Protocols for Demonstrating the Performance of In Situ Nutrient Analyzers

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1. Background on ACT Technology Evaluations

Instrument performance verification is necessary to enable effective existing technologies to be recognized and to encourage the development and adoption of promising new technologies that support coastal science, resource management and the long-term development of an Integrated Ocean Observing System. The Alliance for Coastal Technologies (ACT) has therefore been established to provide an unbiased, third party testbed for evaluating coastal sensors and sensor platforms.

The following protocols describe how ACT will examine the environmental performance characteristics of commercial-ready and prototype, in situ nutrient analyzers through the evaluation of objective and quality assured data. The goal of ACT's evaluation program is to provide technology users with an independent and credible assessment of instrument performance in a variety of environments. Therefore, the data and information on performance characteristics will cover legitimate information that users need. ACT will look to the broader community to define the data and operational parameters that are valuable in guiding instrument purchase and deployment decisions. Since this evaluation is being run as a Demonstration study we will also focus on promoting awareness of this emerging technology to the scientific and management community, and highlighting the potential capabilities of in situ nutrient analyzers by demonstrating their utility in a broad range of coastal environments.

It is important to note that ACT does not certify technologies or guarantee that a technology will always, or under circumstances other than those used in testing, operate at the levels verified. ACT does not seek to determine regulatory compliance; does not rank technologies or compare performance among specific instruments tested; does not label or list technologies as acceptable or unacceptable; and does not seek to determine "best available technology" in any form. ACT will avoid all potential pathways to picking "winners and losers". Therefore, although the following protocols will apply to all instruments evaluated, no direct comparisons will be made between instruments from different manufacturers and instrument-specific Performance Demonstration Statements will be released to the public for each instrument type as a final report.

2. Introduction to Technology

There are a number of challenges in assessing nutrient concentrations in aquatic systems that point to the value of sustained in situ observations. High spatial horizontal variability is typical of many coastal, estuarine and fresh water systems, as are strong depth gradients. High temporal variability in natural background concentrations are typical of many locations, often in response to short-term forcing (e.g., vertical mixing) or input events (e.g., runoff, river discharge). A lack of consistent relationships to other variables often makes inferences regarding nutrient-related impacts from other, more easily measured proxies (such as chlorophyll-a fluorescence) problematic. Finally, in many aquatic ecosystems, assessing responses to nutrient inputs from various sources requires monitoring of multiple nutrient species.

In situ nutrient sensors can play an important role in addressing these challenges and offer promise for range of applications including: regulatory, applied, observing system and basic research. For any of these types of applications, users will be concerned about the traditional performance attributes including: reliability, comparability, affordability, and calibration before and through field deployments. However, specific system requirements and performance metrics will vary among the different types of applications.

The in situ nutrient sensor technologies that appear likely to remain the dominant commercial options for the next decade are reagent-based in situ auto-analyzers (or fluidics systems) and an optical-based sensors, such as the spectrophotometric measurement of nitrate. The number of available commercial systems has expanded since 2003, and community support for expanded application and further development of these technologies appears warranted. Application in coastal observing systems, including freshwater as well as estuarine and marine environments, was a focus of a recent ACT workshop on in situ nutrient analyzers. Workshop discussion included possible refinements for sustained deployments as part of integrated instrument packages, and means to better promote broader use of nutrient sensors in observing system and management applications. Lastly, the workshop also made a number of specific recommendations concerning the testing protocols that will be used for this Nutrient Sensor Demonstration.

3. Objectives and Focus of Nutrient Analyzer Performance Demonstration

The fundamental objectives of this Performance Demonstration are to: (1) highlight the potential capabilities of in situ nutrient analyzers by demonstrating their utility in a broad range of coastal environments with varying nutrient concentrations, (2) promote the awareness of this emerging technology to the scientific and management community responsible for monitoring coastal environments, and (3) work with manufacturers that are presently developing new or improved sensor systems by providing a forum for thoroughly testing their products in a scientifically defensible program, at relatively minor costs in time and resources to the companies.

ACT has performed two customer needs and use assessments and held two workshops on in situ nutrient analyzers. As part of these reviews, scientists, resource managers, and other users of these technologies were asked about their current use or application of these instruments, limitations or problems and the important criteria they employ when selecting an analyzer/sensor system. The results of these assessments were used to identify the main applications and key parameters that ACT will evaluate in this Technology Demonstration.

The vast majority of respondents use (or plan to use) nutrient sensors to measure nitrate/nitrite and/or phosphate in nearshore, shallow water environments, typically on remote platforms for time-series in situ measurements of nutrient concentrations. However, there was also interest in the performance of in situ nutrient analyzers during underway surface mapping and vertical profiling applications. The performance characteristics that ranked highest included reliability, accuracy and precision. This ACT Performance Demonstration will focus on these applications and criteria utilizing a series of field tests at four of the ACT Partner Institution sites, representing marine, estuarine and freshwater environments. Protocols were developed with the aid of manufacturers and the Technical Advisory Committee to evaluate these specific

areas. Complete needs and use assessment and workshop reports can be found at www.act-us.info.

3.1. Parameters to be Investigated

Field tests will focus on reliability/stability and the ability of the instrument to track natural changes in nutrient concentrations.

- **Accuracy** – a measure of the closeness of an estimated value to the true value (see below). For this demonstration, the accuracy of the test instruments will be determined in field test by comparing the difference between in situ instrument determined nutrient concentrations and laboratory measured concentrations of collected reference water samples using approved analytical methods. The amount of disagreement in measurements can be expressed as a percent of the signal or as an absolute difference. Laboratory analyses will follow approved standard operating procedures and be checked against external certified reference standards to ensure they represent the best possible measure of the nutrient concentration. All laboratory analyses will be run in triplicate to assess the precision of these reference measurements.
- **Reliability** – Reliability is the ability to maintain integrity or stability of the instrument and data collections over time. Reliability of instruments will be determined in two ways. In field tests, comparisons will be made of the percent of data recovered versus percent of data expected. In addition, instrument stability will be determined by pre- and post-measures of blanks and reference standards to quantify drift during deployment periods. Comments on the physical condition of the instruments (e.g., physical damage, flooding, corrosion, battery failure, etc.) will also be recorded.

