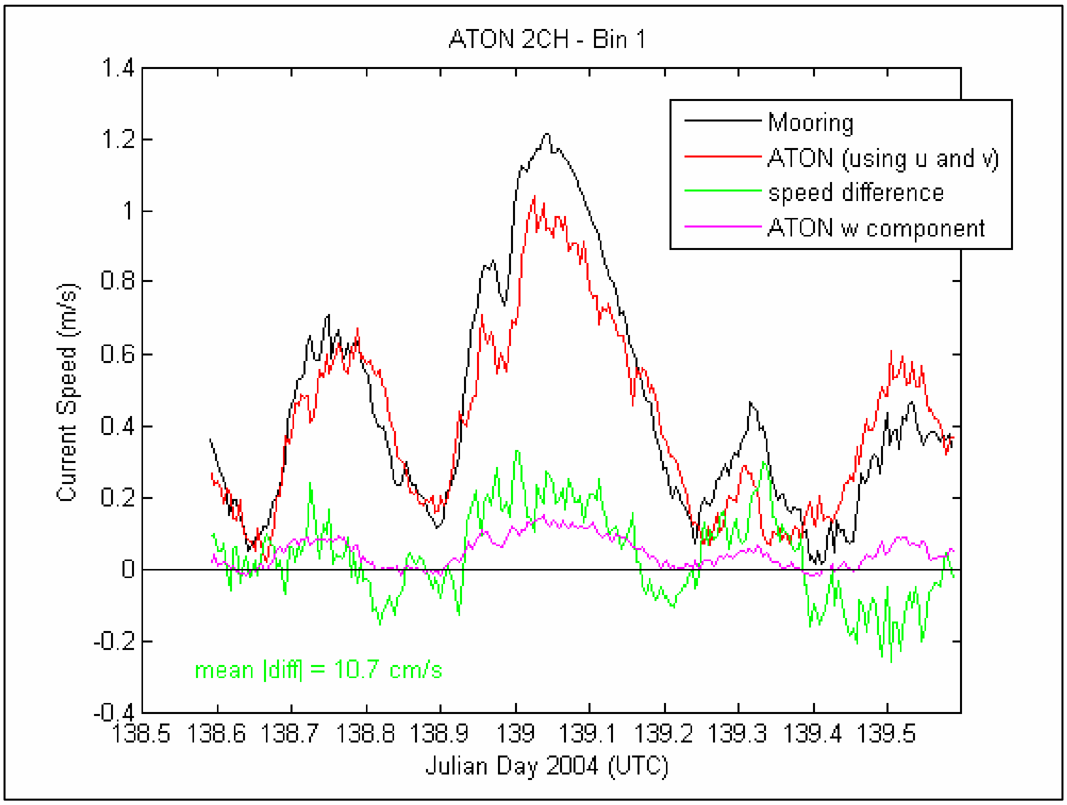

Figure 63. Near surface current speed observed by the hull-mounted ADCP (black) compared to that observed by ATON-mounted system (red). The difference is shown in green. A very large vertical velocity is observed in this top bin.

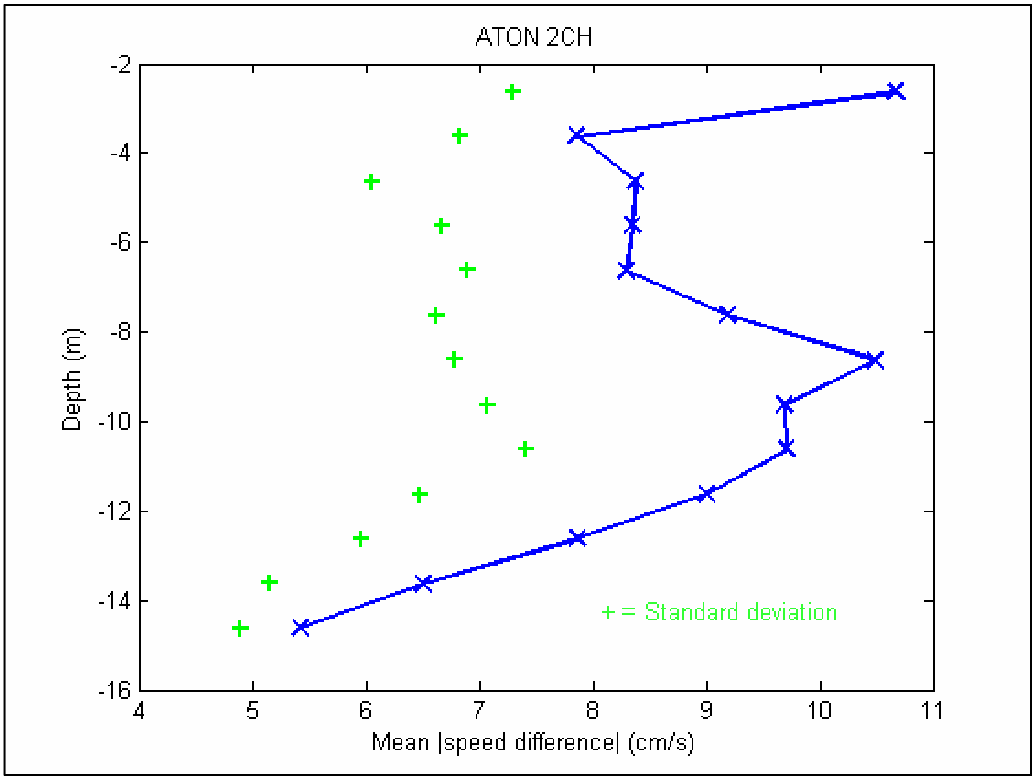

Figure 64. Depth relationship of the speed difference between ship- and ATON-mounted current measurements

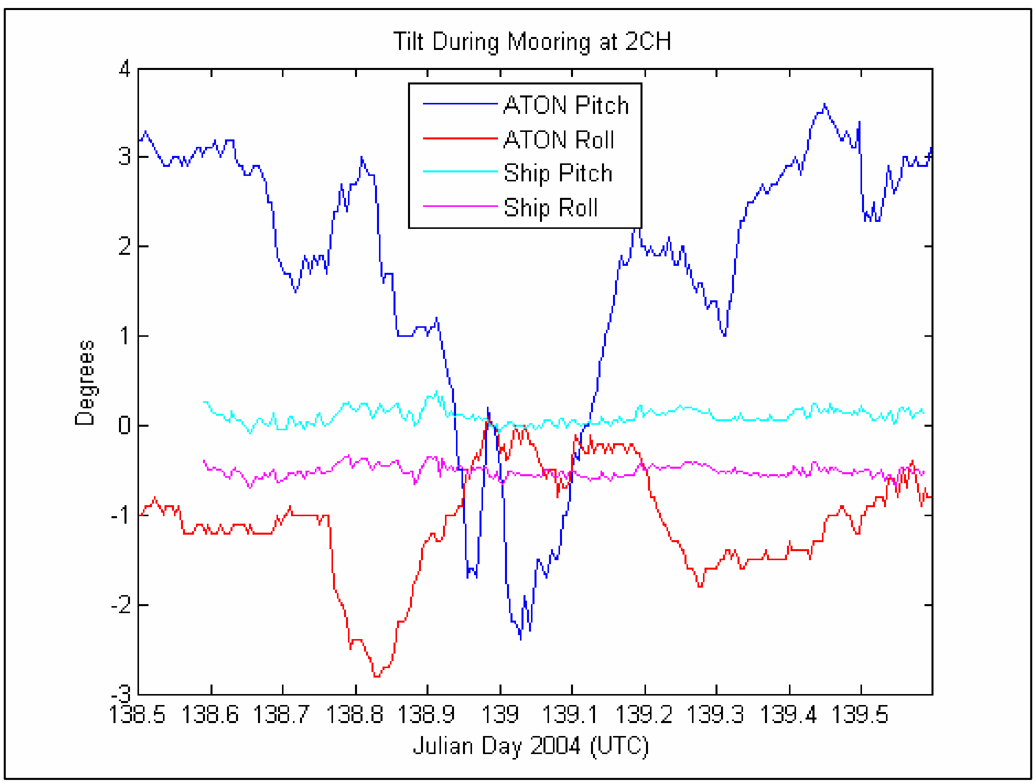

Figure 65. Pitch and roll from both current measurement systems

As with previous studies, CO-OPS was most concerned about the agreement between the current direction measured. The general current patterns were observed by both measurement systems. For the 3.5 m bin, the mean of the absolute value of the difference in six-minute directions is 27.8° (s.d. = 33.9°) (Figure 66). The agreement was slightly better in the near-bottom bin, with the mean of the absolute value of the difference in six-minute directions of 20.6° (s.d. = 18.7° [Figure 67]). The sample-to-sample differences in direction are not all uniform with depth, and are particularly noisy when the current is reversing (Figure 68).

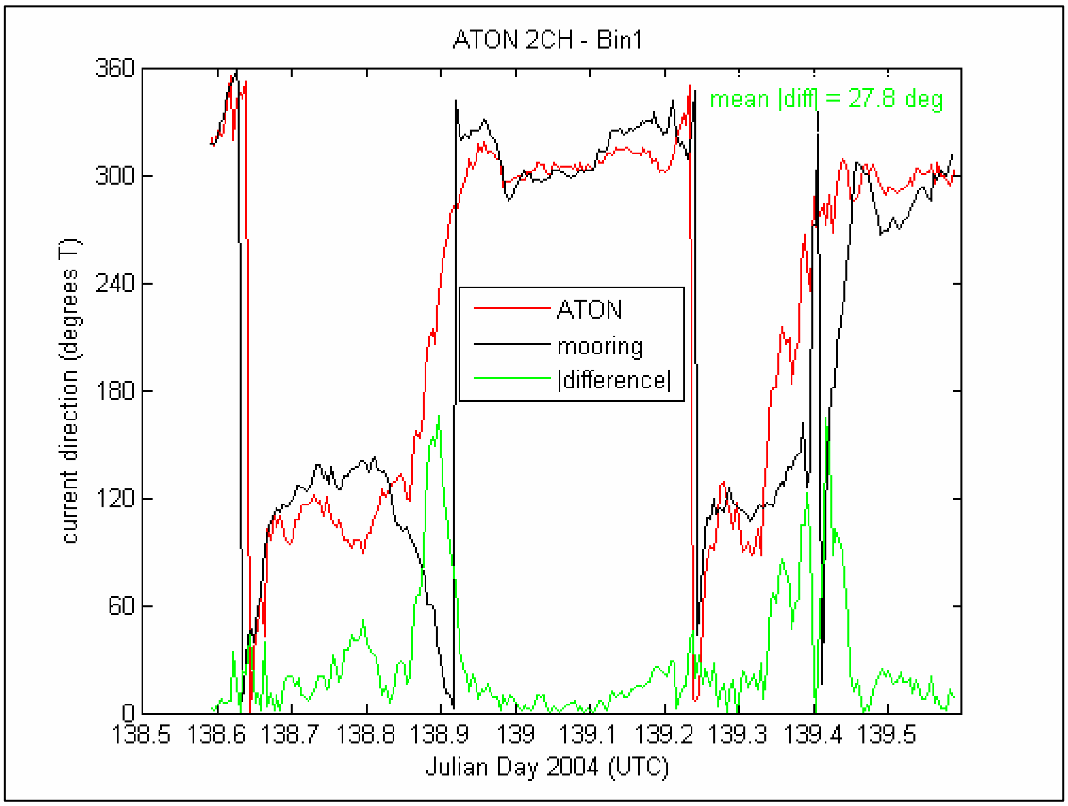

Figure 66. Direction measured by the ship and ATON current profilers and the absolute value of the difference

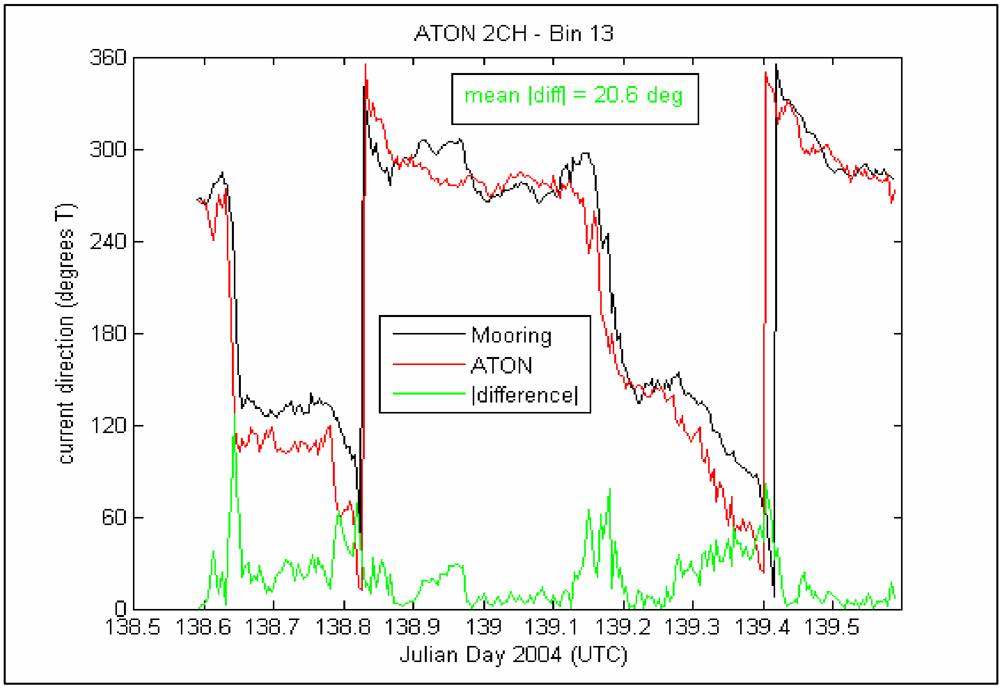

Figure 67. Time-series of current direction and current direction difference, Buoy 2CH comparison, May 2004

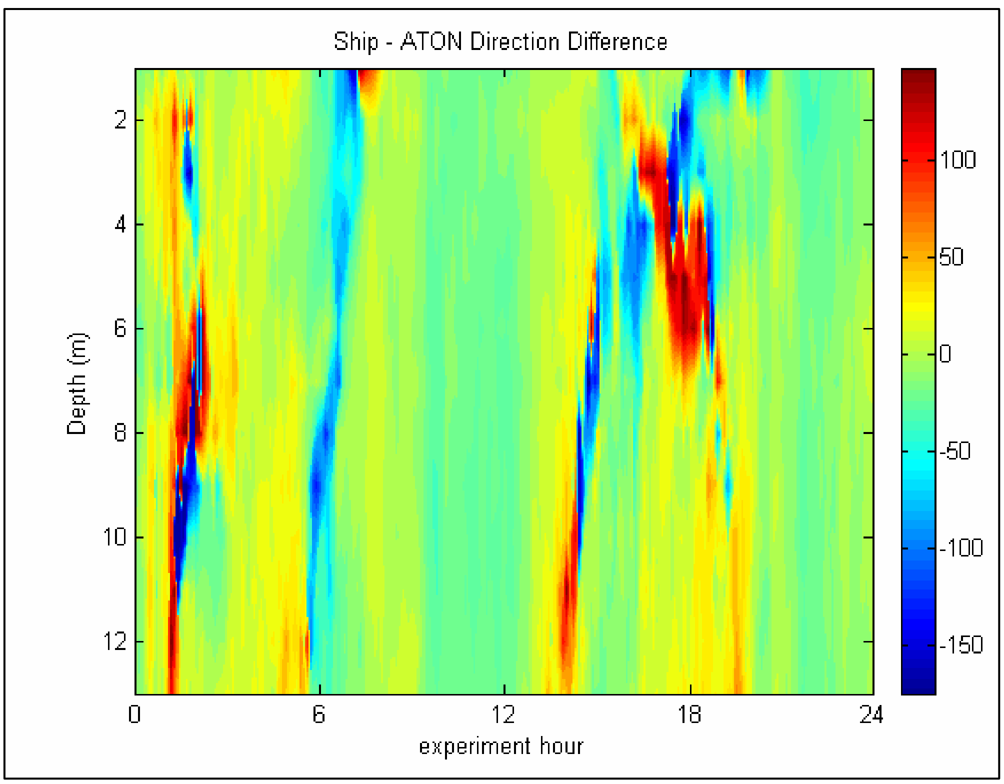

Figure 68. Time-series of current direction difference over depth, Buoy 2CH comparison, May 2004

4.0 FIELD PROCEDURES

4.1 Pre-Deployment ATON Reconnaissance

As with any measurement system installation, a detailed reconnaissance of the particular ATON and at the shoreside station location is essential.

