Washington State Department of Ecology

Environmental Assessment Program

Standard Operating Procedure for Installation, Deployment, and Retrieval of Oceanographic Sensors and Safety at Marine Mooring Stations

Version 2.1

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Please note that the Washington State Department of Ecology's Standard Operating Procedures (SOPs) are adapted from published methods, or developed by in-house technical and administrative experts. Their primary purpose is for internal Ecology use, although sampling and administrative SOPs may have a wider utility. Our SOPs do not supplant official published methods. Distribution of these SOPs does not constitute an endorsement of a particular procedure or method.

Any reference to specific equipment, manufacturer, or supplies is for descriptive purposes only and does not constitute an endorsement of a particular product or service by the author or by the Department of Ecology.

Although Ecology follows the SOP in most instances, there may be instances in which Ecology uses an alternative methodology, procedure, or process.

SOP Revision History

Revision Date	Revision number	Summary of changes	Sections	Reviser(s)
October 4, 2012	2.0	Revised **Title, Scope** and **Applicability** sections to specify the focus of the SOP on installation, deployment, retrieval, and safety.	1,2	David Mora, Suzan Pool, Julia Bos
October 4, 2012	2.0	Updated **Definitions, Personnel Qualifications, Equipment and Reagents, and Record Management** sections to be consistent with current convention and practices.	3, 4, 5, 7	David Mora, Suzan Pool, Julia Bos
October 4, 2012	2.0	Reorganized and updated **Summary of Procedure** into basic sections: installation, telemetry installation, securing instruments, deployment, retrieval and safety. Removed much of the discussion related to programming, seawater sampling, etc. and replaced it with references to the program QAPP.	6	David Mora, Suzan Pool, Julia Bos
October 4, 2012	2.0	Removed most of **Quality Assurance** section, instead referring to the Mooring QAPP.	8	David Mora, Suzan Pool, Julia Bos
October 4, 2012	2.0	Updated safety section to include discussion previously included in a technical note.	9	David Mora, Suzan Pool, Julia Bos
2/11/2013	2.0	Removed TOC; updated cover page		B. Kammin
2/11/2016	2.1	Minor edits and clarifications, updated authorship, updated references.	All	Suzan Pool

1.0 Purpose and Scope

1.1 This document is the Environmental Assessment Program (EAP) Marine Monitoring Unit (MMU) Standard Operating Procedure (SOP) for field operations at mooring stations in Puget Sound and Willapa Bay. The MMU uses mooring station data to help characterize water quality dynamics. Mooring data feature high temporal resolution and are thus useful towards describing the timing of water quality fluctuations and events. Mooring sensor packages utilize various internal and attached sensors for monitoring temperature, conductivity, pressure, dissolved oxygen, and fluorescence. Future sensor packages may utilize other oceanographic sensors. Specifically, the scope of this document covers installation/ implementation of mooring sites, deployment, and retrieval of deployed sensor packages, and field safety. More specific information on sampling methods, instruments used, and procedures can be found in the Marine Moorings Program's Quality Assurance Monitoring Plan (Mora et al., 2014).

2.0 Applicability

2.1 This document will be followed during the installation and maintenance of MMU mooring stations.

3.0 Definitions

3.1 Anti-foulant: Device used to remove or discourage accumulation of organisms or foreign matter that may impair or alter the performance of oceanographic sensors.

3.2 CTD: Conductivity-temperature-depth sensors used for water monitoring.

3.3 Davit: Crane-like structure with pulleys and a winch to hoist moorings during deployment and retrieval.

3.4 Fixed (rigid) mooring: Any mooring consisting of a CTD package that is attached to a weighted chain/line, mounted at a fixed altitude from the bottom, does not float, and thus, experiences a range of water pressure, depending on tide and local conditions. Typical sensors consist of a CTD package with conductivity, temperature, depth (pressure) sensors, dissolved oxygen, and flow-through or optical fluorometer (Figure 1).

Figure 1. Fixed (rigid) mooring raised above the water prior to deployment.

3.5 Free-floating mooring: Any mooring consisting of a CTD unit that floats at a single depth, in our application, just below the water surface. Typical sensors consist of a CTD with conductivity, temperature, depth (pressure) sensors and a flow-through or optical type fluorometer. These units are housed in a protective stainless steel cage outfitted with flotation devices and mounted to a fiberglass I-beam to allow vertical movement with the tide (Figure 2). The I-beam is secured to the piling with U-bolts and plastic mounts. For additional information, please see diagrams and details in Appendix 1, "Example of I-beam Replacement Plan."

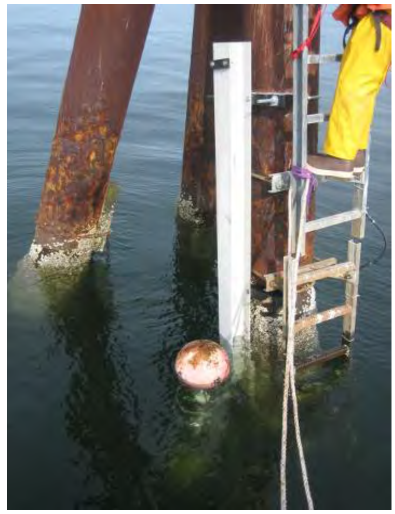

Figure 2. Free-floating mooring on I-beam track.

3.6 Pinger: Underwater acoustic beacon which sends out an electronic pulse when immersed in water. This device helps to locate an instrument package, if lost.

3.7 Self-cleating block and tackle: A system consisting of two pulleys, cleat, and rope used to raise the sensor package above the I-beam at free-floating moorings.