4. Summary of Basic Demonstration Approach

These testing protocols are based on an amalgamation of standard procedures for calibrating and testing nutrient analyzers provided by the participating manufacturers, and protocols recommended by ACT personnel and an external Technical Advisory Committee. The protocols were refined through direct discussions between all parties during an ACT Nutrient Analyzer Performance Demonstration Protocol Workshop held on 12-13 February, 2007. Participants at this workshop included ACT Headquarters Staff, ACT Partner Institution Technical Coordinators, an ACT Quality Assurance Manager, a Nutrient Analyzer Technical Advisory Committee, and representatives from the participating manufacturers. A consensus was reached that the testing protocols will:

- utilize standard, approved laboratory analytical methods to provide best possible measure of the 'true' nutrient concentration from field samples, which will serve as performance standards against which instrument estimations will be compared.
- employ USEPA Method No. 365.5 for phosphate as applied in Standard Operating Procedures of the Nutrient Analytical Services Laboratory (NASL) at the Chesapeake Biological Laboratory (CBL), Solomons, MD, where all reference sample analysis will be conducted to determine true nutrient concentrations

- employ USEPA Method No. 353.4 for nitrate, as modified in the Standard Operating Procedures of NASL to utilize an enzymatic reduction step instead of cadmium reduction, where all reference sample analysis will be conducted to determine true nutrient concentrations
- include moored (one month in duration) and profiling (surface mapping and vertical casts) field tests under a wide range of environmental habitats including freshwater, estuarine and oceanic ecosystem
- employ a wide geographic distribution of test sites that includes freshwater, estuarine, and coastal ocean conditions.
- employ locations that will provide a wide range of appropriate nutrient concentrations and water quality characteristics (e.g. salinity, turbidity) to fully characterize the potential utility of the instruments

All ACT personnel involved in this Demonstration will be properly trained on use of instruments by manufacturer representatives and on a standardized water sampling, storage and shipping method. Since this evaluation is being run as a Demonstration, manufacturer representatives will directly assist in the initial set-up and calibration of the instruments, instrument retrieval, and data management. All laboratory nutrient analysis will be conducted at the CBL Nutrient Analytical Services Laboratory using standardized automated wet chemistry. The Laboratory follows rigorous QA procedures and will be undergoing both an external and ACT audit to assure that all components of established SOPs are being thoroughly followed. Additional agreements for the protocols include:

- All numerical data will be recorded to two or more significant digits where appropriate.
- Nutrient concentrations will be reported over time, position, or depth as directly downloaded from the test instruments and using pre-determined algorithms.
- ACT will do an independent analysis of any on-board nutrient standards at the start and end of the deployment.
- Any post-corrections of data based on degradation of internal standards or other environmental variable are the responsibility of the companies.
- Post-corrected data can be included in the companies' response page that is included within each report.
- Nutrient concentrations will be reported in either elemental mass units (mgN/L and µgP/L) or as micromoles per liter (µM) for NO_3^- or PO_4^{3-}.
- For instruments that also include other raw reporting units, such as digital counts, the manufacturer will supply the required algorithms for converting the data to concentration units. In such cases where data need to be converted, ACT will send all original data from the field test back to the manufacturer where they can independently verify that conversion algorithms were applied correctly
- Reports will include means, standard deviations, and number of replicates of laboratory based nutrient concentration for corresponding reference samples at the same time, position, or depth of instrument measurements
- Reports will include associated physical conditions (e.g., temperature, salinity, fluorescence, and beam attenuation) within the water column over corresponding time, position, or depth.

The goal of this Demonstration is to test the same model instruments in both a moored and profiling (surface and vertical) application, wherever applicable to the design of the submitted instrument, and within a range of coastal environments. It is also preferred to evaluate instruments incorporated in stand-alone packages, which include features such as data logging, data transformation/conversion equations, independent power supplies, and biofouling prevention. In some cases, however, submitted test instruments may only be tested in one type of field application (if they are designed and sold for one particular use) and some independent sensors will be incorporated into other associated equipment (e.g., datalogger, CTD) owned and operated by ACT Partner Institutions.

One instrument of each particular model will be evaluated during this Demonstration. The instrument will be evaluated sequentially at up to four different ACT test sites, with a three-week period between each field test to allow individual manufacturers to recondition and recalibrate the instruments. An exception to this schedule will be made for the transition following the surface mapping field test at Moss Landing Marine Laboratory. Since this test will only require approximately one day of in situ exposure, it was agreed that instruments could be sent directly to the next moored application test site in Seward, Alaska and any required servicing done at the new test site prior to deployment. Moored application tests will be offered at three sites including Chesapeake Bay, MD, Resurrection Bay, Seward, AK, and Clinton River, MI. A surface mapping application will be conducted in Monterey Bay, CA. The vertical profiling application will be offered at the Seward Alaska test site where well defined pycnoclines and nutrient-clines have been observed from previous monitoring studies. Moored test will take approximately one month to complete, while profiling tests should be completed within a one to two days for any given analyzer. Each instrument will be tested at a minimum of two test sites.

4.1. Phosphate (Orthophosphate) Analysis of Reference Samples

Phosphate concentrations for all reference and quality control samples will be determined by the Nutrient Analytical Services Laboratory at CBL following their Standard Operating Procedures Manual (CEES, UMD, Publication Series No. SS-80-04-CBL). The methodology is based on U.S. EPA Method 365.1, *in* Methods for chemical analysis of water and wastes. (United States Environmental Protection Agency, Office of Research and Development. Cincinnati, Ohio. Report No. EPA-600-4-79-020 March 1979). In brief, ammonium molybdate and antimony potassium tartrate react in an acidic medium with dilute solutions of phosphate to form an antimony-phospho-molybdate complex. The complex is reduced to an intensely blue-colored complex by ascorbic acid. The color produced is proportional to the phosphate concentration present in the sample.

All laboratory nutrient analyses will be conducted on an Aquakem 250. A statistically determined method of detection limit has been established at 0.0007 mgP/L by prior laboratory studies. The typical working concentration range for the method and SOP is between 0.0035 – 1.48 mgP/L. The system contains an auto-dilutor to bring any higher concentrations down to the established linear calibration range. A sample reagent blank is analyzed in conjunction with every sample as part of the routine operation of the Aqaukem 250. Approximately 40 samples

per hour can be analyzed. All internal standards will be verified and calibrated using certified external nutrient standards (such as Spex Certi-Prep or NIST). In addition, Field Trip Blanks and Field Sample Spike Additions (defined below) will be conducted once per week as part of established QA/QC protocols.