4.1.1 Safety Precautions

NOAA and CO-OPS safety procedures require life vests to be worn by all persons at all times while on a vessel of any size. Closed-toe shoes are also required. The following is an excerpt from the *CO-OPS Field Facility Safety Rules – 4/7/04 draft* which applies to ATON current profiler work. These safety rules supplement the *NOAA Safety Rules Manual (4/1/03 draft)*. Risk of injury or loss of life is not to be compromised for data or equipment.

- Installation and recovery of an ATON ADCP have potentially two major safety hazards: being struck by heavy equipment and falling in the water.
- Weather awareness shall be priority; buoy work should not be conducted at winds higher than 15 knots and seas greater than two feet. The crew's discretion shall be used at all times to determine safe conditions.
- Hard hats shall be available on the boat and shall be worn when lifting the instrument on or off the boat.
- Personal Flotation Devices (PFD) shall be worn by all personnel on a boat.
- Lines should be inspected to ensure good condition.
- An installation/recovery shall have a minimum of four employees.

4.1.2 Establish Local Contact

The CO-OPS PORTS® Site Representative or the PORTS® Implementation Manager will establish a Points of Contact (POC) list for each ATON current station and associated shore station.

4.1.3 Will the Clamparatus fit?

Although 8' x 26' ATONs are a USCG standard, there is slight variability in the size of each buoy. The most important factor is whether or not there is enough space behind one of the lifting eyes to accommodate the electronics box and red ring. CO-OPS has encountered one 8' x 26' ATON that did not have enough flat deck space around an eye to secure the clamparatus. In this case CO-OPS had to move the whole station to an ATON nearby. A site visit should be performed prior to initial deployment on each ATON and after the ATON has been rotated out for service.

4.1.4 Can the signal be received at the shore station?

Prior to the installation of a shoreside station at a specific location, it must be determined whether or not a signal transmitted from the buoy mounted system can be received reliably at that location.

The first step in determining the viability of a site is to perform a visual inspection of the area. There should be a clear line of sight between the antenna on the shore station and the buoy. The site should be able to support a mast of appropriate height for the distance between the shore station and the buoy. (See section 4.3.2)

The radio frequency spectrum that is being used should also be checked to see if there are any possible sources of interference in the area where the shore station is located or in the path between the shore station and the buoy. This can be done using a spectrum analyzer, an omni-directional antenna, and a yagi antenna.

4.2 Deployment Preparation

4.2.1 Assembly Steps

The *Field Guide to ATON Current Measurement Systems* (currently being drafted) contains details of the clamparatus assembly.

4.2.2 Electronics Diagrams

The shoreside station consists of a DCP, communication equipment, and batteries. The DCP is the 9210 model manufactured by Sutron Corporation and is part of the Xpert family of DCPs.

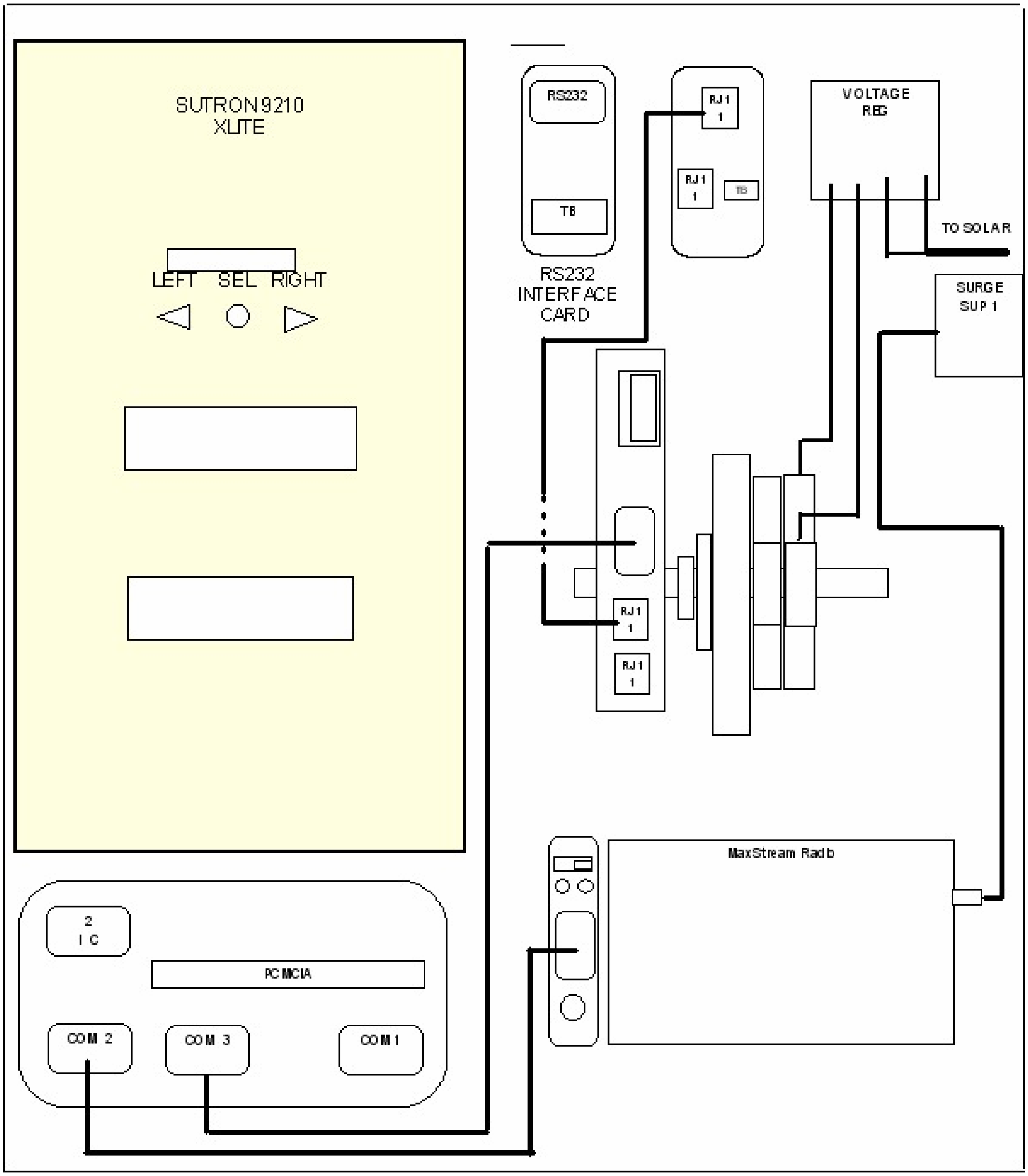

Figure 69. 9210 ADCP shoreside unit with telephone modem

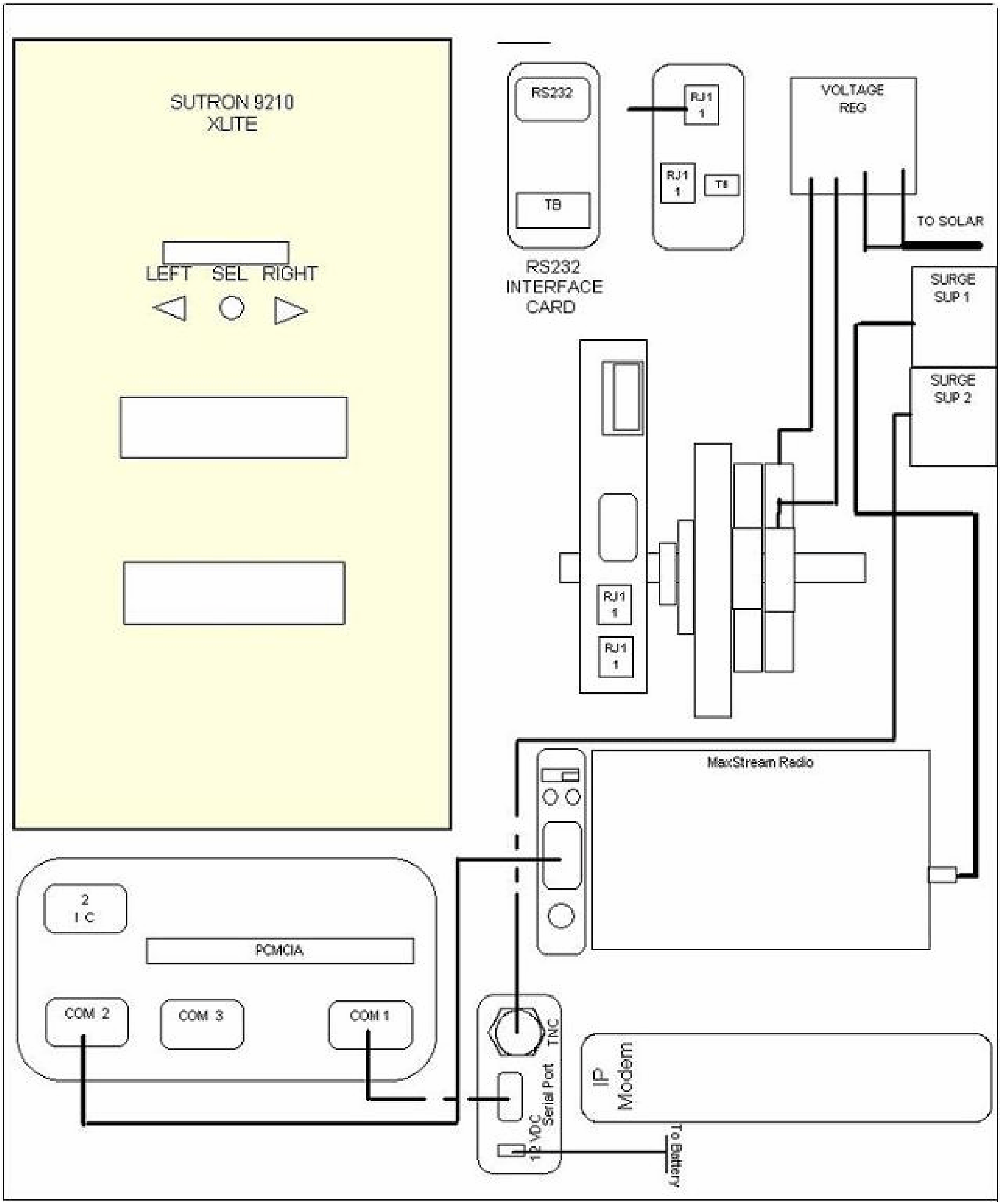

Figure 70. 9210 ADCP shoreside unit with CDMA IP modem

4.2.3 Bench Testing

The following bench testing procedures should be conducted on a complete buoy mount system with an ADCP.

4.2.3.1 Bench test with AquaPro

1. Connect a computer directly to the shoreside radio.
2. Initialize the AquaPro program provided by Nortek.
3. Under the *Communications* tab select *Serial Port*.
4. Set the *Serial port:* field to the com port that the radio is connected to on the computer.
5. Set the *Baud Rate:* field to 2400.
6. Set the *Recorder/Configuration baud rate:* field to 2400.
7. Uncheck the *Hard Break* check box.
8. Left click the *OK* button (Figure 71).

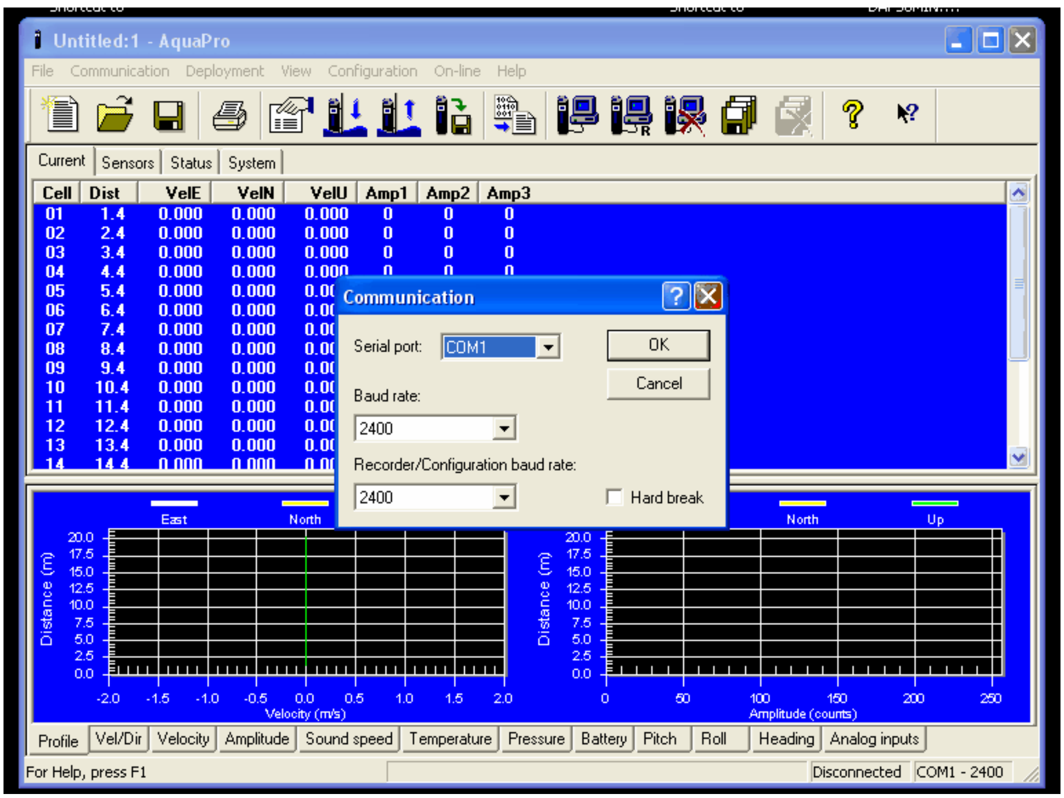

Figure 71. Screen shot of Aquapro bench test configuration

9. Press the *Stop Data Collection* button to initiate the serial port settings. (Figure 72).

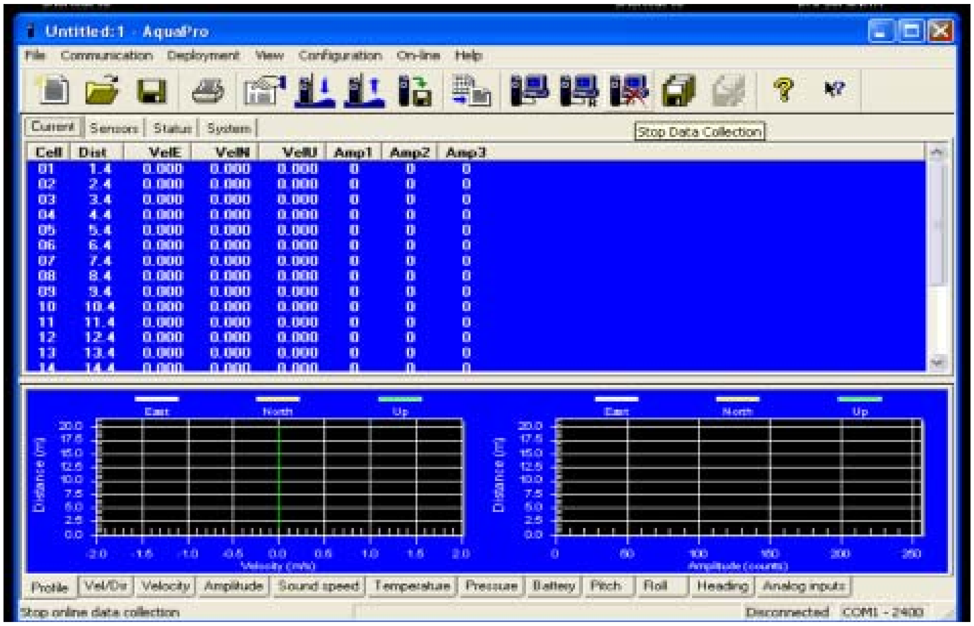

Figure 72. Screen shot of *Stop Data Collection* to initiate serial port settings