3.8 Telemetry: The process of transmitting data from a remote sensor to a data collection point via cabling and cellular communication in order to upload, record, process, and post data in near real-time. The system includes communication cables connected from a moored instrument to a cellular modem, utility box, and power supply system. Through the telemetry system, an in-house software program communicates with instrument packages (CTD), requests a data upload, and then stores data in a repository. From the repository, data are then displayed on the mooring web page.

3.9 U.S. Aids to Navigation System (USCG Nav-Aid): A United States Coast Guard navigational aid is a marker placed to aid in vessel navigation or nautical travel. Common types of such aids include lighthouses, buoys, fog signals, day beacons, and channel markers. Permits and licenses are required to attach or mount non-USCG equipment on any USCG Nav-Aid.

3.10 Zinc Anode: An easily corroded sacrificial metal that is attached to a mooring package to protect more valuable metal surfaces from electrochemical oxidation.

4.0 Personnel Qualifications/Responsibilities

4.1 Depending on the site and type of installation, mooring field operations require at least two technicians to safely perform. Each must be capable of lifting or hoisting up to 50 pounds as well as climbing pilings or other structures.

4.2 Training on the use of Sea-Bird Electronics, Inc. (SBE) and WET Labs equipment (oceanographic sensors) and software.

4.3 Experience with seawater sampling.

4.4 Training in telemetry and electronic communications.

4.5 Training in safety procedures for working on floating structures, near/over open water (dock work), on boats, and using climbing harnesses and ropes.

4.6 Experience working with hazardous chemicals.

5.0 Equipment, Reagents, and Supplies

5.1 Infrastructure Equipment and Supplies

5.1.1 Fixed (rigid) mooring infrastructure components: anchor, galvanized chain, telemetry box and cables, mounting boards, davit mounts, double braided nylon retrieval rope, and hardware. Rope may be 1/2 to 5/8 inch in diameter but will not fit many belay devices, therefore, for belaying, preferable diameter is 3/8 inch.

5.1.2 Free-floating mooring infrastructure components: I-beam, U-bolts, grooved cage mount, protective cage, floats, anchor strap, self-cleating block and tackle pulley system, and boat hook to attach carabiner.

5.2 Davit with winch and pulleys. It must also have a cleat secured to its stem.

5.3 Oceanographic sensors. For example: SBE 16plus, SBE 37-SM, SBE 37-SMP, SBE 43, WET Labs WET Star (See Mora et al., 2014).

5.4 Personal safety equipment including climbing gear: approved life jackets, foul weather gear, goggles, gloves, ropes, climbing harness, climbing slings, carabiners, swing, and helmet.

5.5 Anti-foulants with replacement inserts.

5.6 Zinc anodes.

5.7 Field log notebook with appropriate checklists, forms, procedures, and manuals.

5.8 Mooring data acquisition equipment: laptop computer equipped with SBE and WET Labs software and CTD-to-laptop communication cables.

5.9 Tool box with required tools and replacement parts for hardware.

5.10 Pingers with batteries.

5.11 Telemetry components: utility box, cellular modems (currently Digi brand), power supply, power cords, voltage regulator, data I/O cables, and antennae.

Figure 3. CTD clamped inside a floating protective cage that rides up and down the I-beam with water level changes.

6.0 Summary of Procedure

This procedure covers mooring installation, telemetry installation, mooring deployment, and mooring retrieval. Note: *Although not specifically discussed in this SOP, operations at a mooring field site include many activities beyond installation of the infrastructure, deployment, retrieval, and safety. These activities include pre-visit activities such as scheduling, planning, instrument preparation, service, maintenance, testing, calibration, and software programming. Activities during a mooring site visit include data upload and verification, sensor testing and servicing, seawater sampling, and documentation. Following a field site visit, additional procedures include data processing and information management, quality assessment, and data reporting. Description of these activities and references to procedures along with specific site selections can be found in the Marine Mooring Program QAMP (Mora et al., 2014).*

6.1 *Mooring Installation*

6.1.1 Installation at Free-Floating Mooring Stations

6.1.1.1 Free-floating mooring installations occur on USCG Nav-Aid channel markers. A permit or license is required to install any non-USCG equipment on USCG Nav-Aids. These stations are configured as follows (Figure 2 and Figure 3).

6.1.1.2 An I-beam track is bolted to the outside of a piling with U-bolts that wrap around the piling. Use divers to attach the I-beam to the piling underwater. To facilitate dive operations, attach or remove I-beams during periods of low current velocity, i.e., neap slack tides. *For more detail on I-beam installation, an example of an I-beam replacement plan is in Appendix 1.*

6.1.1.3 The CTD package is secured by hose clamps and inside a stainless steel protective cage.

6.1.1.4 The protective cage is connected to a plastic grooved car designed to securely ride along the I-beam track.

6.1.1.5 Floats mounted to the protective cage keep the depth of the car and instrument package just below the water surface. The floating package travels up and down the I-beam track with changes in water level caused by waves and tides.

6.1.1.6 Stop-blocks bolted to the upper and lower ends of the I-beam prevent the package from floating or sinking off the track.

6.1.2 Installation at Fixed (Rigid) Mooring Stations

6.1.2.1 There are three types of fixed mooring station installations used by Ecology – shallow bottom mooring stations installed by divers, deep bottom stations deployed via research vessel, and stations installed on docks, piers, or piling structure.

6.1.3 Installations at some fixed (rigid), shallow bottom stations are conducted by divers who shackle the CTD package mounting board to an anchor block (example in Figure 4).

Figure 4. Shannon Point Marine Center anchor block with eye bolts for attaching a CTD package.

6.1.3.1.1 Installations at some fixed (rigid), deep bottom stations are conducted by technicians via research vessel. A heavily ballasted tripod is deployed at these sites. This tripod includes acoustic release mechanisms which allow the tripod to release a retrieval line. CTD packages are attached to the tripods and collect data on near-bottom conditions.