4.2. Nitrite + Nitrate Analysis of Reference Samples

Nitrate concentrations for all reference and quality control samples will be determined by the Nutrient Analytical Services Laboratory at CBL following their Standard Operating Procedures Manual (CEES, UMD, Publication Series No. SS-80-04-CBL). The methodology is based on U.S. EPA Method 353.2, *in* Methods for chemical analysis of water and wastes. (United States Environmental Protection Agency, Office of Research and Development. Cincinnati, Ohio. Report No. EPA-600-4-79-020 March 1979), but modified to use an enzymatic reduction of nitrate instead of the traditional cadmium reduction method (Campbell, W.H. E.R. Campbell, and L. Egan 2006. Green Chemistry Nitrate Determination: An Alternative Nitrate Analysis Method. American Laboratory, February 2006). In brief, nitrate in the sample is reduced enzymatically to nitrite in a buffered solution. The nitrite is then determined by diazotizing with sulfanilamide and coupling with N-1-naphthylethylenediamine dihydrochloride to form a color azo dye. The absorbance measured at 540 nm is linearly proportional to the concentration of nitrate + nitrite in the sample. Nitrate concentrations are obtained by subtracting nitrite values, which have been separately determined without the enzyme reduction procedure.

All laboratory nutrient analyses will be conducted on an Aquakem 250. A statistically determined detection limit for this method has been established at 0.0007 mgN/L and 0.0006 mgN/L for nitrate and nitrite respectively, by prior laboratory studies for a wide range of salinities. The typical working concentration range for the nitrate method and SOP is between 0.0049 – 5.6 mgN /L. The typical working concentration range for the nitrite method and SOP is between 0.0042 – 0.28 mgN /L. The system contains an auto-dilutor to bring any higher concentrations down to the established linear calibration range. A sample reagent blank is analyzed in conjunction with every sample as part of the routine operation of the Aqaukem 250. Approximately 40 samples per hour can be analyzed. All internal standards will be verified and calibrated using certified external nutrient standards (such as Spex Certi-Prep or NIST). In addition, Field Trip Blanks and Field Sample Spike Additions (defined below) will be conducted once per week as part of established QA/QC protocols.

4.3. Moored Deployment

Field demonstration tests of instrument performance in a moored application will be conducted at three ACT Partner Institution sites covering freshwater, estuarine, and open-ocean conditions (site descriptions below). One nutrient analyzer from each manufacturer will be deployed for four continuous weeks at each site. Instruments will only be removed from the water after the test period is complete, or in the event of an obvious problem or environmental condition that could jeopardize the safety of the instruments. In addition, for this Demonstration

it was agreed that one time during the month long deployment a manufacturer's representative, or a trained member of the ACT staff, may provide required service to the instrument. The instrument should be out of service for only a few hours and then re-deployed identically to the original deployment. No other instruments will be disturbed during the servicing. If this condition can not be met then servicing will not be permitted. Such servicing requirement will be duly noted in the evaluation report so that the actual uninterrupted deployment period is accurately described. It is recognized that the need for servicing may vary among test sites due to variation in the expected rate of biofouling. It will be at the discretion of the manufacturer if and when to perform any required service. Because each manufacturer is only required to provide one instrument for testing, field tests will be run sequentially. Instrument packages will be returned to manufacturers for a maximum of 3 weeks for reconditioning following each of the month long mooring tests before shipping to the next field test site.

Instrument Setup - Prior to deployment, all instruments will be set up and calibrated as required at the field sites by a manufacturer representative with assistance provided by ACT staff as required. Manufacturers can either supply pre-made reagents and standards or ACT staff can provide these solutions based on provided supply lists and protocols. Instruments will then be programmed to record data based on a time interval that will allow for a 30 day deployment. Specific sampling intervals will vary among test instruments. We envision that the sampling frequency will range between 15 minutes and 2 hours. We will attempt to work out a schedule so that all instruments being tested at the same time will overlap in their sampling timepoints at a minimum frequency of 2 hours. Internal clocks will be set to local time and synchronized against the time standard provided by www.time.gov. A photograph of each individual instrument and the entire instrument rack will be taken just prior to deployment and just after recovery to provide a qualitative estimate of biofouling during the field tests. All instruments will be delivered a low (0) and high (100 µgP/L; 0.5 mgN/L) reference standard (made from certified reference standards) both before and after deployment as an estimate drift over time. Finally, if possible to obtain without introducing any contamination we will collect a sub-sample of the on-board standard solutions both immediately before and after the deployment period for independent analysis by CBL-NASL to help account for any possible accuracy offset and degradation of the standard over time.

Instrument Deployment - The individual start times for the various test instruments may be staggered slightly to allow any necessary individual attention for any given manufacturer, but all instruments should be deployed within approximately two days of each other. All instruments will be deployed for a minimum of 4 weeks, but individual termination times may be staggered by a day or two depending on logistical constraints for either manufacturer reps or ACT staff. Any servicing required during the deployment is the responsibility of manufacturer. ACT will provide any required assistance and access. If the service is of a simple nature and can be easily performed following explicit **written** protocols from the manufacturer, then ACT staff may perform this service at the request of the manufacturer. Instruments are to be set-up as self-recording but should a manufacturer choose, they may add a real-time telemetry component to the test instrument. The manufacturer will be responsible for adding this additional component including all required hardware and software. ACT can facilitate providing server space or web portal access. Manufacturers will determine the protocols for retrieval and data down-loading, and provide these to the ACT Chief Scientist. It is at the companies' discretion if they want to perform the retrieval and down-loading procedures or train ACT staff to perform these functions. All instruments will be returned to the companies containing all of the original data.

Deployment Rack – We will work with the instrument manufacturer to design an appropriate deployment rack for their analyzer. Because of the potential for staggered deployment times each instrument will most likely be contained on an individual mooring frame. However, we will arrange all test instruments in a manner so that we can collect a single representative field sample that is no more than 1 m apart from any of the individual sampling inlets. The deployment frames will be arranged so that all of the instruments remain at a fixed depth of 1 m below the water surface (using a float system or fixed dock in environments not affected by tidal changes or strong wave action). A calibrated CTD package will also be attached to the mooring at each test locale and programmed to provide an independent record of conductivity and temperature at the same depth and the highest required frequency (15 min) to match any of the test instruments. The sensor rack design will also be standardized as much as possible from site to site. However, physical conditions at particular sites may require specialized modifications. Each site will also deploy a transmissometer and a fluorometer, programmed to sample at the same maximum required (15 min) frequency. These instruments will be cleaned on a daily basis and air-calibrated to ensure consistent performance throughout the deployment. To the extent possible, anti-fouling paint or copper coatings will be applied to any mooring structure in proximity of the test instruments to help reduce the extent of biofouling. Finally, mooring frames and attachment points will be designed in such a manner that no instrument will be disturbed during the retrieval or servicing of other instruments.