10. Under the *Deployment* tab select *Planning* and *Load from Instrument* (Figure 73.)

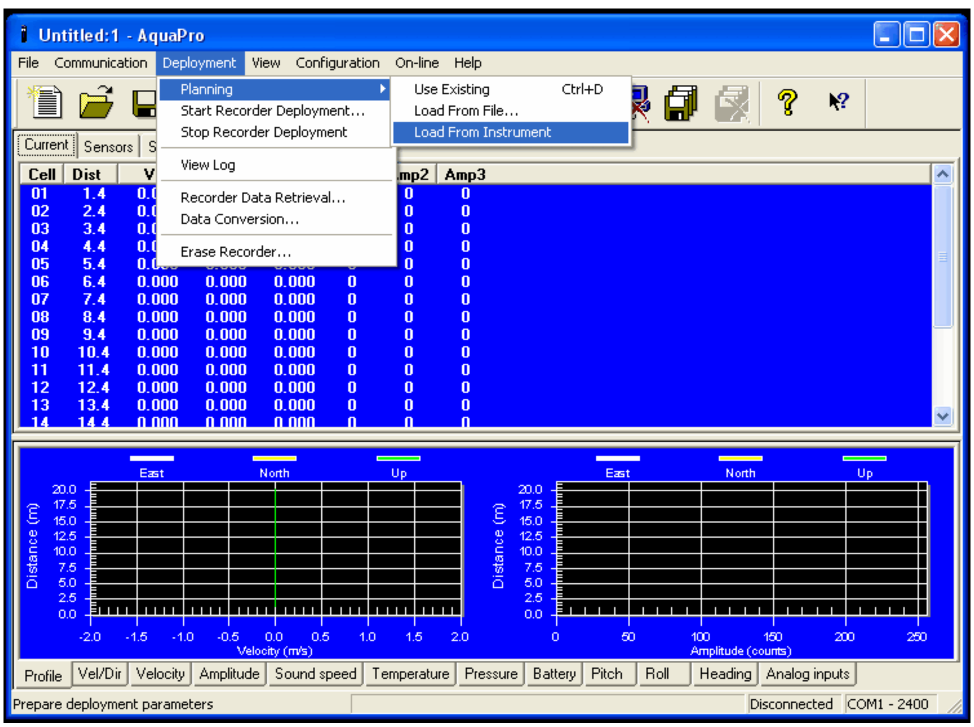

Figure 73. Screen shot of *Load from Instrument* setting

11. Enter the *Deployment Planning* settings as in the following figures and left click the *OK* button.

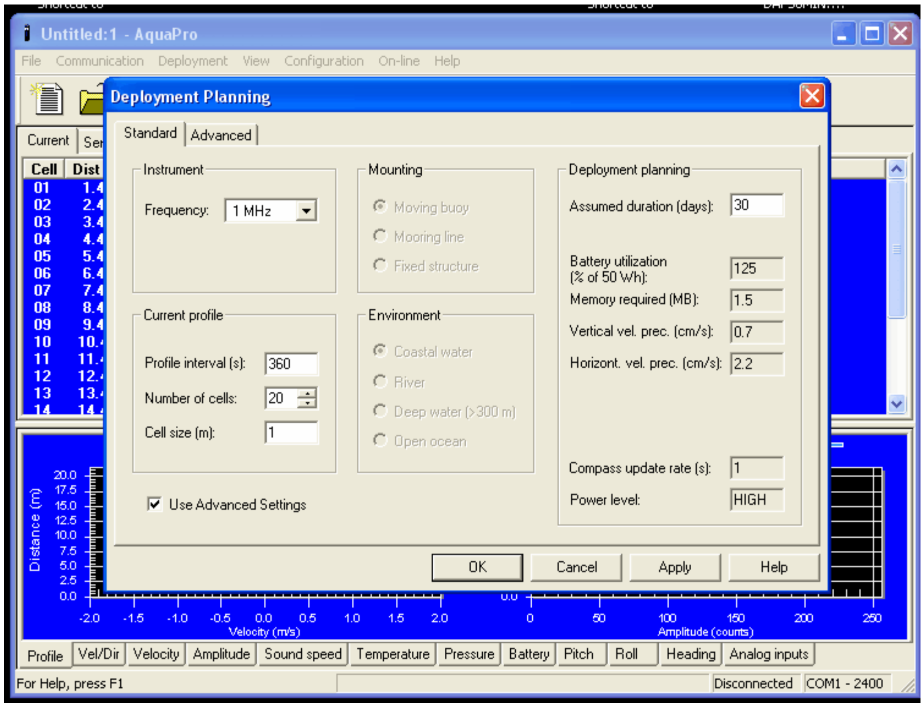

Figure 74. Screen shot from *Deployment Planning* settings – Standard Tab

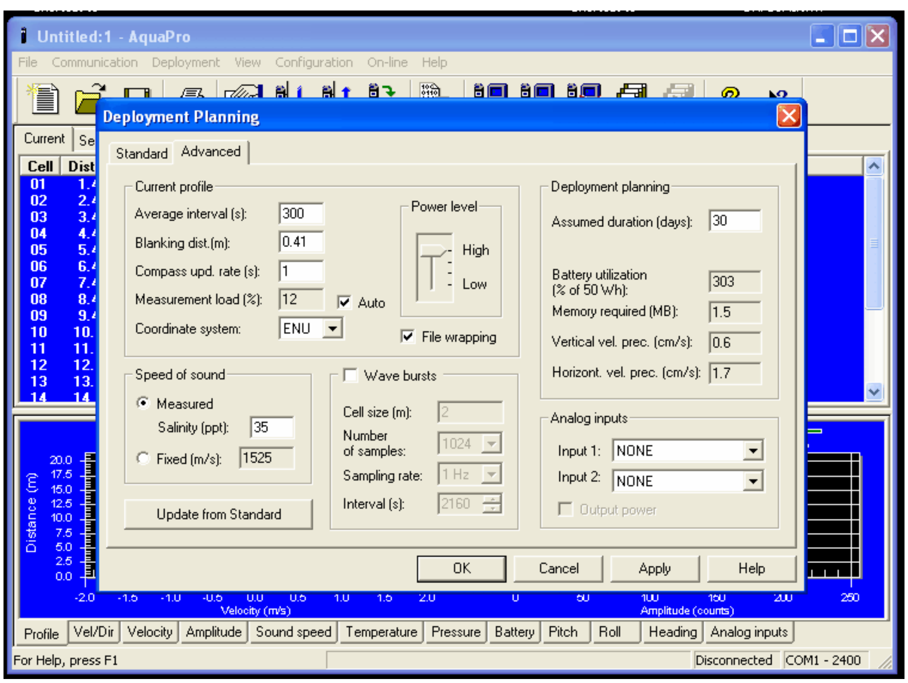

Figure 75. Screen shot from *Deployment Planning* settings – Advanced Tab

12. Under the *Online* tab select *Disk Filename* and enter an appropriate file name in the *Base Name and Folder:* field.
13. Left click on the *OK* button.
14. Under the *Online* tab select *Start Disk Recording* and then select *Start Data Collection*. See Figures 76-77.

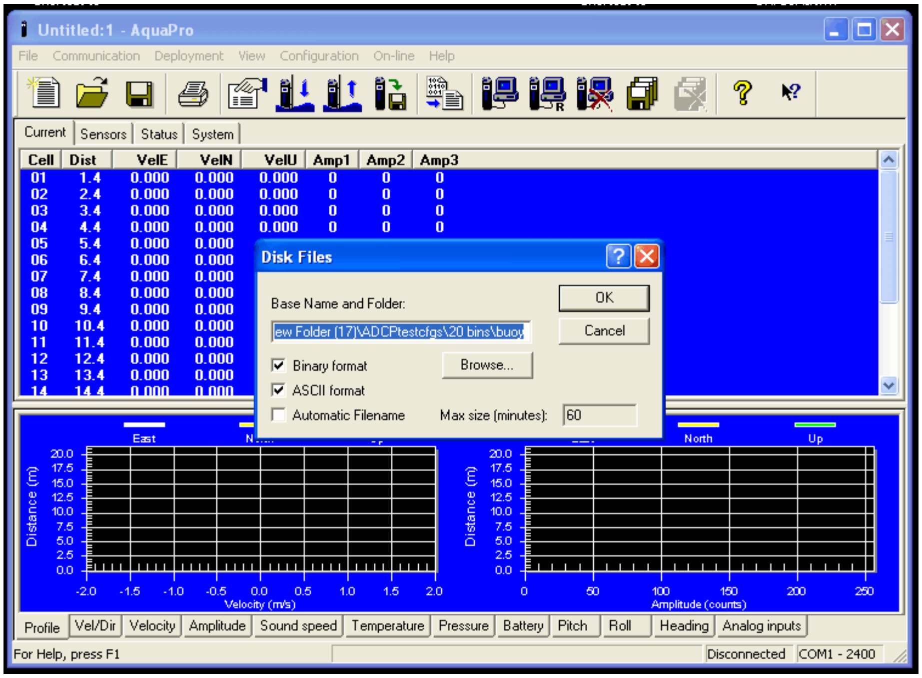

Figure 76. Screen shot from *Start Data Collection Disk Files*

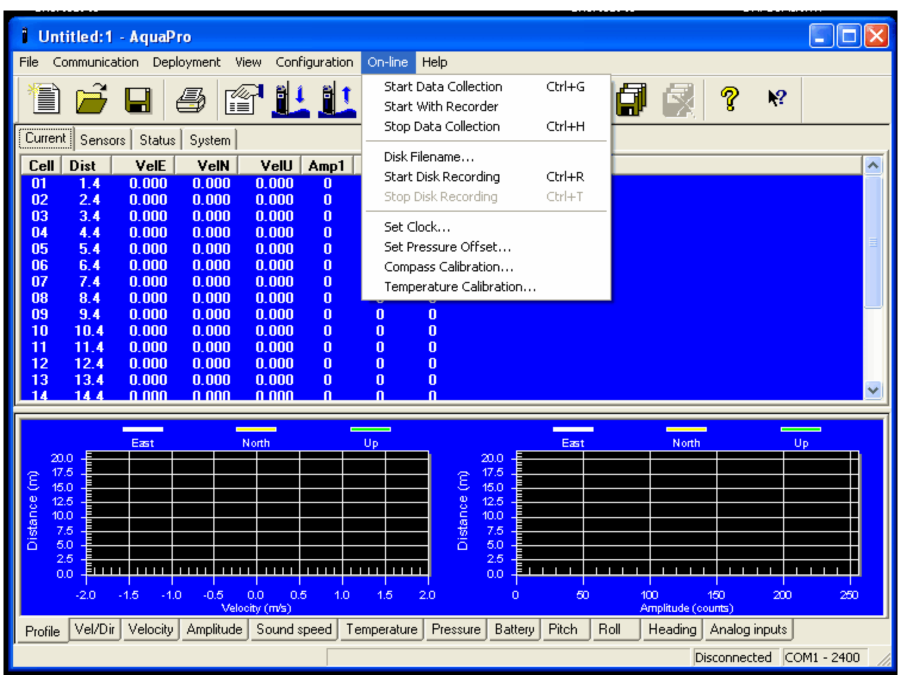

Figure 77. Screen shot from online

15. Allow the ADCP to collect data and observe these data. With the *Deployment Planning* settings used in this test procedure, data will be available in the cell fields after 300 seconds. Data will be available in the other fields and graphs after 360 seconds.

4.2.3.2 Bench test with a 9210

1. Connect COM2 of the 9210 directly to the MaxStream radio and power on the 9210.
2. Connect a computer to COM1 of the 9210 and initialize XTerm. Check to see that recording is ON.
3. After 12-15 minutes have passed, transfer the current MMDDYYYY.dat file and the Recent.dat file to your computer using the *File Transfer* button on XTerm. (Figures 78-79).