6.1.3.1.2 Installations at some fixed (rigid) stations rely on a pier, dock, or piling structure. For this type of installation, the mooring sensor package is secured to a mounting board that is suspended from the dock by a galvanized steel chain and stabilized by a concrete anchor block (Figure 5). Attach two lines to an anchor block, a deployment/retrieval line and a 1-meter length of line for attachment to the lower end of a plastic mounting board. Attach the 1-meter line to the mounting board using a shackle. Secure all shackles with cable ties. Attach the CTD package to the mounting board using stainless steel hose clamps. Attach the upper end of the mounting board to galvanized chain using a shackle, secured with a cable tie. Place zinc anodes on the chain at any point where two types of metal come in contact with one another. Attach the upper end of the galvanized chain to the pier using a shackle, secured with a cable tie. Adjust chain length by placing the shackle appropriately. Mooring chain length is correct when the anchor block rests on the sea floor with a few inches of additional slack along the entire mooring. Additional mounting boards and sensor packages may be linked in to the anchor chain, where anchor chain lengths are attached to the lower and upper ends of the mounting board using shackles.

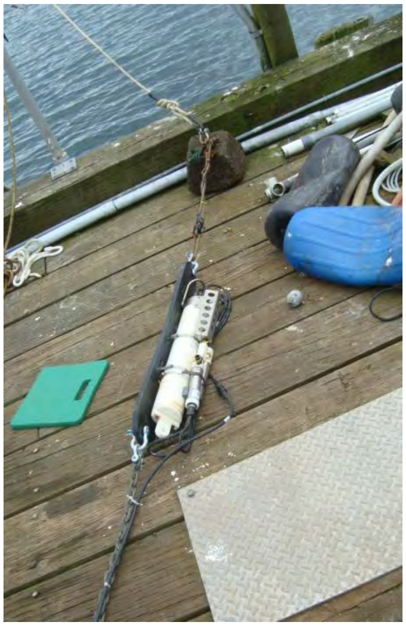

Figure 5. Anchor block attached to both retrieval line and a mounted CTD package.

6.1.3.2 Care must be taken to place the near-surface sensor packages at depths such that they remain submerged throughout the full range of spring tides.

6.1.3.3 Alternative fixed (rigid) deployment configurations may also be utilized where the CTD package is held in place without using a bottom anchor block for stability. One option is to thread an extended retrieval line through an anchoring block or other anchoring structure. Secure the extended retrieval line tautly at the surface. Care must be taken to provide sufficient retrieval line length to allow CTD package retrieval.

6.1.3.4 Polyvinyl Chloride (PVC) pipe or other similar structure may be used to fix sensor packages in place. For this type of deployment, PVC pipe is secured to piling structure (Appendix 2).

6.2 *Telemetry Installation*

6.2.1 The mooring program's telemetry system consists of cellular modems that are placed in utility boxes. Inside the utility box, cellular modems are connected to an external power supply, an antenna, and telemetry cables that receive and transmit CTD data (Figure 6).

6.2.2 Use a telemetry cable with a bulkhead CTD connector on one end and a pigtail at the other end. A pigtail end has exposed wires without a serial port connector.

6.2.3 Lay out sufficient length of telemetry cable to span between the utility box and the CTD's data I/O extension cable. Use cable ties to secure the telemetry cable to the mooring chain. The spacing between these attachment points should generally be less than three feet near the CTD mounting board and less than six feet elsewhere along the chain.

Figure 6. Telemetry system with cellular modem, pigtail end of cable, and RS-232 serial connectors.

6.2.4 Use a 0.5-meter data I/O extension cable to attach to the CTD's data I/O bulkhead connector designated by the manfacturer. The telemetry cable should not be attached directly to the CTD data I/O bulkhead connector.

6.2.5 Run the pigtail end of the telemetry cable through the bottom of the utility box (Figure 6).

6.2.6 Use RS-232 serial connectors to attach the pigtail end of the telemetry cable to the cellular modem. The serial connection pin arrangement for connecting internal wires from the telemetry cable to the serial connector can be found in the appropriate drawing/cable diagram or in sensor manufacturer's manuals. Figure 7 gives an example of pin assignments for the SBE 16*plus*' data I/O bulkhead connector.

6.2.7 Prior to plugging the serial connector in to the cellular modem, verify that the pin assignment connection is correct and that communications are functional by using a laptop computer to communicate with a CTD through the telemetry cable. Be certain to verify both transmission and reception of data.

6.2.8 Connect the serial connector to the cellular modem. On a Digi modem, the serial port 1 is typically used for the near-bottom sensor communication and the serial port 2 is used for near-surface sensor communication (Figure 8).

6.2.9 Connect antenna and power supply to the cellular modem.

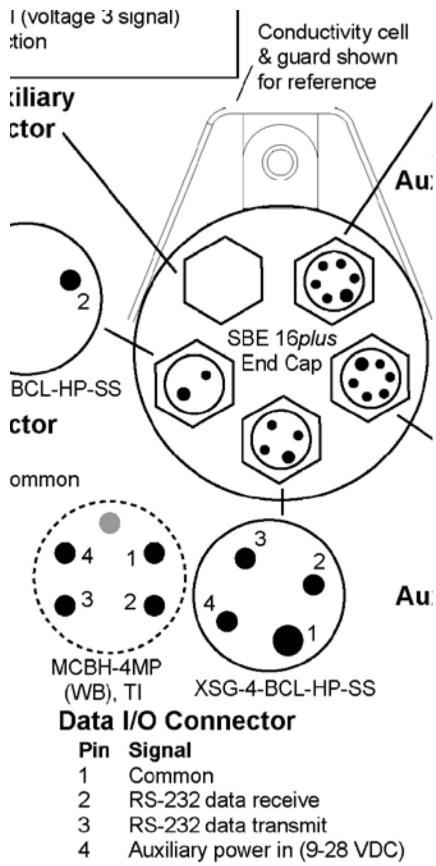

Figure 7. Data I/O pin assignments leading from bulkhead connector. (Image: Sea-Bird Electronics, Inc.)