Reference Water Sampling Schedule – The sampling frequency will be structured to examine changes in nutrient concentrations over daily and whole-month time scales. Specifically once each week we will conduct an intensive sampling event that consists of 4 consecutive samples spaced at two-hour intervals. For the remaining 4 days of the week we will sample only once per day. The initial intensive sampling event will occur within the first two days of the deployment after all instruments have been deployed, and the final intensive sampling event will occur during the last two days of the deployment. This schedule will provide a higher density of comparative data at the beginning when instruments should be functioning at optimum performance and again after the challenge of a 30 day deployment. To the extent possible, the middle two intensive sampling events will be selected to correspond to specific meteorological or hydrological events that are likely to correspond to significant changes in the expected level of nutrient concentrations. This sampling schedule should be sufficient to capture both diurnal and event based scales of variation and provide a 'continuous' check on instrument performance throughout the deployment. The specific timing of when water samples will be collected will be left up to the individual sites, but with the goal of capturing maximum variations in nutrient concentrations. In the event of weather limitations or un-avoidable schedule conflicts it will be permissible to miss a single-timepoint sampling day and simply collect a second sample on the following day to keep a similar number of reference points for each test site. All sampling times will be recorded on logsheets and entered into a database for final data comparisons.

Reference Water Sample Collection - A standard 2L Van Dorn bottle will be used at each field test site to collect water samples for laboratory nutrient concentration analysis. These samples will be used as the reference samples for examining instrument performance and stability over time. The sampling bottle will be lowered to the same depth and as close as physically possible to the sampling inlets and should be no more than 1 m from any of instrument sampling inlets. The sampling bottle should be allowed to soak at sampling depth for 1 minute prior to sampling. If water is not flowing the bottle should be moved to ensure that it is

being flushed with the ambient water. The bottle will be triggered to close at the same time that the test instrument are initiating sample uptake, to ensure that the same water mass is being compared with regards to nutrient concentrations. All environmental reference samples will be processed while wearing clean laboratory gloves to minimize potential sources of contamination. The entire water sample will be transferred to an acid washed 2L polypropylene bottle. The bottle should be rinsed 3x with small amounts of the sample before filling. The sample should be immediately processed into individual sampling tubes that are ready for respective nutrient analysis or storage. In brief, the field sample will be filtered through a 0.22 µm Nylon filter into chemically clean 20ml polypropylene scintillation vials. Six vials are needed for each reference sample to accommodate 2 separate analytical runs at NASL, each of which are performed in triplicate. All filtration devices and sample storage vials should be rinsed with each new sample before a final sample is captured. Filtration will be done either immediately in the field using a chemically clean BD disposable syringe and pre-assembled syringe filter units, or within 10 minutes of collection back at the laboratory using pre-assembled Nalgene, sterile, filtration flask equipped with larger diameter 0.22 µm Nylon filters. The later arrangement may be required for sites with high particle loads in order to generate a sufficient amount of filtrate. The field sample will be kept on ice in the dark during transport to the lab. Each field sample should be processed in triplicate for each of the nutrient analysis to be performed. Vials should be filled no more than ¾ full to allow adequate headspace for freezing. Filtered samples should also be stored on ice in the field and during transport, and frozen immediately upon return to the laboratory. Vials should remain upright during the freezing processes, and caps should be re-tightened after the water has frozen as they may loosen during freezing.

Cleaning sampling apparatus – Between each consecutive sample taken on the same day, sample bottles and filtration equipment should be rinsed with the new sample water. Filtration apparatus and sample storage vessels will be cleaned daily by acid washing with 10% HCl and copious rinses (5x) with high purity deionized water back at the laboratory.

Sample Shipping – Samples will be shipped frozen to NASL at CBL for nutrient analysis. Samples will be shipped using either dry ice or liquid nitrogen dry shippers if deemed necessary. Each test site will conduct a preliminary 'shipping test' to ensure that samples will remain frozen under either convention. Shipping containers will be sent for next morning delivery, or the soonest possible delivery time possible from a given shipping location. All samples, including the condition shipped and received, will be recorded onto Chain of Custody forms and a copy will be sent with the samples. The laboratory will confirm receipt and condition of samples within 24 hours of their arrival by signing and faxing a copy of the form to the test site. Original copies of these forms will be maintained on site.

4.4. Profiling Deployment

Field demonstration tests of instrument performance in surface profiling application will be conducted in Monterey Bay, CA and in a vertical profiling application at the Seward Alaska test site. Only instruments with a sampling rate of less than 1 minute will be considered for the vertical profiling test.

4.4.1 Surface Mapping

Surface mapping profiles will be conducted on board MLML's R/V J.H. Martin by mounting sampling inlets into a flow-through sampling chamber mounted in-line with the vessel's debubbled sea intake drawing from approximately 1.5m below the surface. The mapping test will consist of a 4 – 6 hours cruise over a cross-shelf region that will represent regions highly influenced by coastal runoff and out into open-ocean waters. The vessel will run at approximately 4 knots during the cruise. The vessel's underway data acquisition system provides continuous records (ca. 0.5Hz) of surface temperature, conductivity, optical backscatter and chlorophyll fluorescence, as well as, GPS coordinates of the sample stream.

Instrument Setup - Each of the manufacturers participating in a profiling application test will work with the ACT Chief Scientist and Tech Coordinator at MLML to design an appropriate sampling platform for the test. Specifically, manufacturers will have to state whether their instrument needs to be submerged continuously during the mapping test or if the instrument can be operated bench top with only the inlet tubing fixed into the flow-through chamber. Also, the sampling frequency of the mapping test will be determined on a case by case basis as best suited to the individual instrument test package. However, it is our goal to establish a common set of protocols to the greatest extent possible. Prior to deployment, all instruments will be calibrated as suggested in individual manufacturer manuals and exposed to low and high reference standards similar to the moored test. The instruments will be programmed to record data at time intervals between 1 Hz to a maximum of 15 minutes for the surface profiling tests, depending upon the manufacturer's recommendation. All instrument clocks will be synchronized to the vessels data acquisition system clock to facilitate subsequent geo-referencing of sampling positions.