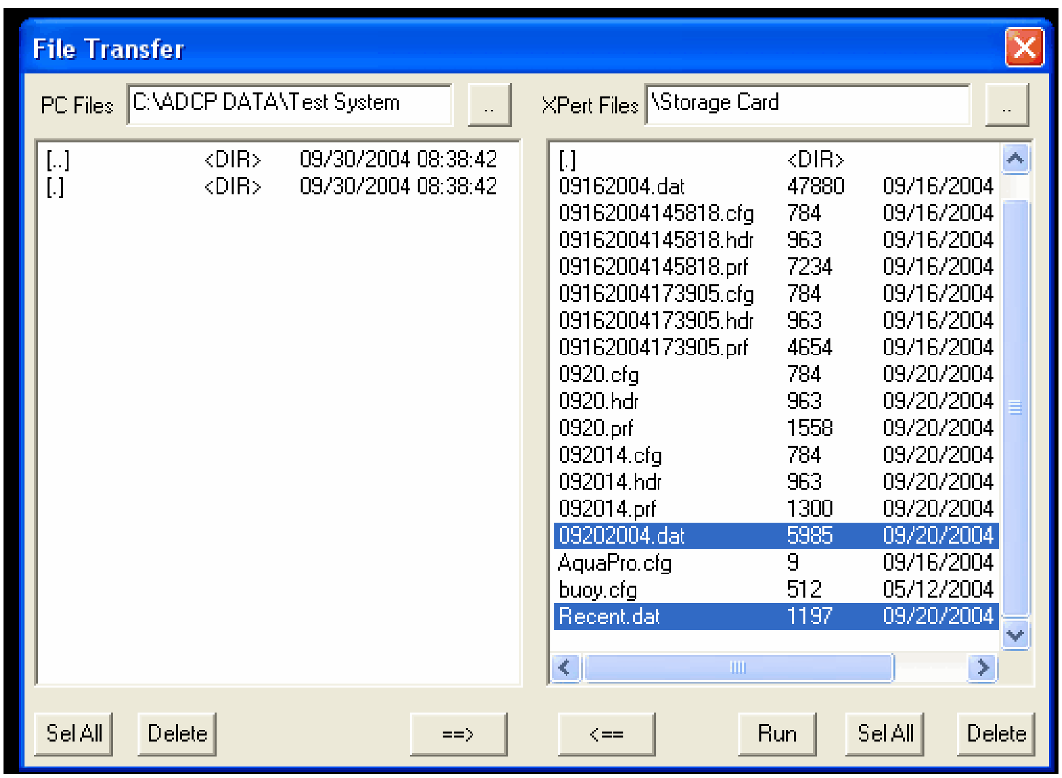

Figure 78. Screen shot of file transfer selecting files to be transferred to PC

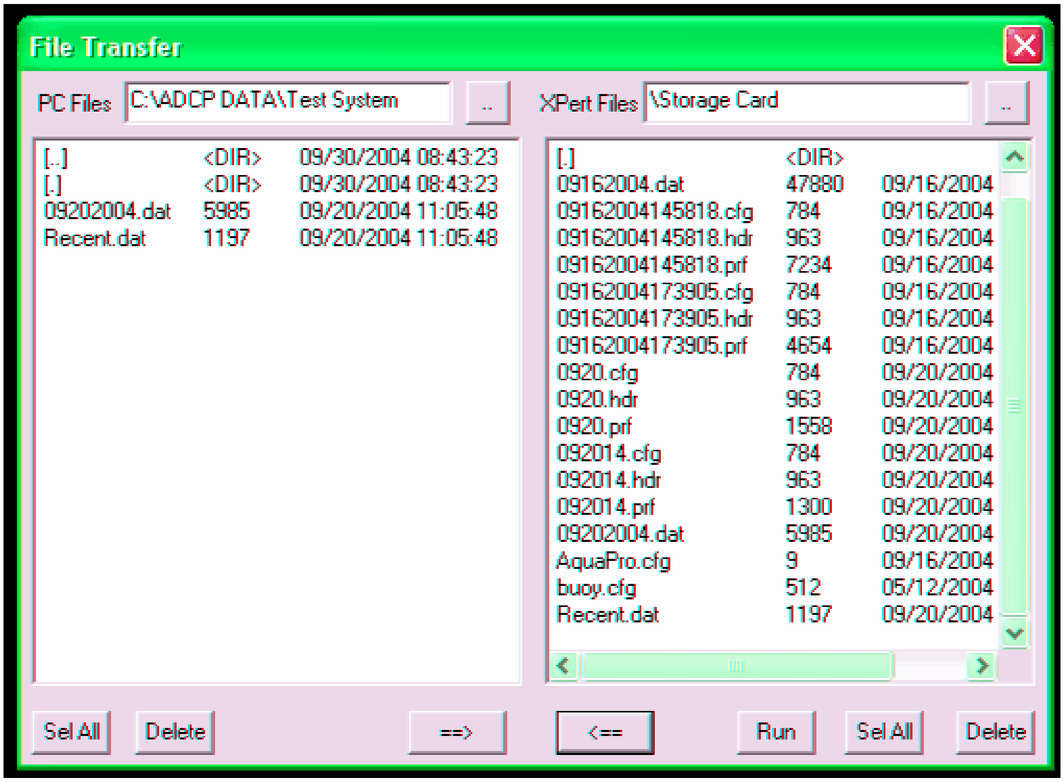

Figure 79. Screen shot of completed file transfer

4. Open the Recent.dat and MMDDYYYY.dat files and check to see that valid data were entered for the last reading. Table 1 is an example of valid data set retrieved from a bench test.

Table 1. Valid data set retrieved from a bench test

****

09	20	2004	14	59	44	00000000	00101100	12.2	1528.1	111.1	56.6	59.8	0.666	23.25	0 15281
	0.916	-0.159	0.464	25.0	24.0	26.0									
	0.426	0.036	-0.449	24.0	24.0	26.0									
	0.850	-0.270	-0.257	24.0	24.0	26.0									
	0.069	0.362	-0.427	24.0	24.0	26.0									
	0.162	0.412	0.060	24.0	24.0	26.0									
	0.551	-0.021	-0.192	24.0	24.0	26.0									
	0.812	0.019	-0.124	24.0	24.0	26.0									
	0.756	0.265	-0.472	24.0	24.0	26.0									
	0.657	0.077	0.396	24.0	24.0	26.0									
	0.420	0.074	0.234	24.0	24.0	26.0									
	0.643	-0.096	-0.154	24.0	24.0	26.0									
	1.133	-0.446	0.143	24.0	24.0	26.0									
	0.647	0.065	-0.432	24.0	24.0	26.0									
	0.341	-0.100	-0.458	24.0	24.0	26.0									
	0.602	0.132	-0.225	24.0	24.0	26.0									
	0.640	0.183	-0.414	24.0	24.0	26.0									
	0.336	-0.233	-0.236	24.0	24.0	26.0									
	0.637	0.021	-0.433	24.0	24.0	26.0									
	1.053	-0.365	0.795	24.0	24.0	26.0									
	1.082	-0.529	-0.504	24.0	24.0	26.0									

5. Allow system to run for 24 hours. Inspect the MMDDYYYY.dat files at the end of this time period for zero fill entries. Also inspect the BadData.dat and BadTime.dat files if necessary.

4.2.4 ATON Current Profiler Deployment Packing List

Prior to installation/maintenance visits, personnel must ensure that the following items are in each of the three ATON bags (Black Duffle, Install, and Calibration). A hard copy of the following text is in a plastic sleeve inside the blue tool bag marked *ATON CAL*. Personnel are encouraged to print a spare and place it somewhere else in their field gear.

On Boat

- Clamparatus with bridle attached (take off clamp block and hardware)
- Life vests
- "Throne" (wooden platform for laptop during calibration spin)
- Line for calibration spin
- "Hoistaratus" (block and tackle used to lift system)

Black Duffle

- First aid kit
- Rags
- Handi-wipes
- Plug grease
- Camera
- Aquadopp Manual
- PORTS® brochures & cards
- Spares (in black zippered pouch)
- Wire snips
- Cable ties
- ½-inch ratchet and open wrench
- Antenna mount /2 U-bolts & hardware
- Clamp block/ bolts & hardware
- 1 ⅛-inch ratchet and open wrench

Blue Bag #1 - Install

- Gloves
- Wire snips
- Cable ties
- ½-inch ratchet and open wrench
- Antenna mount / 2 U-bolts & hardware
- Clamp block/ bolts & hardware
- 1 ⅛-inch ratchet and open wrench
- Large crescent wrench
- Anti-theft Allen screwdriver
- Never Seize
- Marine caulk

Blue Bag #2 - Calibration/Radio

- Laptop w/ AquaPro
- Calibration directions
- Deployment/Recovery Logs
- 12-volt battery
- Test cable
- Dummy plug
- Shore radio and power supply
- Serial cable
- Power inverter
- Vulcanizing tape
- Electrical tape
- Knife

4.3 Initial Installation

4.3.1 ATON Installation

4.3.1.1 Notify Local Contact

The CO-OPS PORTS® Site Representative or the PORTS® Implementation Manager will supply the field crew with a POC list for each ATON current station and associated shore stations. The Field Crew Chief should notify the appropriate local contact several days in advance of the installation. If the ATON is located near a busy navigation channel, the local pilot dispatcher should be notified as a precaution.

4.3.1.2 Safety Precautions

See Section 4.1.1.

4.3.1.3 Securing the Clamparatus

CO-OPS designed and assembled a block and tackle for lifting the clamparatus from the boat onto the ATON. This system of rope, pulleys, and clips is nicknamed the "hoistaratus". The following outlines the steps to be taken to secure the clamparatus.

1. One crew member transfers to the ATON and ties down the bell clappers for noise comfort and safety so the clappers don't pinch anyone.
2. The same or different crew member then carries the hoistaratus to the top of the ATON superstructure and secures it to the cage frame (Figure 40).
3. The three clips are then secured to the eyes in the top ring of the clamparatus.
4. The transfer operation requires two people on the ATON and two people on the boat. One person on the ATON pulls on the lifting line as the two people on the boat guide the clamparatus up and over the bulkhead, taking special care to protect the sensor's acoustic transducers at the end of the tube.
5. One crew member releases the hoistaratus, once the clamparatus has been lowered over the ATON lifting bail.
6. The two crew members on the ATON then place and secure the clamp block.
7. One crew member then climbs to the top of the ATON, removes the hoistaratus and installs the radio antenna. The antenna cable is secured with tie wraps all the way down the ATON's superstructure.
8. At this point the crew member who is running the calibration software should board the ATON.

4.3.1.4 Calibrating a Nortek Compass on an ATON

The ATON's steel hull has a significant magnetic effect on the Nortek compass. Because of this effect, a compass calibration must be run each time a Nortek is installed or swapped out. The calibration is performed by running Nortek's Aquapro software and rotating the buoy slowly at least three rotations of 360° each. The spinning is most easily accomplished by tying one end of a polypropylene line to the buoy's lifting eye and handing off the line to the boat. The boat then circles the ATON three times and prepares to "pull the cord". A hard copy of the following text is in a plastic sleeve inside the blue tool bag marked *ATON CAL*. Personnel are encouraged to print a spare and place somewhere else in their field gear.

The procedure detail is outlined on the following pages.

ATON Calibration Procedure

1. Connect to instrument:

- Unplug sensor cable from electronics box and plug into the test cable
- Put dummy plug on bulkhead connector
- Plug other end of test cable into serial port on laptop computer and power into battery

2. Power up and log onto laptop computer

3. Start Aquapro

4. Increase baud rates to maximum: Communications > Serial Port (no hard break)

5. Calibrate Compass:

- Press Online > Compass Calibration
- Notify the boat that you are ready and push start when spinning starts
- Push STOP when buoy stops spinning or just before (better than after)
- Select Update Instrument if it was a quality calibration
- Select NO if the trace was not three complete revolutions, you think it went too fast, or there was a stop in the spinning
  - If you elected not to update the instrument repeat Step 5
  - When satisfied select **Update Instrument**

6. Save Calibration Data:

In order to export results of the calibration to buoyXXX_cal.dat:

- Right-click on the data plot
- Export > Text/Data Only > File > Browse and select folder and filename
- Export > Data > Table >point/subsets
- Export

7. Check laptop computer for files

8. Reset baud rates to 2400:

- Communications > Serial Port (no hard break) - Baud Rate and Recorder/Configuration Baud Rate

9. Start Instrument Sampling:

- Set up file on laptop to record a few samples
- Online > Disk Filename (name it XXX_buoy_aftercalib)

10. Check clock:

- Online > Set Clock (make sure time is GMT)

11. Check settings:

- Deployment Planning > Download From Instrument

- Uncheck use advanced, check all standard settings:
  - Moving buoy
  - Profile interval 360 seconds
  - Compass update one second
  - 20 one-meter cells
- Click Apply

- Then check Use Advanced, check advanced settings:
  - Average interval 300 seconds
  - Compass update one second
  - Turn on File Wrapping
- Click Apply
- Click OK

12. Start Recorder Data Collection

13. Start Disk Recording

14. Collect two six-minute samples

15. Quit Aquapro SAY NO to turn off recorder

16. Reattach sensor cable to box and screw tight the connector's sleeve

17. Return to boat and relax!!

4.3.2 Shore Station Installation

4.3.2.1 Data Collection Platform

See Section 2.4.1.

4.3.2.2 Power / surge protection

The 9210 and the RF radio run off of a 12V 38AHh battery which is charged by a 30 W solar panel through a 12V, 8ah solid state PV charge controller. The Raven CDMA runs off of a 12V 38AHh battery which is charged by a 30 W solar panel through a 12V, 8ah solid state PV charge controller. The radio and IP antennas are connected to their respective devices through Polyphaser 125-1000 MHz impulse suppressors (lightning protection system) which are connected to earth ground. These suppressors are capable of 50,000ah IEC 61000-4-5 8/20 µs waveform surges.

4.3.2.3 Communications

See Section 2.4.2 .

An estimate of the antenna height required for a specific shore station can be determined using the equation.

$r \approx 43.3 \times \sqrt{(d/(4f))}$

Where r is the antenna height in feet, d is the distance between the shoreside station and the buoy in miles, and f is the frequency in GHz. The value of f should be the lowest frequency in the spectrum being used.

4.3.3 Nortek Settings

CO-OPS has experimented with various Nortek configurations in order to balance data quality (requiring more pinging) and power consumption (less pinging). Table 2 contains the standard configuration currently being used.

Table 2. Standard Nortek Configuration Settings

```
****************************************************************
Configuration file buoy.prf has been created, based on this instrument:
Instrument serial no: AQD 1252
Transducer serial no: AQP 1052
Firmware version: 1.11
Frequency: 1000000 Hz

Instrument configuration:
Cell size: 1.00 m
XmitLength: 1.00 m
Number of cells: 20
Blanking:  0.41 m
Coordinate system: ENU
Measurement interval: 360 s
Averaging interval: 300 s
Pings per s: 1
Compass update rate: 1 s
AquaPro software version (that created config): 1.23
```

Note: this configuration file must be used only with a 1 MHz profiler.

****

4.3.4 Verifying Data Flow

1. Connect a computer to COM1 of the 9210 and initialize XTerm.

2. Check to see that recording is ON.

3. From 12-15 minutes after initiating the recording on the 9210, transfer the current MMDDYYYY.dat file and the Recent.dat file to your computer using the *File Transfer* button on XTerm (Figures 78-79).

4. Open the Recent.dat and MMDDYYYY.dat files and check to see that valid data were entered for the last reading. Table 1 provides a valid data set retrieved from a bench test.

5. Allow the system to run for one hour.

6. Inspect the MMDDYYYY.dat files at the end of this time for zero fill entries. Zero fill entries indicate an unstable radio link or a source of interference.

7. Also inspect the BadData.dat and BadTime.dat files if necessary.

4.4 Preventative Maintenance and Repair Visits

4.4.1 Notify Local Contact

The CO-OPS PORTS® Site Representative or the PORTS® Implementation Manager supplies the field crew with a POC list for each ATON current station and associated shore stations. The Field Crew Chief notifies the appropriate local contact several days in advance of the maintenance visit. If the ATON is located near a busy navigation channel the local pilot dispatcher should be notified as a precaution.

4.4.2 Call CORMS

As with any PORTS® maintenance or repair visit, the CORMS watch stander must be notified prior to starting any work on the shore station or on the ATON itself, and again upon completion of the job. The procedure is as follows:

- Call 301-713-2540
- Identify yourself and the station to be worked on
- Give a general description of the procedure
- Provide an expected time to return the station to operational

4.4.3 Safety Precautions

See Section 4.1.1.

4.4.4 Maintenance Checklist

- Inspect the enclosure for any visible signs of damage. Inspect the weather seal on the enclosure and any cable feed-throughs for damage.

- Visually inspect the mast for damaged or off-axis solar panels, GOES antennas, and radio antennas. Re-adjust or replace as necessary.

- Copy the daily data files off the storage card and delete all daily files except for the most current one.

- Check desiccant tabs and packs and replace if necessary.

- Check battery voltage levels. If below 11.5V direct current (DC), change battery.