6.2.10 The cellular modem must remain continuously on to buffer the telemetry line from errant false stop and start commands to the CTD that can result from any external electromagnetic signals generated around the pier. Ideally, power supply will be from an AC source (a plug-in power socket) fitted to the utility box. For some stations, this will not be practical and solar power is used. If powering the cellular modem using a single solar panel, two or more 12-volt batteries will be required to sustain sufficient electrical charge between monthly servicing trips.

Figure 8. Serial port 1 and serial port 2 on right side of a DIGI cellular modem.

6.2.11 Domain name system (DNS) proxy server attacks on cellular modem can disrupt service and/or generate excessive data usage (far above and beyond terms of data usage plans). Please follow the link below for a description of DNS proxy server attacks and prevention measures:

http://ftp1.digi.com/support/documentation/dnsproxyvulnerabilityissue.pdf.

6.2.12 Following the guidance suggested, filters are set so that our cellular modems will respond only to communication from the Department of Ecology static IP address (the internet protocol address assigned to the Department of Ecology network)[1]. Additional standard settings for a Digi cellular modem include[2]:

1) Under port profile, enable only Transmission Control Protocol (TCP) sockets.
2) For serial port 1, enable TCP access using port number 4001.
3) For serial port 2, enable TCP access using port number 4002.

6.3 *Mooring Deployment*

6.3.1 Securing CTD and Sensors

6.3.1.1 CTDs and sensors are mounted onto 1/2-inch thick plastic boards with pre-cut hose clamp slots. These non-metallic mounting boards are resistant to chain corrosion encountered using other designs. Insulated, stainless-steel hose clamps are used to secure CTD packages to the mounting boards.

6.3.1.2 A pinger is attached to each near-bottom sensor package to facilitate recovery of equipment that is inadvertently dropped to the sea floor.

6.3.1.3 Stainless steel cages protect free-floating moorings from floating debris. Insulation tape is used to minimize metal on metal contact between hose clamps and the protective cage.

6.3.1.4 Zinc anodes must be tightly secured to stainless steel cages and along galvanized steel chain to minimize electrical corrosion, especially near points where different types of metal come into contact (for example at a stainless steel shackle to galvanized steel chain connections) or at sites where stray current in the water could be an issue (marinas or docks with electrical wiring).

6.3.2 Deployment at Free-Floating Mooring Stations

6.3.2.1 Access via vessel and climbing is required to service floating moorings attached to USCG Nav-Aid markers. This type of servicing requires two technicians.

6.3.2.1.1 One technician works with boat operator to safely secure the boat to pilings.

6.3.2.1.2 The other technician, designated as the climber, dons the climbing, anchor strap, climbing slings, locking carabiners, harness, helmet, and hip pack containing tools for stop-block removal.

[1] From Digi web page: **ConnectPort WAN VPN Configuration and Management**>Configuration>Network>IP Filtering>Only Allow Access From Following Networks>

[2] From Digi web page: **ConnectPort WAN VPN Configuration and Management**>Configuration>Serial Ports>Port Profile Settings>TCP Server Settings>Enable Raw TCP Access Using Port>

6.3.2.2 The climber ascends the ladder and attaches the anchor strap to the base of the USCG Nav-Aid platform or similar and above the I-beam (Figure 9).

6.3.2.3 The climber attaches the self-cleating block and tackle pulley system's rigging to lower end of the anchor strap.

6.3.2.4 The climber pays out enough line to reach the CTD package on the boat deck.

6.3.2.5 The other technician and/or boat operator (deck crew) hands out supplies and conducts deck operations during block and tackle installation.

6.3.2.6 The climber uses climbing slings and carabiners to anchor and secure himself/herself to the ladder to while removing stop-block from the I-beam.

6.3.2.7 The climber removes the top I-beam stop-block.

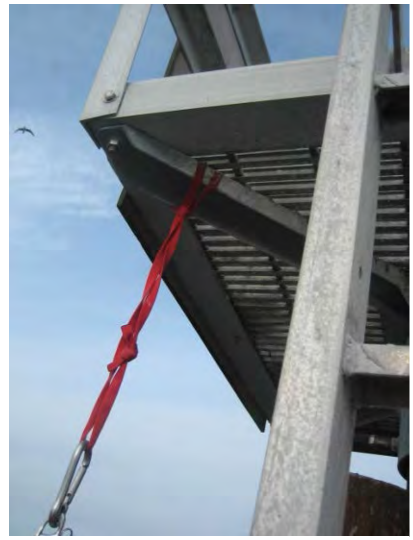

Figure 9. Anchor strap position on an USCG Nav-Aid platform.

6.3.2.8 Technicians on the boat connect the carabiner end of the block and tackle pulley system's rigging to the stainless steel cage inside of which the CTD is secured.

6.3.2.9 Technicians on the boat haul in the line of the block and tackle pulley system to hoist the package up to the climber and I-beam track.

6.3.2.10 The climber guides the suspended CTD package to fit on the track of the I-beam.

6.3.2.11 The deck crew lowers the CTD onto the track.

6.3.2.12 Once the CTD package's plastic car is on the I-beam track the deck crew stops lowering the CTD package and the climber loops a short length of rope through the cage and holds both ends of the rope braced against the ladder.

6.3.2.13 The deck crew lowers the CTD further so that tension is now on the bracing rope and off the block and tackle rope.

6.3.2.14 The climber unclips the carabiner and releases one end of the bracing rope which then releases the CTD package into the water.