Water Samples – The timing of reference sample collection will be set to match a common frequency of sampling timepoints for the instruments. This frequency will be no less than every 15 minutes. Water samples for reference nutrient concentrations will be collected manually from the sampling chamber using an acid cleaned wide-mouth 1L polypropylene bottle. The bottle will be rinsed 3x just prior to a designated sampling time and then filled at the designated time. The sample will be immediately processed onboard according to the protocols defined above for the mooring test. The filtered samples will be frozen immediately if possible, or minimally stored on ice in the dark until return to the lab. All sampling and filtration equipment will be rinsed 3x with each new sample. Sample time points, latitude and longitude will be recorded on log sheets.

4.4.1 Vertical Profiling

For the vertical profiling test, only instruments that can sample at a frequency of 1 per minute, or greater, will be tested in this application. The test will consist of two independent profiles conducted at varying locations during a single cruise, where simultaneous instrument measurements and discrete samples are collected from the ship at six discrete depths throughout the water column. The basic sampling design will be to collect two reference samples in the surface mixed layer, two within the pycnocline, and two within the hypolimnion in order to capture the maximum variation in nutrient levels. One of the six discrete depths will be sampled in replicate with two independent bottle collections. The exact depth locations will be determined on the basis of water column depth and the observed temperature and fluorometer

profiles obtained in real-time during the downcast of the rosette system. In the event that the real-time data acquisition fails, the hydrographic profiles will be obtained from a separate initial cast, and the rosette will be deployed immediately after, in AutoFire mode with preprogrammed depths, based on the temperature, salinity, and fluorometry profiles from the previous cast. The rosette and test instrument assembly will be lowered and raised at the standard rate of between 0.25 – 0.5 m/sec and the data collected by test instruments will be presented for both down- and up-casts. The rosette will be maintained at sampling depths for 2 minutes prior to firing the sampling bottle to ensure that water has reached equilibrium with respect to any mixing influence from lowering the unit and that the bottle is well flushed.

For vertical profiles the test instruments will be mounted within a modified 6 or 8 Niskin bottle profiling rosette so that all instruments and bottles measure and sample near the same depth as physically possible. A standard and calibrated CTD package will be attached to the rosette and programmed to provide an independent record of conductivity, temperature, depth and time during each instrument sampling event. For any of the test instruments that cannot be connected directly into the CTD logging unit of the rosette, profiling data will be internally logged and then matched up to the CTD profiles by synchronized time-stamps.

Reference Water Samples - Water samples for reference nutrient concentrations will be collected only on the up-cast. At each of the selected depths, the rosette will be paused for 2 minutes to ensure that all test instruments have equilibrated to those conditions and that a sample has been collected at that specific depth. After the delay, one Niskin bottle will be fired at each depth (except where a field duplicate will be taken) in correspondence with the test instruments sampling time. For test instruments that sample at high frequencies (such as 1Hz) we will average the instrument readings for 10 seconds before and after the specific time at which the bottle was fired. Bottle numbers, depth, and profile number will be recorded on the field data log. Water samples will be processed immediately upon retrieving the rosette on deck, following the same procedures defined for the mooring test.

4.5. Ancillary Environmental Data

A series of ancillary data sets will also be collected during field deployments to both fully characterize the different field conditions during testing and to provide qualitative comparisons as to whether particular environmental parameters correlate with instrument nutrient measurements. At each of the mooring test sites, a calibrated CTD package will be attached to the test rack and positioned at the same depth as the test instruments to provide an independent record of conductivity and temperature measured at 15-minute intervals. A calibrated in situ fluorometer and transmissometer will be connected to a datalogger and placed into the water (at the same depth and as close as possible to the test instruments with cross interference) to collect ancillary data on relative fluorescence and beam-c 660, respectively, every 30 minutes (again corresponding to the timing of test instrument readings). However, because these optical instruments are sensitive to biofouling, they will be cleaned daily just prior to a sampling event. After the daily cleaning, one value for both the fluorometer and transmissometer will be taken in air prior to returning to the water. The cleaned/in air values will be recorded directly on a datasheet as they are collected and all logged values reviewed to ensure that instruments are being maintained at desired performance levels.

In conjunction with each water sample collection, each deployment site will also record other basic site-specific conditions. At the time of water sample collection, each site will log on standardized datasheets: date and time, weather conditions (e.g., haze, % cloud cover, rain, wind speed/direction), air temperature, recent large weather event or other potential natural or anthropogenic disturbances, tidal state and distance from bottom of sensor rack, and any obvious problems or failures with instruments. Datasheets will be transmitted on a weekly basis to the ACT Chief Scientist, for data archiving and ACT personnel performance QA/QC.

Each test site will either establish a meteorological station, or identify one in the vicinity, that can record air temperature, humidity, wind speed and direction and precipitation on a continuous basis to help identify the timing and intensity of any storm events.

Ancillary data will be used in a qualitative sense to understand the history of weather patterns and changes in ambient water quality conditions. These data will not be used for any direct calibration, correction, or statistical comparison to the nutrient concentration test data.

5.0. Demonstration Schedule

Note that the below schedule is provisional and actual dates for each milestone may vary.

- The Final Demonstration and ACT Demonstration Contract will be sent to Manufacturers by April 2, 2007
- Signed contracts are due back to ACT Headquarters by April 27, 2007
- All relevant deployment equipment or complete instrument packages should be delivered to the CBL test site by May 4, 2007
- A Nutrient Training Workshop will be held at CBL on May 14 -15, 2007. Manufacturers can demonstrate their instruments at this time and then immediately prepare them (or a second unit) for the CBL moored-deployment test.
- The CBL mooring test will run from May 16 - June 14, 2007. ACT will provide its Chief Scientist and 4 Tech Coordinators to help set-up instruments and initiate the deployment.
- All instruments will be sent back to individual Manufacturers for reconditioning and calibration by June 20, 2007
- Instruments will be sent from Manufacturers to the MLML test site by July 16, 2007 in preparation for the surface mapping test.
- Depending on level of manufacturer interest we will offer a second Training workshop at MLML from July 17 – 18.
- The surface mapping profiling test will be conducted from July 19 – 20, 2007.
- Instruments from companies that will participate at the Alaska test will be sent directly from MLML to Alaska by July 23rd. Manufacturer reps should plan on conducting any required servicing on site in Alaska prior to deployment.
- The Alaska vertical profiling test will be conducted from July 31st - August 1st.
- The Alaska moored deployment test will run from August 2nd – August 31st.