- Check voltage entering the voltage regulators from the solar panels and the voltage exiting the voltage regulators. Voltage exiting the regulators should be approximately 13.5VDC, and voltage entering the regulators should be approximately 18VDC on a sunny day.

4.4.5 Deployment and Recovery Logs

For each deployment and recovery of a current profiler, a log sheet must be filed with the Product and Services Division's (PSD's) CECAT team. The log includes date, time, crew, instrument information, location, and weather. A hard copy of the log sheet is in a plastic sleeve inside the blue tool bag marked *ATON CAL*. Personnel are encouraged to print a spare and place it somewhere else in their field gear.

ATON CURRENTS DEPLOYMENT LOG

GENERAL INFORMATION

PORTS:________________________ Date & Time (UTC):________________________

Station ID:______________________ Field Party: _______________________________

Station Name: ___________________ Captain: __________________________________

Vessel: ________________________ Crew: _____________________________________

AQP SETUP INFORMATION

ADP Platform:_______________________ USCG ATON (Light List No):_______________

AQP Make:__________________________ AQP Probe SN:________ AQD SN:__________

Frequency:__________________ Bin length:___________ # bins:________________

Blanking Dist:_______________ Averaging Interval:_____ Sampling Int.:__________

Start Time:__________________ Config. File:__________ Calibration File:________

Data Types:_________________ Offset to UTC:_________ Recorder size:__________

LOCATION INFORMATION

Position:__________________________________ NOS Chart No.:______________________

Local Magnetic Variation:___________________ Station Depth and Source:_____________

Sensor Depth (m):__________________________ Location/Bearings:___________________

ENVIRONMENT

Water Level Station Name:_____________________ Water Level Station No.: ___________

Wave Height:______________ Water Temp:__________ Air temp:______________

Wind Speed:______________ Wind Dir.:____________ Weather Obs:__________

ATON CURRENTS RECOVERY LOG

GENERAL INFORMATION

PORTS:________________________ Date:______________________________________

Station ID:______________________ Field Party: _______________________________

Station Name: __________________ Captain: ___________________________________

Vessel: ________________________ Crew: _____________________________________

LOCATION INFORMATION

Position:___________________________________ NOS Chart No.:______________________

Local Magnetic Variation:____________________ Station Depth and Source:_____________

Sensor Depth (m):__________________________ Location/Bearings:___________________

ENVIRONMENT

Water Level Station Name:______________________ Water Level Station No.: _____________

Wave Height:_____________ Water Temp:__________ Air temp:_______________

Wind Speed:______________ Wind Dir.:____________ Weather Obs:_____________

RECOVERY INFORMATION

Reason for visit:____

Time on Deck or Time of Download:____

AQP DATA RETRIEVAL INFORMATION

ATON Description:___________________ USCG Buoy (Light List No): ________________

AQP Make:_____________ AQD SN:___________ AQP Probe SN: ____________________

Frequency: _____________ Data Types: ________ Time of download:_________________

File name:______________ File size:_____________FTP Location:______________________

4.4.6 Downloading Data from a Nortek on an ATON

The Nortek profiler can store data on an internal recorder, as well as send data out over the serial port in real-time. This capability should always be enabled so that small gaps in communications do not cause gaps in the current data available for comparisons, predictions, and other historical/retrospective data products. The data on the profiler's memory card should always be downloaded *before* removing the clamparatus during maintenance visits.

The following procedure describes how to download data from the instrument and then resume operation. A hard copy of the following text, *Downloading Data*, is in a plastic sleeve inside the blue tool bag marked *ATON CAL*. Personnel are encouraged to print a spare and place it somewhere else in their field gear.

Downloading Data

1. Connect to instrument:

- Unplug sensor cable from electronics box and plug into the test cable
- Put dummy plug on bulkhead connector
- Plug other end of test cable into serial port on laptop computer and power into battery

2. Power up laptop computer

3. Start Aquapro

4. Increase baud rates to maximum: Communications > Serial Port (no hard break)

5. Retrieve Data:

- Select Recorder Data Retrieval icon - select files - save to desktop
- Repeat as necessary to get all data
- Close Data Retrieval dialog box

6. Check desktop for files and file size

7. Reset baud rates to 2400:

Communications > Serial Port (no hard break) - Baud Rate and Recorder/Configuration Baud Rate

8. Start Instrument Sampling:

- Set up file on laptop to record a few samples:
- Online > Disk Filename (name it XXX_buoy_aftercalib)

9. Check clock:

- Online > Set Clock (make sure time is GMT)

11. Check settings:

- Deployment Planning > Download From Instrument

- Uncheck use advanced, check all standard settings:
    - Moving buoy
    - Profile interval 360 seconds
    - Compass update one second
    - 20 one-meter cells
- Click Apply

- Then check Use Advanced, check advanced settings:

- ■ Average interval 300 seconds
- ■ Compass update one second
- ■ Turn on File Wrapping

- Click Apply
- Click OK

12. Start Recorder Data Collection

13. **Start Disk Recording**

14. Collect two six-minute samples

15. Quit Aquapro SAY NO to turn off recorder

18. Reattach sensor cable to box and screw tight the connector’s sleeve

Return to boat and relax!!

4.4.7 Downloading Data from the Shore Station DCP

Data can be retrieved from the DCP in two forms, either as Recent.dat file or the daily files.

4.4.7.1 Recent.dat

The Recent.dat file is mainly used when the system is being polled. This file provides the most recent data set. The Xpert operating system allows the user to create a custom login, which provides the Recent.dat file when prompted with that login.

4.4.7.2 Daily Files

The daily files are in the form MMDDYYYY.dat. These files contain all the data sets from that day. These files can be retrieved by logging into the 9210 under a *Setup* login. Open the file transfer screen by pressing the *File Transfer* button. Highlight the appropriate daily files and press the "<==" button to transfer the files to the connected computer (Figure 80).

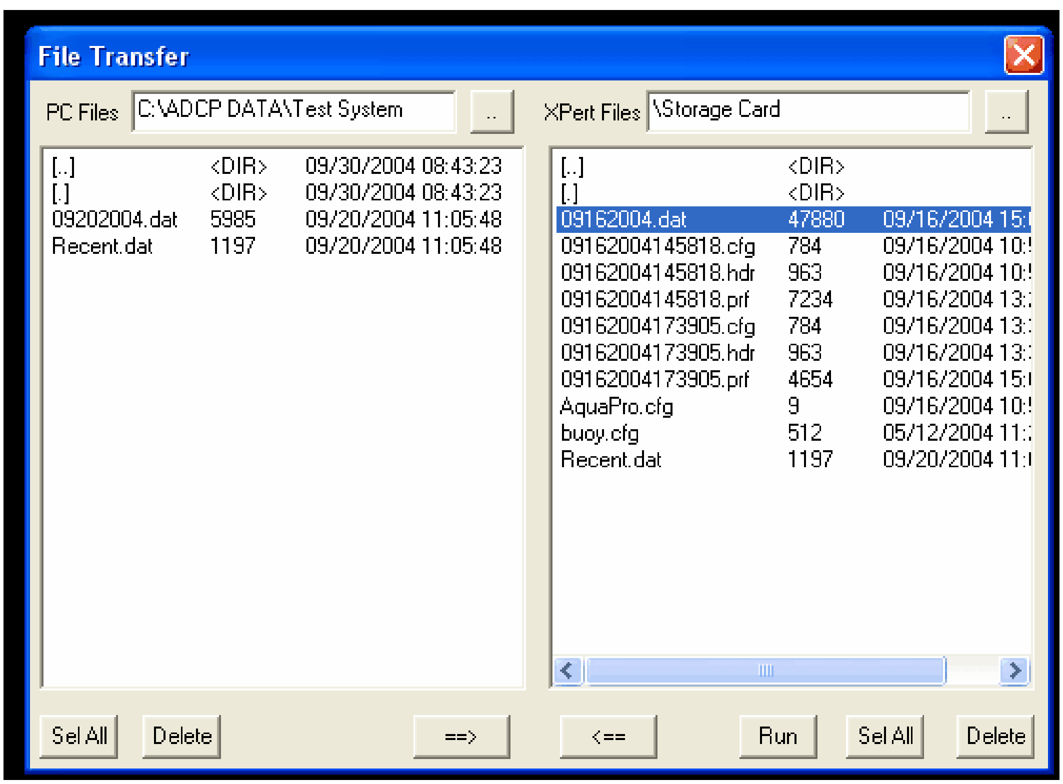

Figure 80. Screen shot of file transfer to connected computer

4.4.8 Nortek Settings

See Section 4.3.3

4.4.9 Verifying Data Flow

See Section 4.3.4.

5.0 DATA FLOW

5.1 From the ATON to Shore

The clamparatus electronics box contains a MaxStream spread-spectrum radio, which transmits the current data to the shore station every six minutes. The Sutron DCP is connected to the receiving MaxStream radio modem at the shore station. Once the DCP is at full power, it performs a number of self-tests on its internal systems; any errors are displayed on the front panel LCD and recorded in the system logs. After the self-tests, the system reads the setup file and initiates the AquaPro.sll, the software that performs the following:

- Sets the recording options (daily, weekly recent, and/or time sync)
- Checks COM ports and baud rates
- Wakes up the MaxStream radio on the buoy
- Establishes communications with the profiler
- Stops the profiler
- Sets the profiler time and date
- Sets the profiler parameters (settings are taken from the buoy.cfg file on DCP)
- Starts the profiler
- Establishes the following files on the DCP storage card
    - ■ MMDDYYYYHHMMSS.hrd — ASCII text file based on the Buoy.cfg file that lists the profiler's parameters
    - ■ MMDDYYYYHHMMSS.cfg—a copy of the Buoy.cfg file
    - ■ MMDDYYYYHHMMSS.prf—raw profiler data
- Starts polling the radio serial port every three seconds

Every six minutes the profiler sends the raw data to the DCP. When the DCP receives the data the following actions are taken:

The received message length is compared to the expected message length.

If the message is complete:

- Copies the raw message to the MMDDYYYYHHMMSS.prf file
- Converts the raw message to ASCII
- Places a copy of the raw ASCII data in the Recent.dat file
- Appends the MMDDYYYY.dat or weekly.dat file with the raw ASCII data

If the message is not complete:

- Appends the raw message to the BadData.dat file.
- Writes the time the data was received, the message length, and an error flag to the BadTime.dat file

If a message is not received within a given time frame

- Takes the time and date from the DCP, writes an ASCII file with that time and date, and copies it to the Recent.dat file.
- Sets all data fields in the file to zero.
- Writes the file to the MMDDYYYY.dat

5.2 To the Data Acquisition System (DAS)

The data flow for the Nortek profiler is consistent with other types of current meters used in CO-OPS, with one exception. With other current profilers the DAS directly polls the instrumentation, but with the Nortek the DAS polls an Xpert DCP. The DCP collects data from the Nortek and creates a data file for the DAS.

The DAS collects data from the DCP every six minutes. Data collection is controlled by a LINUX "cron" process. The "cron" process starts a data collection script, which uses kermit to retrieve the data from the DCP. The DAS acquires the data from the DCP by using various communication methods. With a connection to the DCP, the DAS enters a special login, which triggers the DCP to output the last data sample collected from current profiler. The DCP outputs the data in a pre-determined format file called *recent.dat* (example in Table 3):

Table 3. Example of a "recent.dat" format file

```
*******************************************************************************************
Login user: a
  Password:
Recent.Dat
09 27 2004 13 54 52 00000000 00110001  11.9 1520.1 115.1  -3.5   4.3   2.701  20.58     0 15201
  -0.488  -0.258  -0.116 103.0 195.0 106.0
  -0.299  -0.173  -0.035 100.0 153.0 115.0
  -0.181  -0.077   0.032  96.0  71.0 113.0
  -0.305  -0.059   0.107 106.0  58.0 115.0
  -0.394  -0.022   0.124 107.0  61.0 112.0
  -0.433  -0.217   0.121 105.0  59.0 102.0
  -0.530  -0.248   0.123 103.0  52.0  90.0
  -0.529  -0.318   0.085  89.0  47.0  80.0
  -0.428  -0.392  -0.002  69.0  42.0  70.0
  -0.379  -0.306  -0.027  69.0  39.0  68.0
  -0.373  -0.334  -0.034  79.0  43.0  79.0
  -0.264  -0.343  -0.021  97.0  53.0  93.0
  -0.087  -0.102  -0.022 136.0  88.0 131.0
  -0.008  -0.047  -0.021 106.0 112.0 127.0
   0.030  -0.065  -0.021  31.0  52.0  51.0
  -0.187   0.007   0.064  21.0  25.0  24.0
  -0.159  -0.035   0.022  20.0  22.0  21.0
  -0.079  -0.080   0.127  20.0  21.0  21.0
   0.102  -0.223   0.009  21.0  20.0  20.0
  -0.113   0.075   0.167  20.0  20.0  20.0

End Recent.dat
      *************************************************************************************
```

After the DAS has acquired the current data, it begins a series of steps to produce quality control (QC) flags that indicate the quality of the data. A *Criteria Table* is used to implement QC checks. The table contains a set of high and low ranges, against which the data collected are compared. This table and the actions that result from the flag generation are described in Section 6.0 (Quality Control).

The result of the processing and data checking is that the DAS produces a PUFFF (PORTS® Uniform Flat File Format) file, a PORTS® standard data product, which is used to share PORTS® data with our users. A detailed description of the PUFFF documentation is available at http://co-ops.nos.noaa.gov/publications/pufff4.pdf. Table 4 contains an example of an ATON PUFFF.

Table 4. ATON PUFFF

```
***************************************************************************************************************8***
**********Chesapeake Bay PORTS
cb1101 LBB "92"

  1142   -42    18  2056   271     0     0     0     0     0 15201         0         0
 2004 09 27 13 54  20 00000000000000000000000000001000 401 FCSC
   1   -396   -270    -53    236    479     49     84     50      0      0      0   2056
00000000000000000000000000000000
   2   -311   -230     -3    233    387     45     65     49      0      0      0   2056
00000000000000000000000000000000
   3   -330   -118     54    250    351     44     32     48      0      0      0   2056
00000000000000000000000000000000
   4   -354   -111    132    253    371     46     28     49      0      0      0   2056
00000001100000000000000000000000
   5   -414   -111    146    255    429     46     29     48      0      0      0   2056
00000000000000000000000000000000
   6   -385   -231    150    239    449     43     28     43      0      0      0   2056
00000000000000000000000000000000
   7   -441   -320    132    234    545     41     26     37      0      0      0   2056
00000000000000000000000000000000
   8   -449   -371     75    230    583     36     22     33      0      0      0   2056
00000000000000000000000000000000
   9   -348   -307     40    229    464     31     19     32      0      0      0   2056
00000000000000000000000000000000
  10   -243   -316      7    218    398     29     18     30      0      0      0   2056
00000000000000000000000000000000
  11   -299   -323     -5    223    440     31     18     31      0      0      0   2056
00000000000000000000000000000000
  12   -246   -312     -7    218    397     41     22     40      0      0      0   2056
00000000000000000000000000000000
  13    -26    -97    -14    195    101     58     38     56      0      0      0   2056
00000000000000000000000000000000
  14     59      0    -24     90     59     43     49     54      0      0      0   2056
00000000000000000000000000000000
  15    -45     64     21    325     79     13     23     22      0      0      0   2056
00000000000000000000000000000000
  16     31    -38    -11    141     49      9     11     10      0      0      0   2056
00000000000000000000000000000000
  17      0    253     74      0    253      9      9      9      0      0      0   2056
00000000000000000000000000000000
  18     78    277    148     16    288      9      9      9      0      0      0   2056
00000000000000000000000000000000
  19    158     91     65     60    182      9      9      9      0      0      0   2056
00000000000000000000000000000000
  20   -122   -538    118    193    552      9      9      9      0      0      0   2056
00000000000000000000000000000000
               0       0       3       0       0       1       2     1       0
       0       0       0      49       0       0       0       0     0       0
       0       0       0       0       0       0       0      60  2709
CORMS 01000000000000000000000000000000 01010000000000000000000000000000
***************************************************************************
```

5.3 Data Flow to CORMS and to Products

The DAS then begins the process of sending data back to Silver Spring for CORMS and ingestion into the CO-OPS databases. The data are transferred from the DAS to TESTPORT, a server in Silver Spring, which adds no value to the data but acts as a traffic cop by transferring data to the appropriate servers throughout CO-OPS.