6.3.2.15 The climber then bolts the plastic stop-block to the top of the I-beam, removes the rigging, and returns to the boat.

6.3.3 Deployment at Fixed (Rigid) Mooring Stations

6.3.3.1 Davits and ropes are used to deploy fixed (rigid) moorings mounted on docks or piers (Figure 10). The davit is set up in a pre-mounted davit holder. Because of safety considerations, installation of davit holders should be approved by the Operations Center Manager. Belay devices may also be used, if one can be attached at a fixed location forward of the davit.

6.3.3.2 Verify that the upper end of the chain is secured to the pier and that the telemetry cable is secured to the galvanized chain with well spaced and snugly secured cable ties. Loosely fit cable ties can lead to improper CTD orientation, damaged bulkhead connections, and potential entanglement with the anchor block. Cable ties near sensor packages should be snug enough to prevent the cable from slipping along the chain. Damage to the telemetry system occurs at the telemetry-to-CTD data I/O bulkhead connection when the cable slips out of proper orientation, placing the weight of the chain and anchor block on the CTD bulkhead connection. Therefore, using a data I/O extension cable on the CTD reduces the risk.

Figure 10. Lowering a CTD mooring package using a davit on a pier.

6.3.3.3 Place the davit in the davit holder.

6.3.3.4 Run the retrieval line through davit pulley and around the winch.

6.3.3.5 Crank the winch until the anchor block is suspended off the pier/dock and above the water.

6.3.3.6 Starting from the upper end of the chain, pay out by hand the mooring chain, instruments, and mooring mounts until all but the anchor block is suspended.

6.3.3.7 Using friction of the davit winch slowly release the retrieval line through the davit to lower the anchor block to the sea floor.

6.3.3.8 During deployment, it is possible for the anchor block to become entangled with the telemetry cable and/or retrieval line, thus preventing the anchor block from properly resting on the sea floor. If entanglement occurs, then the CTD package may be deployed in an improper configuration and/or at the wrong depth with high risk of damage to the telemetry cable and CTD. Verify that the anchor block is resting on the sea floor by checking tension on the mooring chain and retrieval line. When tugging on the deployment chain, the technician should feel for a few inches of slack prior to feeling the weight of the anchoring block. The technician should conduct a similar test with the retrieval line. If no slack is detected in the chain or retrieval line, the mooring should be retrieved to determine whether or not entanglement has occurred with the telemetry cable. If entanglement has not occurred, then sufficient chain should be payed out to allow the anchor block to rest on the sea floor.

6.3.3.9 For sites without a davit holder, the retrieval line can be deployed manually or using a roller fitted to the end of the dock to reduce friction on the line.

6.3.3.10 For some fixed (rigid) deployments on an USCG Nav-Aid, a climber is needed to deploy the mooring. The climber will wear helmet and harness throughout this type of deployment. Climbing ropes, straps, harness, carabiners, block and tackle pulley system, and pulleys will be used for these deployments and for safely securing the climber to the USCG Nav-Aid. A swing may be used as long as the seat is sturdy and can withstand the weight of the climber along with his/her personal safety equipment. The climber, with assistance from another technician and boat operator, rigs ropes, straps, and block and tackle to the Nav-Aid platform (not the railing). To minimize falling force, there must be less than 12 inches of slack in the safety line when climber is situated on the swing. The technician and boat operator will use a block and tackle to raise a CTD and deployment chain. From the swing, the climber receives the CTD and chain and then lowers it onto or into a device (e.g., PVC pipe) for fixed position below the water surface.

6.4 *Mooring Retrieval*

6.4.1 Retrieval at Free-Floating Mooring Stations

6.4.1.1 Climber ascends the ladder and attaches the self-cleating block and tackle pulley system to an anchor strap looped onto the base of the Nav-Aid platform/walkway and above the I-beam.

6.4.1.2 Climber pays out enough line to reach the CTD package.

6.4.1.3 Climber anchors climbing straps to the ladder to secure himself/herself while removing the stop-block from the top end of the I-beam and to attach the lower end of the block and tackle rigging to the stainless steel cage on the I-beam track.

6.4.1.4 Vessel crew and/or climber attaches the retrieval carabiner to a boat hook (with a slot to hold carabiner open).

6.4.1.5 Climber uses boat hook to attach the carabiner to the top ring of the protective stainless steel cage and located closest to the I-beam.

6.4.1.6 Climber returns to the stop-block position and, using carabiner and climbing straps previously anchored to the ladder, ties in to the ladder to help guide the CTD package off the I-beam and onto the vessel deck.

6.4.1.7 Vessel crew hoists the mooring off the I-beam by pulling the line attached to the block and tackle system and guides the mooring safely to the vessel deck for servicing, assessment, and data collection activities.

6.4.2 Retrieval at Fixed Mooring Stations

6.4.2.1 At certain shallow bottom sites, divers recover moored instruments bolted to fixed structures by unbolting the CTD’s plastic mounting board from the installed anchor block, attach the mount to a float, and guide it back to shore for service, assessment, and data collection activities.

6.4.2.2 At certain deep bottom fixed sites, research vessel teams recover moorings mounted on heavily ballasted tripods by activating acoustic release floats that bring a mooring retrieval line to the surface. The team then hoists the tripod and mooring package to the surface using a research vessel crane.

6.4.2.3 At certain fixed mooring sites, technicians use a davit and retrieval line to retrieve fixed moorings deployed off of piers/docks.

6.4.2.3.1 Place the davit into the davit mount.

6.4.2.3.2 Run the retrieval line through the pulleys and around the winch in the proper orientation to pull up the anchor block. In addition, a belay device may be used if it can be secured to a fixed location away from the edge of the pier/dock.

6.4.2.3.3 While one technician holds tension to the retrieval line, the other technician cranks the davit arm to pull in the retrieval line and raise the anchor block.