- All instruments will be sent back to individual Manufacturers for reconditioning and calibration by Sept 5th.
- Instruments will be sent from Manufacturers to the Michigan test site by September 26th 2007. The moored deployment test will run from Oct 1 – 26, 2007.
- Instruments will be sent back to Manufacturers by October 30, 2007.
- ACT Chief Scientist, Technical Coordinators, Technical Advisory Committee, and Quality Manager, will meet for 3 days to analyze results and evaluate the Performance Demonstration processes in early December 2007.
- ACT Performance Demonstration Statements for each individual instrument will be drafted and sent out for review by, Technical Advisory Committee, Technical Coordinators, Quality Manager, Partners, and Stakeholders in January 2008
- Final Performance Demonstration Statements will be sent to Manufacturers by February 15, 2008
- One page comment letters from Manufacturers are due by February 22, 2008
- Final Performance Demonstration Statements will be released to the public in March 2008

6. Data Recording, Processing and Storage

This section describes methods employed during data recording, processing, and storage to minimize errors and assure high quality analyses in the Performance Demonstration Statements.

6.1. Documentation and Records

A variety of data will be acquired and recorded electronically and manually by ACT staff in this Demonstration. Operational information and results from the reference method will generally be documented in a field/laboratory record book and on the data sheet/chain-of-custody forms (see below). An electronic copy of these raw data will be transferred to the ACT Chief Scientist weekly, who will store it permanently along with the rest of the study data.

The results from the test instruments will also be recorded electronically. Test data will only be downloaded and analyzed upon completion of the four-week field deployments. Once collected, one copy of these data will reside at the corresponding ACT test facility and a second copy at ACT Headquarters until the entire Demonstration is finished. The table below summarizes the types of data to be recorded and the process for recording data.

Data to be Recorded	Responsible Party	Where Recorded	How Often Recorded	Purpose of Data
Dates, times of sampling events	Each ACT Partner	Field record books/data sheets	Each reference sample collection and laboratory analysis	Used to organize/check test results; manually incorporate data into spreadsheets - stored in study binder
Test parameters (site conditions)	Each ACT Partner	Field record books/data sheets	Each reference sample collection	Used to define site characteristics; manually incorporate data into spreadsheets - stored in study binder
Test instrument calibration data	Each ACT Partner	Laboratory record Book/data sheets	Start/end of test	Document correct performance of test instrument
Test instrument data - digital display - electronic output	Each ACT Partner	- Data sheets - Instrument data acquisition system (data logger)	After completion of the 26-day field deployments	Used as part of test results; incorporate data into electronic spreadsheets - stored in study binder
Reference analytical results	CBL Nutrient Analytical Services Lab	Laboratory record Book/data sheets	At the conclusion of each analytical sample batch.	Used to check test results; manually incorporate data into spreadsheets - stored in study binder
Reference calibration data	CBL Nutrient Analytical Services Laboratory	Laboratory record books/data sheets	Whenever zero and calibration checks are done	Document correct performance of reference method
Performance evaluation audit results	ACT HQ	Laboratory record books/data sheets	At times of performance evaluation audits	Test reference method with independent standards/ measurements

6.2. Data Review

All data are to be recorded directly in the field/laboratory record book as soon as they are available. Records are to be written in water-proof ink, written legibly, and have any corrections initialed by the person performing the correction. Any corrections will be crossed out with a line (not blackened or white-out), and the correction made, with initials and date of correction. These data will include electronic data, entries in field/laboratory record books, operating data from the ACT Partner test facility, and equipment calibration records. Records will be spot-checked within two weeks of the measurement to ensure that the data are recorded correctly. The checker shall not be the individual who originally entered the data. Data entries shall be checked in general for obvious errors and a minimum of 10 percent of all records shall be checked in detail. Errors detected in this manner shall be corrected immediately. The person performing the review will add his/her initials and the date to a hard copy of the record being reviewed. The ACT Technical Coordinator (TC) will place this hard copy in the files for this Demonstration. In addition, data generated by each ACT Partner test site will be provided to the ACT Chief

Scientist and reviewed before they are used to calculate, evaluate, or report demonstration results.

7. Quality Assurance/Quality Control

The In Situ Nutrient Demonstration will be implemented according to these test protocols and technical documents (e.g. Standard Operating Procedures) prepared during the planning stages of the test. Prescribed procedures and a sequence for the work have been defined and all work performed during the Demonstration shall follow those procedures and sequence. Technical procedures include methods to assure proper handling and care of test instruments. All implementation activities are documented and are traceable to the test/QA plan and SOPs and to test personnel.

7.1. Laboratory Test Quality Control

All laboratory instrumentation at NASL used to measure nutrient concentrations of the reference samples will be calibrated by a highly trained technician using established SOPs that have met both State of Maryland and ACT audit checks. NASL will maintain a log of all calibration and reference QA/QC samples analyzed during the Demonstration. The logs shall include at least the following information: name and identification number of instrument, date of calibration, and calibration results. These logs shall be provided to the ACT Chief Scientist and maintained in a master calibration file as part of the QA/QC records. QA/QC samples will include:

a. Internal Nutrient Calibration Standards - Solutions prepared from stock standard solutions to calibrate the laboratory instruments with respect to analyte concentrations. Five standards will be measured in duplicate during each set of analyses. Consistency in absorbance values for each standard will be compared to long-term daily records.

b. External Certified Nutrient Standards - An external certified nutrient standard will be prepared and analyzed in duplicate during each set of analyses. External standards are used to verify the accuracy and consistency of the internal calibration standards.

c. Laboratory Reagent Blanks - an aliquot of reagent water that is treated exactly as the laboratory calibration standards including exposure to glassware, equipment, and reagents will be analyzed in duplicate during each set of analyses.

7.2. Field Quality Control – Mooring and Profiling Deployments

Field quality control represents the total integrated program for assuring the reliability of measurement data. It consists of the daily field logs, quality control samples, and sample custody procedures.

7.2.1. Field Logs

Standard, uniform field logs should be maintained for all fieldwork. These logs should report name of staff conducting fieldwork, date (month, day, and year), operating status of all equipment, and manual readings of environmental conditions.