TESTPORT distributes the current data along with all the other data types collected as PUFFF files to a number of CO-OPS servers that are involved in the ingestion process (Figure 81). The Data Ingestion Server (DIS) acquires, processes, generates QC flags and loads the data into the NPDB (CO-OPS databases). The CORMS server provides an interface for the CORMS operators to see the flags that are generated at the DAS. It allows the operators to stop and start dissemination of sensor data. The users then access the data using the various interfaces and products that CO-OPS has developed.

It is important to note that ATON current profiler data follow the same path as other CO-OPS data types.

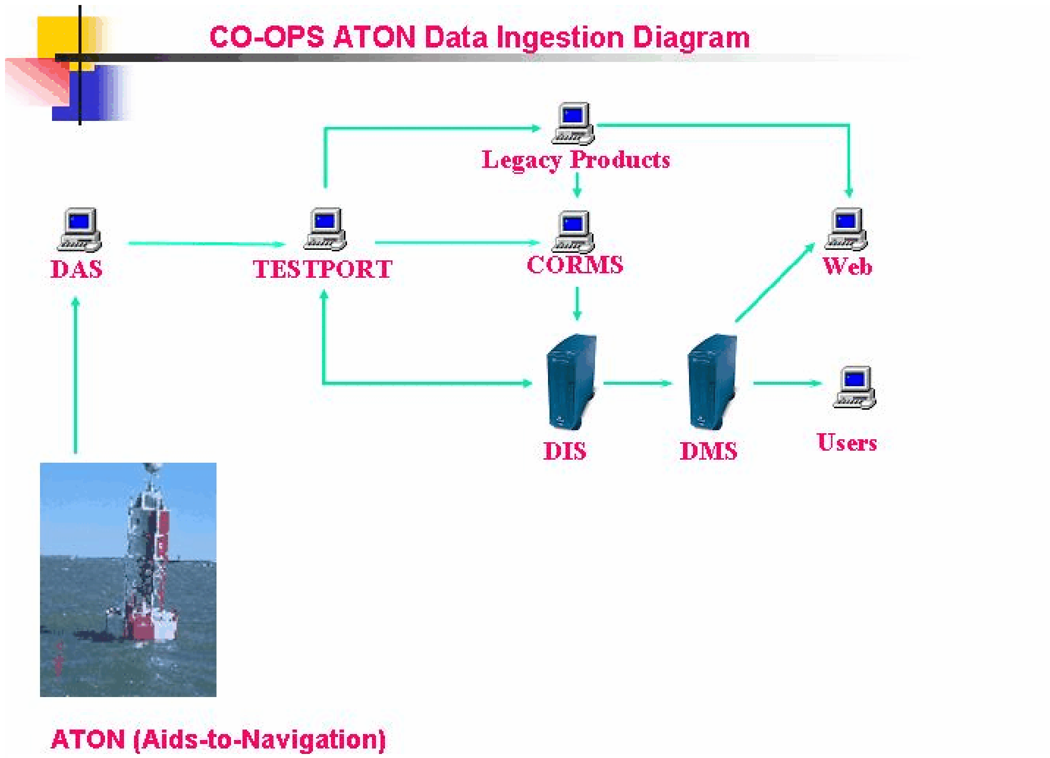

Figure 81. CO-OPS ATON Data Ingestion Process

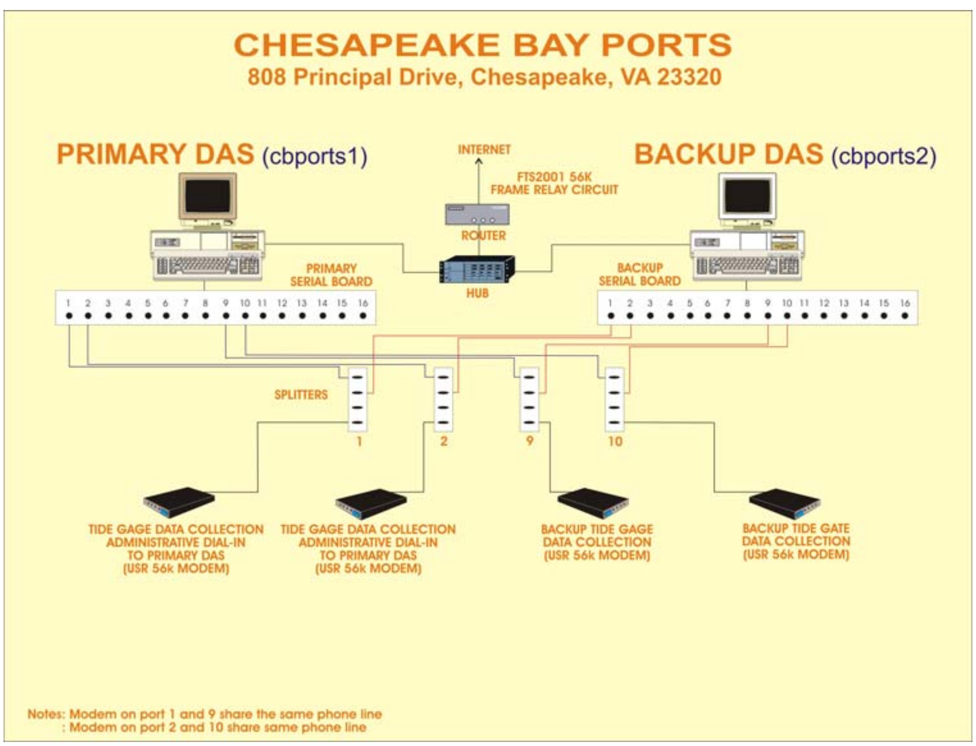

Figure 82. Diagram of the Chesapeake Bay PORTS® data collection system

6.0 QUALITY CONTROL

Dissemination of data of a known quality in an operational real-time environment is a priority for CO-OPS, thus QC is performed at two possible locations during the ingestion process. QC is conducted either when data are collected at the DAS or when the data arrive at the DIS via GOES transmission. The same QC criteria are used at each of the ingestion sites. Data quality is evaluated by the CORMS Operators who have plotting tools to visually inspect the data using the CORMS Interface.

The DAS provides point-to-point QC as data are collected. The following checks are performed on the data to generate QC flags. The types of QC checks that are flagged are:

- Time Check

The time associated with each data sample is compared to the DAS system clock, which is synchronized daily with the Naval Observatory clock. The DAS uses a time range from 18 minutes into the past to two minutes into the future. If the time of the data is outside this range, then the DAS flags these data as bad. The data are saved to a log file on the DAS. This log provides a troubleshooting history. The time check was implemented to handle clock drifting issues that occur in all types of sensors and to check for setup errors associated with time zone changes (i.e., GMT versus standard or local time).

- Absolute Range

The values for speed, pitch, roll, heading, water temperature, pressure, and echo amplitude must fall between a pre-determined lower and upper limit (see Table 6). If any value is greater than the upper limit or less than the lower limit, the DAS sets a warning flag for the data. The range limits for each of the parameters at each station may be adjusted after 30 days of good data are acquired.

- Rate of Change

Rate of change values listed as “delta warn” in the criteria file are not implemented at the DAS level at this time. The rate of change flags will be implemented in the future.

- Real-Time Bin

The real time bin is the depth area in the water column chosen to be reported in real-time for dissemination to the public. The real-time bin is defined in the station control file (Table 6) along with a valid lower limit. If there are any QC flag warnings or failures at the real time bin, the next lower bin is used until the lower limit is reached. Data below the lower limit are saved to a file, but not disseminated.

Table 5 provides an example of a Criteria File.

Table 5. Sample Criteria File

```
************************** Sample Criteria File ********************************
#lowest    below this value is an error
#highest   above this value is an error
#
#lowest   highest
#error    error
 0.0         150.0        FSPD min/max speeds cm/s
-19.0         19.0        FXTL pitch (x axis)degrees
-19.0         19.0        FYTL roll  (y axis)degrees
 0.0         360.0        FHDG heading     degrees
-99999     999999       FXPR     pressure     decibars
0           100           FEAM      echo amp.       db
1          10             FRT1   limits for bin to use
*************************************************************************
```

All Nortek AQDs are assigned as instrument (ADCP) type "5" in the DAS control file (see Table 6). Specific parameters of the criteria file are associated with each instrument type. The criteria parameters of the Nortek Aquadopp are speed, pitch, roll, heading, water temperature, echo amplitude, and limits for bin to use. Criteria ranges are site specific and based on long term data trends. Table 6 contains an example of a control file for Buoy 2CH at Cape Henry Light Wreck of Lower Chesapeake Bay.

Table 6. Sample control file for Buoy 2 CH

```
************************ Sample Control File *******************************
cb0102                                  station id (Nortek s/n 0895)
Buoy 2CH                                station name
i073                                    instrument id number
                                        calib id number              adcp
                                        calib id number              press
                                        calib id number              temp
                                        calib id bumber              cond
/tables/critr                           criteria id number
/ports                                  absolute unix directory      path
/archive                                raw hex data path
/tables/calib                           calib table path
/tables/instr                           instrument table path
/tables/locat                           station table path
  36 57 33                              latitude north
  76 00 46                              longitude west
71.0                                    charted depth                feet
71.0                                    fathometer reading           feet
(uncorrected)
soft, sand                              bottom type
39.00                                   ht. trans. above bottom      inches
                                        weather
                                        divers' observations
33.                                     length of deployment         days
rt                                      operational mode (rt or sc)
05 22 2000 20.817                       start time first record      m d y hh.hh gmt
                                        stop time last record        m d y hh.hh gmt
25                                      number of bins sampled
1.0                                     bin length                   meters
1                                       pulse rep. rate              seconds
1                                       transmit interval            seconds
1.0                                     depth cell length            meters
0.0                                     blanking time
0.4                                     blanking distance            meters
120                                     # pings per ensemble
25                                      % good threshold
1.00                                    time between pings           seconds
360                                     ensemble period              seconds
-10.8                                   compass deviation            degrees
adcp/devel                              processed data file path
0                                       speed range (0=low,1=high)
25.0                                    salinity                     ppt
298                                     flood direction              degrees True
117                                     ebb direction                degrees True
0                                       adcp orientation, see devel.f (1-4)
4    4    20   4                        bin to use for real-time
5                                       local standard time zone     hours
5                                       adcp type (0=narrowband,1=broadband,2=sontek)
0                                       time used in this instrument (GMT=0)
01010000000000000000000000000000        Sensors installed
        *****************************************************************
```

Processing checks include leader checks where the following are consistent from one time stamp to the next. If not, then data are flagged and stored in a log file.

- instrument serial number
- transducer serial number
- frequency of the sensor
- firmware version
- coordinate system
- number of cells
- cell size
- transmit length
- sampling interval
- averaging interval
- blanking distance
- pings per ensemble
- compass update rate
- AquaPro software version that created the configuration file

The error and status codes listed in the first line of the PUFFF file are not quality-controlled through the criteria file; since there are no range limits, they are either good or bad. If any of the status and error codes fail, then the data are ingested into the database without being disseminated.

CORMS. CORMS is a quality control and decision support system that combines use of real-time communications, data analysis, system monitoring graphical user interface (GUI), and system "watch dog" and notification capability. The objective of CORMS is to have the capability of 24-hour per day monitoring and quality control to ensure the availability and accuracy of tide, meteorological and current observations that are used for navigation and safety of life and property decisions.

CORMS functions include:

- ingest real-time and near real-time data and information
- determine data completeness
- measure data quality
- generate statistics used to evaluate system performance
- provide decision making information for possible field team response
- communicate to real-time and near real-time users the identification of invalid or suspect data

ATON current data are fed to the CORMS system just like any other sensor that CORMS monitors (Figure 83). The CORMS Operators have Standard Operating Procedures (SOPs) for all instrument data types (Appendix C). CORMS operators use these SOPs when monitoring ATON current data.

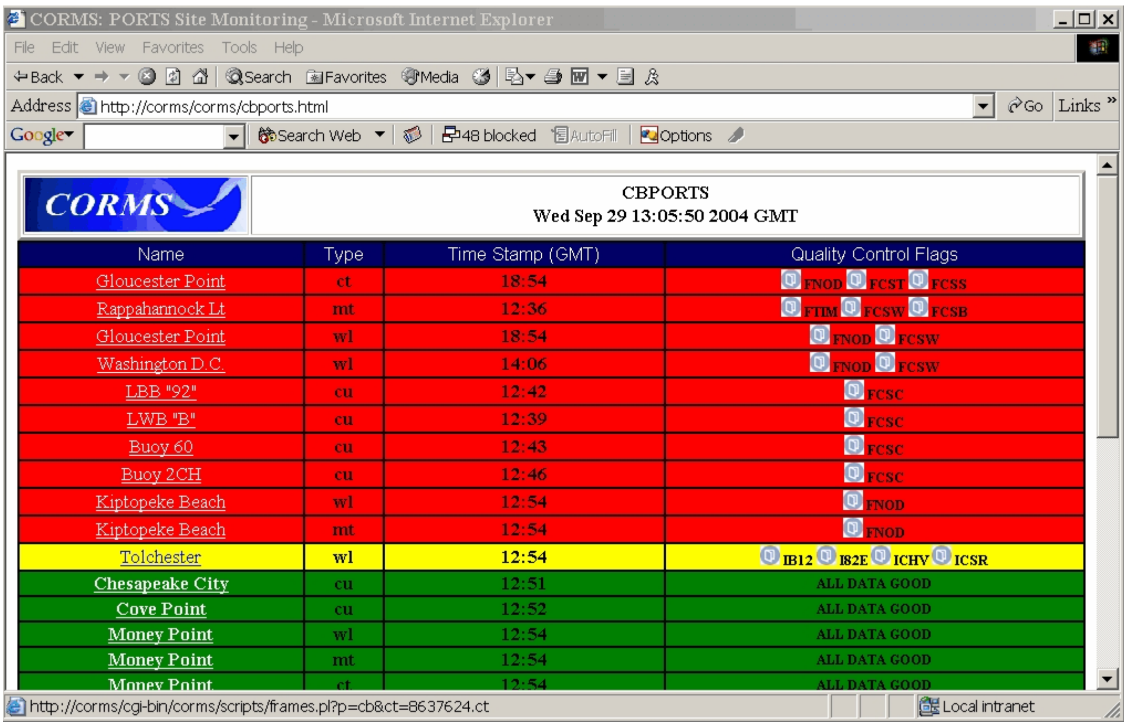

Figure 83. ATON current data fed to CORMS, current profiler stations are labeled "cu"

7.0 PRESENT PRODUCT SUITE

The products generated for current data derived from ATON-mounted current profilers are identical to those from bottom-mounted systems in PORTS®. There is a composite page as shown in Figure 84, plus a three-day time-series of currents. Data are also available in text form and on the voice system. PUFFF files are generated and made available for all ATON current data. In addition to the web-based graphics, harmonic constants of the buoy-mounted current data can be produced after at least 30 days of good data are acquired. The predictions from PORTS® stations may also be published in the *NOAA Tidal Current Tables* if deemed necessary.