6.4.2.3.4 Raise the anchor block to or near the top of the dock, depending on the davit installation design.

6.4.2.3.5 Use the davit’s cleat to tie off the retrieval line to prevent the anchor block from slipping or dropping back into the water.

6.4.2.3.6 Manually pull up the galvanized chain that is attached to the mooring package, leaving the top end of the chain secured to the pier/dock.

6.4.2.3.7 Once the mooring package is out of the water and on the dock, immediately lower the anchor block to the dock to avoid accidental slipping and additional stress on equipment.

6.4.2.3.8 Lay out, at full length on the dock, the mooring line, telemetry cable, and chain to organize redeployments and to prevent entanglements and damage to equipment.

6.4.2.3.9 For retrieval where there is no davit, the retrieval line can be retrieved manually using a roller fitted to the end of the dock to reduce friction on the retrieval line.

6.4.2.3.10 If a mooring was deployed using a climber, the mooring must also be retrieved using a climber. From the USCG Nav-Aid, the climber sets the swing to the USCG platform/walkway to retrieve the CTD package and chain. For safety, the climber ties in to a safety line anchored to the USCG Nav-Aid platform. To minimize falling force, there must be less than 12 inches of slack in the safety line when situated on the swing. Assistance in retrieval will be provided by another technician and a boat operator.

6.4.2.3.11 Following retrieval of the mooring, CTDs will be worked on for service, assessment, and data collection activities.

7.0 Records Management

7.1 Field log sheets (paper or digital) are used to record information such as location, date and time, field conditions, equipment serial numbers, instrument status, data file names, and verification sample information.

7.2 Upon return from the field, logs and CTD data files are archived in appropriate folders on network servers as soon as possible.

7.3 Digital CTD data, sensor information, field log information, and observations following processing are entered into a centralized database.

7.4 All seawater samples collected for sensor assessment or verification are documented and processed further as specified in the Marine Mooring Program QAMP (Mora et al., 2014).

7.5 Additional details about records management are in the Marine Mooring Program QAMP (Mora et al., 2014).

8.0 Quality Assurance and Quality Control

8.1 To assure high quality data collection at all mooring sites, installations are established in conjunction with Ecology's senior oceanographers, other scientific experts, and local groups who may be knowledgeable about relevant conditions at a mooring site and may have access to resources necessary to maintain a mooring site. If possible, mooring site conditions are assessed prior to site establishment by conducting preliminary current and sensor measurements to establish baseline conditions. Through site assessment, the best applications along with types and method of measurements can be implemented.

8.2 All mooring site installations are reviewed and approved by appropriate Ecology technical staff, including construction managers and technicians, in order to ensure appropriate engineering and construction methods are utilized as site conditions necessitate.

8.3 As further discussed in the Marine Mooring Program QAMP: 1) All moored sensors are maintained and calibrated according to manufacturer specifications; 2) In between manufacturer calibrations, prior to, and following each deployment, we conduct tests to assess sensor performance; 3) To minimize impairment of sensor performance due to bio-fouling, we mount tri-butytin anti-foulants on sensor intake and exhaust ports.

8.4 All data collected at mooring sites are reviewed on a routine and frequent basis, and tested against established quality assessment methods.

9.0 Safety

9.1 General Mooring Field Hazards

9.1.1 Mooring deployments involve significant hazards:

1) Lifting heavy objects near water using davits, ropes, and chains
2) Climbing structures while maneuvering heavy objects over the water, and
3) Securing water vessels to pilings in challenging current, wind, and wave conditions.

9.2 Environmental Assessment Program Safety Manual

9.2.1 All field staff must understand and comply with the Environmental Assessment Program Safety Manual with extra emphasis on fall protection, working over water, chemical safety, and boating. Proper use of appropriate protective barriers is mandatory for all field staff.

9.3 Davit Safety

9.3.1 Catastrophic failure of the davit mount could expose technicians to high risk. Some davit mounts are bolted into wooden structures and these bolts can loosen. Davit mounts must be inspected for signs of potential failure. With the davit installed into the mount, a technician will push and pull the davit a few times to check whether bolts are loosening. If the bolts are determined to be loose, efforts will be made to retighten them or consider moving the davit mount.

9.3.2 Another potential davit failure can be caused by metal fatigue. Periodically check the davit stem and arm for any bending of metal that may be caused by weight stress.

9.4 Line/Rope and Chain Safety

9.4.1 For rope safety, we generally use 1/2 to 5/8 inch diameter double braided nylon rope with option of using 3/8 inch diameter rope to fit belay devices. This rope is suitable for mooring lines and climbing safety lines so long as the potential for falling prior to being arrested by the rope is less than 12 inches.

9.4.2 Failure of the retrieval lines and galvanized chains could expose technicians to high risk. Retrieval lines and galvanized chains are replaced annually. Ropes can become excessively viscous and begin to fray over time. Chains corrode in sea water over time. Routine inspections of the connection between lines, chains, and anchor block are conducted. Technicians should avoid standing in bight and loops of lines and chains, particularly during deployments and retrieval of moorings.

9.5 Anchor Strap and Rigging Safety

9.5.1 The anchor strap attached to the bottom of an USCG Nav-Aid platform should be inspected prior to connecting the self-cleating block and tackle pulley system’s carabiner. Confirm that cut and sealed strap ends are tied into an appropriate knot such as a water knot (ring bend) to make a loop which can then be secured to the platform using a girth hitch. Rigging (self-cleating block-and-pulley tackle system with line) should be inspected for wear and tear and replaced as needed.