7.2.2. Field Quality Control Samples

To ensure that the reference sample collection and analysis procedures are properly controlled, field trip blanks and field sample spike additions will be taken once a week during the test period. Field trip blanks and field sample spike additions will be analyzed in the same manner as the collected reference samples and should comprise a minimum of 5% of the total samples collected. Each field reference sample and field QA/QC sample will be analyzed in triplicate.

a. Field Trip Blank: Sample containers filled with reagent water (Type 1 reagent grade deionized water) are taken to the field and processed identically to field reference samples to evaluate contamination introduced during sampling, storage and transport.

b. Field Sample Spike-Additions: An aliquot of a reference sample to which a known quantity of the analyte of interest is added in the laboratory. The field sample spike is analyzed exactly as the initial reference sample and is designed to determine whether the sample matrix contributes bias to the analytical results. The background concentration of the sample matrix must be determined independently and subtracted from the field spike.

c. Field Duplicates – for profiling applications only, we will collect two reference sample water bottles simultaneously at approximately 10% of the sampling points.

7.2.3. Sample Custody

All reference samples will be accompanied by the sample collection sheet and Chain-of-Custody (COC) forms. The COC specifies time, date, sample location, unique sample number, requested analyses, sampler name, required turnaround time, time and date of transaction between field and laboratory staff, and name of receiving party at the laboratory. Proper labeling of sample bottles is critical. The COC is a mechanism by which a sample can be tracked through the various phases of the process: collection, shipping, receiving, logging, sample prep/extraction, analysis and final data QA/QC review.

7.2.4. Sample Handling

All collected reference samples at each test site will be handled in the same manner. All environmental reference samples should be processed while wearing clean laboratory gloves to minimize potential sources of contamination. Each reference sample should be dated and coded according to site and sample sequence. The actual sample container should be labeled with a number for identification. The reference sample number should be used in all laboratory records and COCs to identify the sample. Transfer of reference samples from field personnel to laboratory personnel is also recorded on the COC and records are maintained in the laboratory with the names and signature of persons leaving and receiving the custody. Samples stored for any period of time shall be routinely inspected by the TC to assure proper preservation and label

integrity. The storage containers and storage devices (i.e. freezers and refrigerators) must be visually inspected on a routine basis to assure proper operation and integrity. Results of all inspections shall be included in the sample records. All logs shall be duplicated weekly. The original shall be retained at the ACT Partner site and a copy shall be sent to the ACT Chief Scientist.

7.3. Audits

Independent of the QA activities that are being conducted at each Partner test facility, the ACT Chief Scientist will be responsible for ensuring that the following audits are conducted as part of this demonstration at a minimum of two ACT Partner test sites. Audits shall be performed by QA Manager, who shall be independent of direct responsibility for performance of the Demonstration.

7.3.1. Performance Evaluation Audits

A performance evaluation audit will be conducted of the NASL to assess the extent and compliance of their QA program, adherence to SOPs, and quality of external QA tests of round-robin samples. We propose to conduct our evaluation in conjunction with a previously scheduled 3 day audit being conducted on behalf of the Maryland Department of Environmental Quality.

7.3.2. Technical Systems Audits

ACT's QA Manager will perform a Technical Systems Audit (TSA) at least once during this Demonstration. The purpose of this audit is to ensure that the Demonstration is being performed in accordance with the test/QA plan, published reference methods, and any SOPs used by the Partner test facility. In this audit, the ACT QA Manager may review the reference methods used, compare actual test procedures to those specified or referenced in the test/QA plan, and review data acquisition and handling procedures. A TSA report will be prepared, including a statement of findings and the actions taken to address any adverse findings.

7.3.3. Data Quality Audits

ACT's QA Manager will audit at least 10% of the data acquired in the Demonstration to determine if data have been collected in accordance to the test/QA plan with respect to compliance, correctness, consistency, and completeness. The ACT QA Manager will trace the data from initial acquisition to final reporting.

7.3.4. Assessment Reports

Each assessment and audit will be documented, and assessment reports will include the following:

a. Identification of any adverse findings or potential problems,
b. Response to adverse findings or potential problems,

c. Possible recommendations for resolving problems,
d. Citation of any noteworthy practices that may be of use to others, and
e. Confirmation that solutions have been implemented and are effective.

7.4. Corrective Action

The ACT Chief Scientist, during the course of any assessment, audits, or review of laboratory results will identify to the party performing the specific activities any immediate corrective action that should be taken. If serious quality problems exist, the ACT Chief Scientist is authorized to stop work. Once the assessment report has been prepared, the ACT Chief Scientist will ensure that a response is provided for each adverse finding or potential problem and will implement any necessary follow-up corrective action. The ACT QA Manager will ensure that follow-up corrective action has been taken.

7.5. QA/QC Document Control

It is the responsibility of the ACT Chief Scientist to maintain QA/QC records, which shall include the following:

a. records of the disposition of samples and data.
b. records of calibration of instruments.
c. records of QA/QC activities, including audits and corrective actions.

8. Roles and Responsibilities

The Demonstration is coordinated and supervised by the ACT Chief Scientist and ACT Partner institution personnel. Staffs from the Partner institutions participate in this test by installing, maintaining, and operating the respective technologies throughout the test; operating the reference equipment, collecting the water samples, downloading the data from the instrument package, and informing the ACT Chief Scientist staff of any problems encountered. Manufacturer's representatives shall train ACT Partner staffs in the use of their respective technologies and, at their discretion, observe the calibration, installation, maintenance, and operation of their respective technologies throughout the test. QA oversight is provided by the ACT QA Manager. In addition to aiding the development of these protocols, the external Technical Advisory Committee will be consulted during the evaluation in the event problems occur, will assist in the analyses of results, and will review the final Performance Demonstration Statement prior to release. Specific responsibilities are detailed below.

The ACT Chief Scientist has the overall responsibility for ensuring that the technical goals and schedule established for the Demonstration are met. The ACT Chief Scientist shall:

- Prepare the draft Test Protocols/QA Plan and Performance Demonstration Statements.
- Revise the draft Test Protocols/QA Plan and Performance Demonstration Statements in response to reviewers' comments.
- Coordinate distribution of the final Test Protocols/QA Plan and Performance Demonstration Statements.
- Coordinate testing, measurement parameters, and schedules at each ACT Partner institution testing site.

- Ensure that all quality procedures specified in the test/QA plan are followed.
- Respond to any issues raised in assessment reports and audits, including instituting corrective action as necessary.
- Serve as the primary point of contact for manufacturers and ACT Partner Technical Coordinators.
- Ensure that confidentiality of proprietary manufacturer technology and information is maintained.