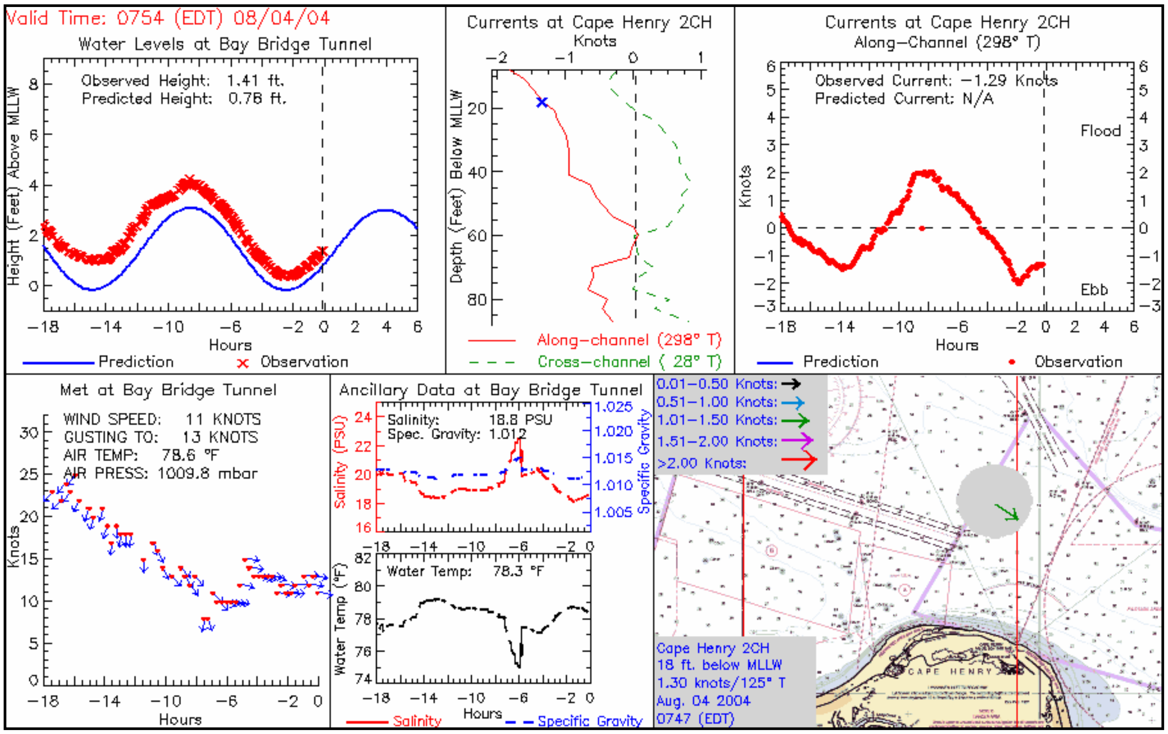

Figure 84. Composite page from PORTS®

8.0 RECOMMENDATIONS AND NEXT STEPS

Successful deployment of this system represents an important step forward for the PORTS® Program. The multi-year test and evaluation process has been challenging at times, however CO-OPS can now release ATON current observations to the public as part of the CO-OPS suite of real-time products. CO-OPS plans to continue to enhance current information provided by the ATON system by investigating 1) the use of a GPS compass during calibration to produce a refined compass correction table, and 2) better methods for compensating for the ATON's motion.

CO-OPS management personnel have reviewed this document and concur that the evaluated sensor/system, when deployed and implemented as described herein, meets the defined requirements and is suitable for operational use. While additional testing may lead to superior performance or more economical operation, the existing sensor/system configuration is sufficient as described for use in the PORTS® program.

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Vendor Contacts

NortekUSA

Malcolm A. Williams
(410) 295-3733
222 Severn Avenue, Suite 17
Annapolis, MD 21403
mwilliams@nortekusa.com

The Oceanscience Group

Ron George
(760) 754-2400
110 Copperwood Way, Suite E
Oceanside, CA 92054
rgeorge@oceanscience.com

MaxStream, Inc.

355 South 520 West Suite 180
Lindon, Utah 84042

Sutron

Tony Scott
(703) 406-2800
21300 Ridgetop Circle
Sterling, VA 20166

AirLink Communications

Mary Brandow
(719) 528-8778
mary@airlink.org

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ACRONYMS

ADCP	Acoustic Doppler Current Profiler
ah	Ampere-hours
AQP	Aquadopp Profiler
ASCII	American Standard Code for Information Interchange
ATON	Aid to Navigation
Bps	bits per second
CCPO	Center for Coastal and Physical Oceanography
cm/s	Centimeters per second
CDMA	Code Division Multiple Access
CECAT	Coastal and Estuarine Current Analysis Team
CO-OPS	Center for Operational Oceanographic Products and Services
CORMS	Continuous Operational Real-time Monitoring System
COTS	Commercial Off The Shelf
CSU	Channel Service Unit
DAS	Data Acquisition System
DC	Direct Current
DCP	Data Collection Platform
DIS	Data Ingestion Server
DLL	Dynamic Linked Library
DMS	Data Management System
DSU	Data Service Unit
FOD	Field Operations Division
GMT	Greenwich Mean Time
GPS	Global Positioning System
IP	Internet Protocol
ISD	Information Systems Division
KHz	Kilohertz
LBB	Lighted Bell Buoy
LCD	Liquid Crystal Display
m	Meters
mA	Milliamps
MPA	Maryland Port Administration
NCOP	National Current Observation Program
NGWLMS	Next Generation Water Level Measurement System
NIST	National Institute of Standards
nm	Nautical Miles
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
NPDB	National Ports Database
NSWC	Naval Surface Warfare Center
NWLON	National Water Level Observation Network
OSTEP	Ocean Systems Test and Evaluation Program

PCS	Personal Communication System
POC	Point of Contact
PORTS®	Physical Oceanographic Real-Time System
PSD	Products and Services Division
PUFFF	PORTS® Uniform Flat File Format
PV	Photovoltaic
QA	Quality Assurance
QC	Quality Control
RDD	Requirements and Developments Division
RDI	RD Instruments
s.d.	Standard Deviation
SLL	Sutron Dynamic Linked Library
TOL	Tides On-Line
USACE	United States Army Corps of Engineers
USACE/FRF	United States Army Corps of Engineers / Field Research Facility
USCG	United States Coast Guard
XRTT	Radio Transmission Technology
WH	Watt-hours
3D	Three-Dimensional

APPENDICES

APPENDIX A - AQUADOPP SPECIFICATIONS

Acoustics:

* Three acoustic frequencies: 0.6 MHz, 1 MHz and 2 MHz
* Profiling range (nominal): 30–50 m (0.6 MHz), 12–25 m (1 MHz), 5–12 m (2 MHz)
* Minimum cell size: 1 m (0.6 MHz), 0.3 m (1 MHz), 0.1 m (2 MHz)
* Minimum blanking 0.5m (0.6 MHz), 0.2m (1 MHz), 0.05 m (2 MHz)

Velocity:

* Horizontal velocity range: ±10 m/s (extended range available)
* Accuracy: 1% of measured value ±0.5 cm/s
* Sampling rate: 1 s to several hours

Sensors:

* Compass (flux-gate, automatic up/down detection)
* Tilt (liquid level, max 30° tilt)
* Pressure (piezoresistive, resolution better than 0.005% of full scale)
* Temperature (resistive)

External Sensors:

* Two analog input channels (0-5V) can be input and integrated with the data structure

Data Communication:

* I/O: RS232 or RS422
* Baud rate: 300 to 115200
* User control: Handled via WIN32 software or ActiveX controls

Data Recording:

* Capacity: 5 MB, upgradeable with 20 MB or 76 MB extra boards
* Data record: 32 bytes + 9×Ncells

Mechanical:

* Weight in air: 2.4 kg (2.6 kg for 0.6 MHz) with alkaline batteries
* Weight in water: Neutral
* Dimensions: 75 mm diameter, 550-600 mm length
* Materials: Standard model in plastic, full ocean depth models (2000 m and 6000 m) in titanium and plastic

User Choices:

* Range for pressure range (default is 200 m)
* Recorder size (default is 5 MB, 25 and 81 MB available)
* External battery housing (5, 10, or 20 times standard battery capacity)
* Internal wiring harness (RS232+synch+analog out, RS422+synch, or RS232+analog in)

Water Velocity Measurement

Acoustic frequency	0.6 MHz 1.0 MHZ 2.0 MHz
Maximum profiling range)*	30 – 50 m 12 – 25 m 5 - 12 m
Cell size	1 – 4 m 0.3 – 4 m 0.1 - 2 m
Minimum blanking	0.50 m 0.20 m 0.05 m
Maximum # of cells	128
Velocity Range	±10 m/s (call for extended range)
Accuracy	1% of measured value ± 0.5 cm/s
Max. Sampling rate	1 Hz
Velocity uncertainty	Consult software program

The Aquadopp profiler measures the current profile in a user specified number of cells from the instrument out to a maximum range that depends on the acoustic scattering conditions. The lower range should be expected with clear water and small cells and the higher range with large cells and acoustically turbid water.

Echo Intensity

Sampling	Same as velocity
Resolution	0.45 dB
Dynamic range	90 dB

Transducer

Frequency	0.6 MHZ 1.0 MHZ 2.0 MHZ
Number of beams	3 3 3
Beam width	3.0° 3.4° 1.7°

Standard sensors

Temperature	*Type* Thermistor embedded
Range	-4°C to 30°C
Accuracy/resolution	0.1°C/0.01°C
Time response	15 min
Compass *Type*	Flux gate with liquid tilt
Maximum tilt	30°
Accuracy/resolution	2°/0.1°
Tilt *Type*	Liquid level
Accuracy/resolution	0.2°/0.1°
Up or down	Automatic detect
Pressure *Type*	Piezoresistive
Range	0-100 m (standard)
Accuracy/resolution	0.25%/0.005% of full scale

Analog inputs

Number of channels	2
Voltage supply	Battery voltage. Hardware can be modified to provide 5 V or 12 V.
Voltage input	0-5 V
Resolution	16 bit A/D

Serial Data Communication

I/O	RS232, RS422
Baud rate	300-115,200 (user setting)

Internal Recording

Capacity	5 MB, expandable to 25MB or 81MB
Data record	32 bytes + 9*Ncells
Mode	Stop when full (default) or wrap mode

Software “AquaPro”

Operating system	WIN 32 (WIN 95/98/00, NT 4.0)
Functions	Deployment planning, data retrieval, ASCII conversion, online data collection and graphical display

Power

DC Input	9-16 VDC
Max consumption at 1Hz	0.2-1.5 W
Sleep consumption	0.0013 W
Transmit power	0.3-20 W, 4 adjustable levels

Internal Batteries*)

Type/capacity	18 AA Alkaline cells/50Wh
New battery voltage	13.5 VDC
Duration (10-minute avg.)	120 days for 2MHz, 0.5 m cells
Duration (10-minute avg.)	90 days for 1MHz, 1.0 m cells

Exact battery consumption and velocity uncertainty are complex functions of the deployment configuration. Please consult the AquaPro software for more exact predictions.

Materials

Standard	Delrin and polyurethane plastics with titanium screws
Intermediate and Deep water models	Titanium and Delrin plastics

Connectors

Bulkhead (Impulse)	LPMBH-8-FS (bronze)
Cable	LPMIL-8-MP on10-m polyurethane cable

Environmental

Operating temperature	-5°C to 35°C
Storage temperature	-20°C to 45°C
Shock and vibration	IEC 721 – 3 – 2
Shallow water rating	300 m
Deep water rating	2000 and 6000 m

Dimensions

Weight in air with alkaline batteries	2.4 kg/2.6 kg (0.6 MHz)
Weight in air (deep water)	6-10 kg, depending on model
Length	550 mm
Diameter	75 mm

Options

Batteries	Lithium
External batteries alkaline	200 Wh, 540 Wh or 1080 Wh
Bulkhead connectors	Titanium instead of bronze
Transducer head	Side-looking for 1 or 2 MHz. Inquire for special configurations
Communication:	Request special harness for RS422 communication. Inquire for cables > 100 m

APPENDIX B - CORMS SOPS
OPERATION PROCEDURE 1

CORMS NOTIFICATION OF CO-OPS STAFF FOR A COMMUNICATIONS FAILURE BETWEEN A DAS AND CORMS

Updated: 1 April 2004

Introduction and Purpose

This procedure describes the interaction between CORMS and CO-OPS staff before, during, and after a communications failure between the main CORMS and all sensors in a particular PORTS® estuary system. This communications failure may take the form of all sensors reporting black condition or red condition. The condition for all black sensor indicators is the failure of communications between TESTPORT Computer located in SSMC-2 and the DAS. Ordinarily, this has occurred due to Internet failure (MCI WorldCom) or CSU/DSU Modem, or DAS or router failure. The general case for the all red sensor indicator is a failure of any data to arrive at the DAS. This failure can occur due to local hardware/communications problems.

ISD has developed software that detects the all-black condition and uses phone to contact the DAS and receive data. Notification to CORMS is under development, because the all-black is transparent, since telephone communications would mask the problem. Currently, CORMS receives an e-mail in the morning indicating what PORTS® were dialed and how often. Additional mail may be developed to notify operations of an existing situation after one hour. In the meantime, should something indicate that a blackout has occurred, for the six PORTS® on the text screen on the O2, updates will stop taking place.

Importance of keeping people informed cannot be stressed enough. The POC list identifies who should receive e-mail for different problems. Although most discussions needed to resolve the issues are conducted verbally, it is important to keep a log of each incident where e-mail is unavailable and supplement that with e-mail at a later time.

PROCEDURE

ALL SENSORS BLACK CONDITION

1. If while monitoring the Main CORMS Screen, all of the sensor data quality indicators within a particular PORTS® estuary change color to black, this indicates a communications failure between the port DAS and the active TESTPORT computer (the terminus for all of the Internet connections to the PORTS®). There are now two TESTPORT computers that will automatically switch if one fails.

2. If other PORTS® are communicating normally, there is no need to verify that the TESTPORT 1 computer is working. If all other PORTS® are experiencing the same difficulty, then there could be a problem with TESTPORT 1 and 2 or a local HUB has stopped.

3. This error must be handled promptly. The CORMS operator will determine the time of the outage and make an entry into the Passdown Log.

4. The operator will then link to the Intranet page http://co-ops.nos.noaa.gov/intranet. You may also reach this page through the link provided on the CORMSLINKS page. Select "CORMS Troubleshooting". Select "PORTS/CORMS Network Troubleshooting". From this page, you will be able to perform a "traceroute" or "ping" from TESTPORT 1 to the primary or the backup DAS and the prescribed routers. The traceroute should be run to see where in the communication line is the data transmission being interrupted.