9.6 Climbing Equipment

9.6.1 Essential pieces of equipment are used while climbing and include climbing slings, climbing harness, carabiners, well-fitting approved life jacket, gloves, and helmet. For additional guidance, please see Guidelines for Rope Access (U.S. Department of the Interior, 2004) and Safe Practices for Rope Access Work (Society of Professional Rope Access Technicians, 2012).

9.6.2 Climbing Slings

9.6.2.1 These are robust, tubular webbing nylon straps with sealed ends (to prevent fraying) tied into a water knot (ring bend) to make loops of varying lengths with carabiners attached to them. A looped strap can be secured to, for example, ladder steps using a girth hitch and a carabiner attached between the strap and climbing harness. These straps are intended to replace the need for a fixed climbing line on the USCG Nav-Aid, since environmental factors and wear will compromise the safety of fixed lines. Climbing slings are used to attach the climber to the Nav-Aid to act as a fall prevention device and as a working tether. The climber works in awkward positions where balance points and handholds may not be readily available; therefore, these personal climbing slings come in handy to assist in attaching the climber safely to the Nav-Aid. Several slings and carabiners are carried on the harness and staff is trained to use a 3-point attachment method when securing themselves with the slings and carabiners.

9.6.3 Harness

9.6.3.1 A commercially approved climbing harness is worn by the climber and needs to be well-fitting and worn properly. The harness also needs sufficicent capacity to hold several climbing slings and carabiners. All technicians who climb will be trained in appropriate fastening of a climbing harness. Generally, a climber should put their feet through the leg loops first, tighten the waist strap firmly as the second step, and then adjust all the smaller straps as the final step. The harness should be snug, but not too tight.

9.6.4 Carabiners

9.6.4.1 A carabiner is a metal link with a spring gate used to quickly and reversibly connect components in safety-critical systems. Carabiners connect the entire climbing system of harness, slings, rigging, and retrieval lines. Climbers should have at least one locking carabiner which is attached to the front loop of the climbing harness and always locked during climbs. All weight supporting carabiners used for climbing should have locking gates. Climbers should double-check carabiners for cracks or structural problems and to confirm that gates are working before climbing.

9.6.5 Helmet

9.6.5.1 An approved climbing helmet should be wornat all times when climbing an USCG Nav-Aid or similar structure. Brands such as Petzel, Black Diamond, etc. are recommended.

9.7 General Climbing Safety

9.7.1 Self-protection is the most important safety factor involved with climbing. Technicians should be well versed in the EAP safety manual and understand the concepts and mechanics of climbing. The following two sub sections (9.7.2 and 9.7.3) are the most important rules while climbing.

9.7.2 At least three contact points (hands, feet, climbing slings) are established between the climber and structure. One of the most common causes of slipping/falling is not having enough contact with the structure, resulting in fewer options to recover or prevent a fall. This is especially true while climbing on a slippery surface such as a USCG Nav-Aid.

9.7.3 Awareness of surroundings. Climbers need to watch for falling objects, pinch points, and sharp objects while climbing. Climbers should never place themselves between a boat and the USCG Nav-Aid, as the climber could be crushed if the boat drifted or is swept into the pilings.

9.7.4 Appropriate clothing, boots, and gloves should be worn to prevent injury.

9.7.5 Climbers should readily ask for assistance. The technician and vessel operator on deck should be available to readily assist and give advice before and while climber is on the structure.

9.7.6 Climbers should remain calm and move slowly at all times.

9.7.7 The other technician should be prepared to climb in case of an emergency. While one technician is up in the USCG Nav-Aid, the other should have the backup climbing harness ready in case of an incident.

10.0 References

10.1 Mora, D., J. Bos, and S. Pool. 2014. Quality Assurance Monitoring Plan: Long-Term Marine Waters Monitoring, Mooring Program. Washington State Department of Ecology Publication Number 14-03-103. 76 pp. https://fortress.wa.gov/ecy/publications/SummaryPages/1403103.html

10.2 Society of Professional Rope Access Technicians. 2012. Safe Practices for Rope Access Work. Society of Professional Rope Access Technicians, Wayne, PA. 23 pp. http://www.sprat.org/resources/Safe_Practices%20-%20August%202012.pdf

10.3 U.S. Department of the Interior. 2004. Reclamation: Managing Water in the West; Guidelines for Rope Access. U.S. Department of the Interior, Bureau of Reclamation, Technical Service Center, Denver, CO. 120 pp. http://www.usbr.gov/ssle/safety/rope/Rope_Access.pdf

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11.0 Appendices

Appendix 1 Example of I-Beam Replacement Plan

Appendix 2 SBE 37 Fixed Deployment and Rescue Plans

Appendix 1
Example of I-Beam Replacement Plan

Plan outline for August 3-4 Willapa I-Beam Replacement.

Objectives and Tasks:

1) Safety
    a. Accomplish most our work during slack time periods.
    b. Allow for sufficient time periods to complete work.
    c. Focus on morning sessions to avoid afternoon sea breezes.
    d. Plan out details, however be flexible as needed.

2) Replace I-Beam
    a. Remove old I-beam and components
        i. Secure I-Beam with ropes
        ii. Dive team disassembles submerged components
        iii. Divers exit water
        iv. Surface team removes surface components
        v. Old I-beam is raised and loaded on board Skookum
    b. Replace with new I-beam
        i. Raise new I-beam
        ii. Assemble upper components and secure upper portion of the I-beam
        iii. Divers secure lower portion of the I-beam
3) Deploy Floating CTD (16plus) on I-Beam, collect discrete samples, etc.
4) Deploy Second Fixed CTD (37SM/wpressure sensor) mounted in PVC pipe with Telemetry
    a. Verify depth of water at base of piling.
    b. Adjust 30 X 6 inch PVC pipe length if needed.
    c. Mark chain so that instrument intakes are nestled just outside lower end of pipe.
    d. Deploy PVC Pipe
        i. Raise pipe with ropes
        ii. Fix upper portion(s) of pipe to piling with chain and mini-chain binders
        iii. Divers fix lower portion(s) of pipe to piling with chain and mini-chain binders
    e. Place instrument with chain and telemetry cable inside PVC pipe
    f. Surface team secures solar panels and cellular modem utility box on the NAVAID platform. (note this task is listed sequentially but may be accomplished out of sequence, during a time period when on-water work is less than favored due to currents)
    g. Connect telemetry cable to cellular modem.