The ACT QA Manager shall:

- Review the draft Test Protocols/QA Plan and Performance Demonstration Statements.
- Conduct at least one technical systems audit (TSA) once during the Performance Demonstration.
- Audit at least 10% of the Demonstration data.
- Prepare and distribute an assessment report for each audit.
- Verify implementation of any necessary corrective action.
- Notify the ACT Chief Scientist if a stop work order should be issued if audits indicate that data quality is being compromised or if proper safety practices are not followed.
- Provide a summary of the audit activities and results for the Performance Demonstration reports.
- Review the draft Performance Demonstration reports and statements.
- Have overall responsibility for ensuring that the test/QA plan and ACT QMP are followed.
- Ensure that confidentiality of proprietary manufacturer technology and information is maintained.

ACT Technical Coordinators at each ACT Partner institution shall:

- Assist in developing the Test Protocols/QA Plan.
- Allow facility access to the manufacturers and ACT Headquarters representatives during the field test periods.
- Select a secure location for the tests.
- Install, maintain, and operate the test nutrient analyzers at their respective test locations according to the specified instructions of the manufactures and these protocols.
- Perform sample collections and analyses as detailed in the test procedures section of the test/QA plan.
- One member of TC team will conduct 10% data audit as described in QA procedures. This will be done on all data logs and electronically entered data.
- Provide all test data to the ACT Chief Scientist electronically, in a mutually agreed upon format.
- Remove sensor systems and other related equipment from the test facility upon completing the Performance Demonstration test.
- Provide the ACT Chief Scientist and Quality Managers access to and /or copies of appropriate QA documentation of test equipment and procedures (e.g., SOPs, calibration data).
- Provide information regarding education and experience of each staff member involved in the demonstration.
- Assist in ACT's reporting of their respective test facility's QA/quality control results.
- Review portions of the draft Demonstration Statements to assure accurate descriptions of their respective test facility operations and to provide technical insight on demonstration results.

The Nutrient Analytical Services Laboratory at CBL shall:
- Perform reference sample measurements.
- Perform all QA/QC analysis as detailed in the these Test Protocols.
- Provide the ACT Chief Scientist and QA Manager access to and /or copies of appropriate QA documentation of test equipment and procedures (e.g., SOPs, calibration data).
- Provide information regarding education and experience of each staff member involved in the demonstration.
- Assist in ACT's reporting of their respective test facility's QA/quality control results.
- Review portions of the draft Demonstration Statements to assure accurate descriptions of their respective test facility operations and to provide technical insight on demonstration results.

Manufacturers shall:
- Review the draft test/QA plan and provide comments and recommendations.
- Approve the revised test/QA plan.
- Work with ACT to commit to a specific schedule for the Demonstration.
- Provide a operational sensor systems for each of the agreed upon test sites.
- Provide an on-site operator(s) to directly assist ACT staff in the installation, operation, and maintenance of the sensor systems.
- Review and comment upon their respective draft Performance Demonstration Statements.

Note: ACT reserves the right to dismiss any manufacturer from the Demonstration if it does not comply with agreed upon schedules or requirements.

Nutrient Analyzer Technical Advisory Committee shall:
- Assist in developing the Test Protocols/QA Plan.
- Approve the final Test Protocols/QA Plan.
- Provide specific advice during testing.
- Review and comment upon draft Demonstration Statements.
- Approve final Demonstration Statements.

9. Nutrient Analyzer Technical Advisory Committee

- Dr. Earle Buckley, North Carolina State University and ACT Advisor/QA Manager
- Dr. Jan Newton, ACT Stakeholder and University of Washington
- Dr. Chris D'Elia, University of South Florida, St. Petersburg
- Dr. Lou Codispoti, Horn Point Lab, University of Maryland
- Dr. Patrick Anderson, University of Wisconsin-Milwaukee

10. Field Test Site Descriptions

Chesapeake Biological Laboratory Field Test Site –

The ACT Partner at Chesapeake Biological Laboratory (CBL), University of Maryland Center for Environmental Science, has established a Technology Verification Field Test Site on a fixed pier (Lat: 38°19.039 N, Lon: 76°27.065 W, with an average depth of 7 ft) at the mouth of the Patuxent River, a tributary of the Chesapeake Bay. The Chesapeake is a nutrient rich estuary with a watershed that encompasses portions of six states and the District of Columbia. Water

temperatures at the testing location range from 0° to 35°C and salinities range from 5ppt to 20ppt depending on season, rainfall, wind, and other external factors.

Cooperative Institute of Limnology and Ecosystem Research Field Test Site –

The ACT Partner at the Cooperative Institute for Limnology and Ecosystems Research, University of Michigan, will establish a field test site for this Demonstration on a fixed pier at the MI-Department of Natural Resources facility located at the mouth of the Clinton River in Malcomb County, MI (43º 13.667 N, 86º 20.333W). The site provides direct access to the Clinton River with water depth at the end of the pier averaging 3m. River water temperatures range from 2 to 24°C on an annual basis.

Moss Landing Marine Laboratories Field Test Site –

Surface mapping using the Underway Data Acquisition System aboard the R/V JH Martin or portable UDAS on MLML whalers can take place from the entrance of Moss Landing Harbor to the full extent of Monterey Bay with a daily working grid spanning 36.9º N to 36.6º N and 121.8º W to 122.2º W. The geographical span includes locations adjacent to the M0 (coastal 36.9º N, 122º E) and M1 (oceanic, 36.8º N, 122.1º W) permanent mooring stations in Monterey Bay. Water conditions range from turbid coastal estuarine influence to oceanic conditions for the region.

Alaska SeaLife Center Field Test Site –

The ACT Partner at the Alaska SeaLife Center, University of Alaska Fairbanks (UAF) has established its Technology Evaluation Field Site at the Humpy Cove in Resurrection Bay, northern Gulf of Alaska. Resurrection Bay is a long fjord which protects the ice-free port of Seward, allowing for consistent recreational and commercial boat traffic. Humpy Cove is located in the outer bay outside the fjord's sill approximately 11 nautical miles from Seward. The deployment site (59º 58.32 N and 149º 17.54 W) is on a floating dock, which is situated in a small protected area on the southern side of the Cove. These waters have summer temperature range from 6 ºC to 14 ºC. The near-surface salinity varies from 30.5 psu in spring to about 20 psu by the late summer and is strongly dependent on amounts of snow accumulated in winter and summer rainfall. The site experiences a predominantly semidiurnal tide with mean range of 8.33 feet. The minimum depth at the test site is about 5m at MLW.