******Anchorage/Nikiski, Soo Locks, Tacoma and LA/Long Beach represent departures from the procedure below, they do not have MCI lines*******

When this command is successful, the IP address of the PORTS® should be the last line before the system displays DONE indicating that the traceroute was successful. When a traceroute fails, the command never displays the IP address of the PORTS® on the last line.

There is a suggestion that the last IP address displayed is a good indication of where the interruption may have occurred.

5. Should the traceroute fail, the operator will contact MCI/WorldCom, personnel about the current outage. When placing the call, you must have the following information available: the circuit ID and the IP address. The CORMS operator should state "I am having trouble with one of my internet circuits. Its circuit ID is ...". MCI/WorldCom will check out the line and give you a case number. It is <u>mandatory</u> that the operator record this number in the Passdown log and the Morning Report, as it will be yours and MCI/WorldCom personnel's tracking number for the problem. An e-mail detailing facts will also be sent to the POC list.

6. At this point, the CORMS operator will follow instruction from the MCI/WorldCom personnel for further action. You may be required to call local site personnel if available for supporting the equipment to restart the CSU/DSU, routers or hubs. It is important to note that assistance is sometimes rendered by individuals who are not associated with the program, nor are they compensated for this work. Be thoughtful and patient. The Intranet site contains photographs of our instruments that could provide help; these will not be available to anyone outside the office because of the security. These personnel may not be available after normal business hours. Notify the PORTS® Operations Manager when this occurs to determine what actions to take next.

7. Documentation is required of all actions and conversations during the entire process of restoring communications. Advise MCI/WorldCom personnel that you must provide status reports to users and you will call periodically for updates. Make these status reports available to the POC list. Notify the PORTS® Operations Manager if there are problems resolving the situation either with MCI/WorldCom or site help.

8. During this time, there is no need to stop dissemination of the data. Since communications are the apparent problem, return to normal status should produce no sensor problems. Monitor the data when the condition changes back to green. In the meantime, monitor the sensors if they are transmitting through the satellite.

9. Be sure to notify any PORT that has a 24-hour monitor of the PORTS® Pages (New York, Houston and Soo Locks) that CORMS is unable to provide appropriate monitoring of the data and also notify them of the resolution.

ALL SENSORS RED CONDITION

1. San Francisco represents the only remaining PORTS® that could produce an all red condition. If all of the sensors in the estuary change color to red, this is generally an indication of no data at the DAS. The communications for San Francisco are exclusively IP Modem and if the DAS can not get out to the internet to poll for the data, an all red condition could occur.

2. If the condition continues for one hour, change communications for those stations that have alternate communications. Notify the on-call ISD contact with a page if this does not resolve the issue. Do not stop dissemination, when the error clears, data should resume.

OPERATION PROCEDURE 2

CORMS NOTIFICATION OF AND INTERACTION WITH CO-OPS STAFF FOR A "NO DATA FAILURE" OF AN INDIVIDUAL PORT® SENSOR

Updated: 1 April 2004

INTRODUCTION AND PURPOSE

This Operational Procedure describes the interaction between CORMS and support staff before, during, and after the failure to receive data from an individual sensor. The importance of keeping people informed can not be stressed enough. Communications to all responsible parties is important to the determination of the problem and the subsequent solution.

In each case where an e-mail is specified one individual is to be the addressee with copy (CC) to others, making it clear that the addressee is the sole person responsible for taking action (review the mail POC list for each PORT). The others are being kept informed or may provide some ancillary information or action through the individual who would be responsible.

PROCEDURE

1. If a "Failure No Data Found" (FNOD or FNDF) QC flag has been displayed on the Main CORMS Screen for an individual sensor for thirty minutes, the operator should attempt to switch to the alternate form of communications if available (see interrogation method list on the on off page of Main CORMS). Should data recover, no further action is necessary, except to notify the POC list of the error and the change in communications. Should the errors persist for thirty additional minutes, then the operator should switch back to the previous communications scenario. Dissemination (PICS, TEXT, VOICE,) must be stopped if the error is continuous for one hour. When dissemination is stopped, the operator will send an e-mail immediately to the site representative and the POC list detailing the issue, a response from the appropriate site manager should follow before close of business, provided it is not too late in the day. During off duty hours, Monday through Friday and weekends, the operator will send an e-mail to the site representative and the POC list which will detail the issue, but there may be no response until the next business day. As soon as possible after stopping dissemination, the status page must be updated.

2. Prior to sending e-mail or calling anyone, the operator should determine if any other co-located sensors (i.e. WL, Met, CT) that use the same communications path are experiencing the same problem. If all are sending FNOD, the error is possibly communications. If it is just one of the sensors, WL or MET or CT, then there could be a sensor problem. What do the previous plots show about the data (i.e. sporadic) other problems indicating a history of problems?

Maintenance work just completed could be a problem. Is the data available in NPDB, TIDES On LINE (TOL) or other means? Is there a weather event happening? Results of any evaluation should accompany the e-mail as additional information, not a conclusion; let the field engineers determine this.

3. CORMS staff should monitor the station in the plotting tool to determine if the station begins sending data again and whether or not the data is good. The Red failure indicator on the main CORMS screen (indicating a sensor failure) will return to green when data has resumed and has passed quality control checks at the DAS. Monitor the plotting tool closely and restore the dissemination when data resumes, after reviewing several data points (Refer to Operational Order 4 for guidance).

4. The FOD Site Representative will schedule service either by FOD personnel or by the local O&M contractor should the error persist.

5. The individual responsible for local O&M will diagnose, resolve, or repair the problem and document by e-mail to the FOD Site Representative with CC to POC List. CORMS will place a brief notice of the incident and resolution in the Morning Report and the PORTS® Instrument Status Page. The Site Representative shall determine whether a statement needs to be generated to appear on the PORTS® page. The PORTS® Field Operations Manager should generate any statement and forward it through the PORTS® Program Manager for updating the PORTS® Page.

6. Upon receipt of notification that the sensor repair was affected, depending on the type of repair, CORMS will either review the data using the plotting tools notify the oceanographer to begin reviewing the data as per Operational Procedure 6. Upon appropriate review, the operator will restart data dissemination.

OTHER ACTIONS

1. If a no data failure continues and dissemination is stopped, communications will continue via satellite. Monitor this data to ensure the quality if the data fails to appear at the appropriate transmit time.

2. If satellite communications fails to produce data, stop dissemination in TOL and send e-mail to the POC list for the PORT indicating this also.

FAILURE/MAINTENANCE COMMUNICATION PROCEDURES

1. Upon arrival at the station, the FOD or contractor field team will notify the CORMS watch that maintenance and/or repairs are to take place. CORMS will ensure that dissemination of the data is stopped at this time. An e-mail will be sent to the POC list and a phone log will be made stating the time data dissemination was stopped, who is performing maintenance, when it is complete, and reason for turning it off.

2. Once field team has finished performing the necessary repairs and/or maintenance, they will contact CORMS. CORMS will, depending on the nature of the repair, notify the responsible Oceanographer (see Operational Order 4) or, if it is not a major repair, immediately begin to review data using the Plotting Tool.

3. CORMS personnel will contact the field crew within twenty minutes acknowledging the data that has or has not been received. Begin reviewing the data and compare it with other sensors. Dissemination will be restarted at this time if repairs were not of a nature that an oceanographer need be involved. If data is not received or is questionable, CORMS will inform the field crew of this within the same time frame.

OPERATIONAL PROCEDURE 3

CORMS NOTIFICATION OF AND INTERACTION WITH CO-OPS STAFF FOR ISSUES OF "DATA OF SUSPECT QUALITY" FROM AN INDIVIDUAL PORTS® SENSOR

Updated: 1 April 2004

INTRODUCTION AND PURPOSE

This procedure describes the required interaction between CORMS and support staff before, during and after an issue arises where the quality of data from an individual sensor is questionable. The importance of keeping people informed can not be stressed enough. Although a vast majority of the communications needed to resolve a given issue may take place verbally, a **written log should be created for each incident where mail is not possible** (**i.e. CORMS "Passdown" Log or the CORMS Phone Communications Log).**

PROCEDURE

1. If, while monitoring the PORTS® data, an issue arises as to the quality of the data from an individual sensor, the CORMS Operator will immediately halt dissemination of the data products (Text, PICS, Voice, TOL). It may be difficult to determine if the quality is bad from just one sample, so it is advisable to wait until a second sample appears to make a decision. The issue may be manifest in a variety of ways, including significant departure from predictions, unusual readings relative to neighboring sensors, flat readings for consecutive samples, or other intermittent or questionable behavior. During normal business hours, the CORMS Operator will contact the PORTS® Site Representative as indicated in the Point of Contact List (POC) for each estuary via e-mail. The same e-mail will inform the other members of POC list of the situation . During off-duty hours, during the week, and on weekends, the appropriate e-mail will be sent informing the list, but no further action should be taken without authorization from the PORTS® Operations Manager. For data quality issues, under no circumstances should anyone be contacted overnight unless there is a request to do so and without first contacting the PORTS® Operations Manager.

2. The FOD Site Representative will initiate any and all field contact regarding the matter and notify all necessary individuals unless there is a request that CORMS do so. CORMS will provide any assistance to the site representative that may be required.

3. The FOD Site Representative will contact the individual responsible for local O&M who will diagnose and repair the problem. Upon notification by the

appropriate individual, CORMS will place a brief notice of the incident and resolution in the shift turnover log and the Morning Report.

4. Upon receipt of notification from the appropriate individual, that the sensor repair was satisfactorily completed, and, depending on what that repair entailed, CORMS may evaluate the data using the appropriate tool and restart dissemination. Should the repair require new sensors with different offsets or calibration, CORMS will notify the respective oceanographer (See Appendix 4) for water levels or currents, that the data is available for review. Upon notification from the responsible oceanographer, dissemination will be restarted and e-mail will be sent to the POC list. During off duty hours, nights and weekends, CORMS will not contact an oceanographer but will notify the individual by mail with a cc to the Senior Tech who will track action.

5. For any outage, a notice shall appear in the PORTS® Instrumentation Status Page. For long-term outages, a statement will be generated by PORTS® Field Operations Manager and will be forwarded to ISD through the PORTS® Program Manager for inclusion into the appropriate PORTS® Web Page.

PRELIMINARY STEPS FOR EVALUATING DATA

1. Review adjacent sensors to verify erroneous/questionable data.

2. Review local meteorological reports for anomalous weather events that would be responsible for questionable data.

3. Report only what can be seen with the tools you have. Report any error flag that the CORMS system is identifying.

*****The CORMS Operation is the final Quality Control point. If the operator analysis indicates that there is still a question regarding the data after repair, do not start dissemination, and contact the PORTS® Operations Manager immediately.*********

Ancillary Requirements

1. Update the CORMS Instrument Status Page.

2. Long-term outages require a statement on the PORTS® web page to be generated through the PORTS® Program Manager. The PORTS® Operations Manager will be responsible for contacting the appropriate individual to generate the message.

3. Stop Tides On Line dissemination.

FAILURE/MAINTENANCE COMMUNICATION PROCEDURES

I. The FOD or contractor field team will notify the CORMS watch upon arrival at the station that maintenance and/or repairs are to take place. CORMS will ensure that dissemination of the data is stopped at this time. An e-mail will be sent to the POC list and a phone log will be made stating the time data dissemination was stopped, who is performing maintenance, and reason for turning it off.

II. Once field crew has finished performing the necessary repairs and/or maintenance, they will contact CORMS. CORMS will, depending on the nature of the repair, notify the responsible Oceanographer (see Appendix 4) or if it is not a major repair, immediately begin to review data using the Plotting Tool.

III. CORMS personnel will, if requested, contact the field crew within twenty minutes of acknowledging that the data have or have not been received. Begin reviewing the data and compare it with other sensors. Dissemination will be restarted at this time if repairs were not of a nature that an oceanographer need be involved. If data is not received or is questionable, CORMS will inform the field crew of this as soon as it is detected.

APPENDIX C - AQUADOPP ERROR AND STATUS WORDS

The Aquadopp Profiler outputs two multiple bit binary coded words describing the instrument state. The following explains the meaning of each bit in the Error and Status words. The bits within the words count from right to left starting with zero.

Error word:

The bit is set ("1") if there is an error condition and cleared ("0") if OK.

Bit 7 Coordinate transformation: If the compass fails and the system is set to ENU, the system will output XYZ and this bit will be set.

Bit 6 Sensor: Vector: The tilt sensor is not responding. Aquadopp: The CT sensor (serial only - i.e. Seabird) is not responding.

Bit 5 Beam number: A problem has occurred with the beam order.

Bit 4 Flash: An error has occurred in the primary system flash memory, and the system may not be able to reboot.

Bit 3 Tag bit: There has been an error in the processing, an internal buffer is overflowing.

Bit 2 Sensor data: One of the sensors is not operating correctly.

Bit 1 Measurement data: An error has occurred with some element of the processing, the data is probably corrupt.

Bit 0 Compass: The compass does not respond. If the system is in ENU mode, it will default to XYZ, and a value of 90 degrees will be displayed.

Status word:

Bits 7 and 6 Power level: These bits reflect the power level setting, i.e. how much acoustic energy the instrument transmits into the water. This is set by the user in the deployment planning dialog when configuring the instrument.

Bit 7	Bit 6	Power level
0	0	High
0	1	High -
1	0	Low +
1	1	Low

Bits 5 and 4 Wake-up state: These bits indicate the Wake-up state of the instrument. There are four different ways to cause a wake-up of the instrument; hence, there are two bits in the status field that identify the wake-up source.

Bit 5	**Bit 4**	**Wake-up state**
0	0	Bad power
0	1	Power supplied
1	0	Break
1	1	Real Time Clock (RTC)

Bad power status is used when the input voltage to the instrument during normal operation is so low that the instrument may no longer operate correctly. The hardware is then held in a reset state until the voltage reaches an acceptable level. It is typically caused by a broken cable or a faulty power supply.

Power supplied is the status code when power is applied to an instrument. To get this status code, the power must be removed for a few seconds. Removing power for just one second will typically be indicated as bad power.

Break status indicates an instrument reset because a break was received on the communications port. The break is used when the software communicates with the instrument. This will typically be status code in the first data record in an online measurement.

Real-Time Clock (RTC) status shows that the internal clock in the instrument caused the Wake-up. To reduce the power consumption, the instrument enters sleep mode between measurements for most setups. The internal RTC will ensure that the instrument wakes up at the appropriate time, and this is indicated in the status byte.

Bit 3 Roll: This bit indicates if the instrument roll angle exceeds the tilt sensor operational range limits.

Bit 3	**Roll**
0	OK, valid data
1	Out of range, invalid data

Bit 2 Pitch: This bit indicates if the instrument pitch angle exceeds the tilt sensor operational range limits.

Bit 2	**Pitch**
0	OK, valid data
1	Out of range, invalid data

Bit 1 Scaling: This bit indicates the scaling of the velocity output and depends on the velocity range setting (Vector only). If the instrument is set to use the highest

ranges, the least significant bit is one mm/s. For the lowest range it is 0.1 mm/s. The purpose of varying the scale factor is to make sure that we use as much as we can of the dynamic range that is inherent in the system. This is all transparent if you use the Vector program to convert to ASCII because the data reported in the ASCII files is in engineering units. If you develop your own programs to read the binary data files, the variable scaling must be taken into account.

Bit 1	**Scaling**
0	1mm/s
1	0.1 mm/s

Bit 0 Orientation: This bit indicates the orientation of the instrument.

Bit 0	**Orientation**
0	Up
1	Down