Team to include:

1 Climber/Technician

2 Deck Hands/Technicians

3 Divers

General strategy is to accomplish most of the work during safer slack tide periods. Purposely we have sought out days with relatively weak intertidal exchanges.

Day	High/ Low Tide	Time	Height (ft)	Sunrise/ Sunset	Time	% Moon Visible
Tuesday						
3	Low	1:50 AM	1.3	5:59 AM	Set 3:10 PM	53
3	High	7:47 AM	5.6	8:44 PM		
3	Low	1:05 PM	3.0			
3	High	7:25 PM	8.3			
Wednesday						
4	Low	2:57 AM	0.9	6:00 AM	Rise 12:06 AM	43
4	High	9:08 AM	5.5	8:43 PM	Set 4:17 PM	
4	Low	2:08 PM	3.5			
4	High	8:24 PM	8.4			

Time	Event
August 3, 2010	
0800	Depart OC for Tokeland.
1030-1130	Arrive at Tokeland. Meet divers at boat launch, load gear and launch.
1200	Arrive BC. Connect ropes and pulley to old I-beam, prep for dive team.
1230	Tide starts to turn slack. Dive team enters water and disconnects lower portion of old I-beam by removing submerged U-Bolt and braces.
1305	Low slack tide. Dive team readies I-beam floats if needed. Climbing team removes upper U-bolts Team lowers old I-beam to Skookum. Team secures old I-Beam. Climbing team installs solar panel and cellular modem/utility box. Team measures distance from top of I-beam to bottom (for PVC pipe placement).
1430	Team departs BC.
1500	Team arrives at Tokeland. Clean old I-beam and prep new beam for replacement. Cut PVC pipe to measured dimensions. Mark off chain and instrument so that instrument sensors emerge just below lip of PVC pipe.
1800	Weather permitting, Depart for BC.
1830	Arrive BC. Team raises replacement I-Beam and connects upper portion block.
1900	Tide begins to slack. Dive team connects U-bolts on submerged portions of I-Beam.
1925	Slack tide. Time permitting, team installs PVC pipe. Raises pipe with rope and secures upper portion of pipe with chain and mini-chain binders to piling. Dive team secures lower portion of PVC pipe with chain and chain binders (pipe used as lever). Grab sea-water for performance bath check of sensor.
2000	Depart for Bay Center.
2030	Arrive at BC and prep for following day. Grab sample of dock water too.

August 4

0730	Team arrives and loads Skookum.
0800	Tide starts to slacken, arrive at BC, tie up Skookum to piling, raise I-beam into position with ropes and pulley, climbers connect upper U-bolts and braces to piling.
0908	Divers prepare. Climbing team lowers 37SM CTD and chain/telemetry cable into PVC piping and secure chain to piling using chain and mini-chain binders. Climber cinches together chain links with a carabiner to get chain length to correspond with marked chain link and corresponding depth.
	High slack tide. Divers connect submerged U-bolts and braces to the piling. Divers verify that 37smCTD is sticking of PVC pipe, at depth.
1000	Climbing team deploys 16plus CTD on I-Beam. Telemetry cable attached and internet connectivity assessed.
1508	Back up slack low tide.

Example of Climber Sequence

Upon arrival at BC nav-aid:

1. Secure boat a safe distance away from BC ladder, oriented with either tide or wind and away from obstructions (Brian will know)
2. Set climber up on ladder with safety equip. secured to ladder.
3. With the bitter end of a hank of line, lash a monkey fist knot (or equivalent) around I-beam using either the top stopper block or the top standoff to act as an i-beam tether. Choose where you tether from based upon conditions, if the boom vang will reach, and to reduce/remove any odd angles that will impede the boom vang from acting as an extractor/tether.
4. Rig boom vang on tethering lanyard (hanging from crow's nest) and attach it to the i-beam via the i-beam tether. Be sure to leave enough room to allow for hoisting the i-beam after the standoffs have been released from the u-bolts. Secure the vang (pull slack) and belay the line to the ladder to keep it from swinging.
5. With the bitter end of a hank of line, set a bowline knot around the top standoff (behind the i-beam) and attach one or two floats on a short line (as short and tight to the i-beam as practical) as a safety precaution to keep the i-beam from sinking. You will use these floats later to relieve some of the weight from the i-beam when hauling it to the boat.
6. Set a binder around the i-beam and nav-aid limb below the top standoff to keep the i-beam from drifting or sinking during removal. This will assist the divers as well.
7. Remove as many u-bolts as you can reach from the ladder with the gear-wrench <u>except the u-bolt from the top standoff</u>. This will be the last one to be removed. You may need to wire brush the threads to allow easier removal. DO NOT CROSS THREAD OR STRIP THE THREADING FROM THE NUTs OR BOLTs. The u-bolts can be a pain to remove from around the nav-aid limb. Be patient and work the u-bolt back and forth until it walks off of the limb (a pry bar sometimes helps). After removing the u-bolt, rethread the nuts and washers back on (so you don't lose them). Lash a hank of line tossed from the boat with a monkey fist knot or equivalent around the u-bolt and let the boat deckhand pull the line/u-bolt aboard the boat.

8. Have the diver take a line down with him/her and set it around the bottom standoff and send it to the boat to serve as a hoist line for the i-beam removal.
9. Stand-by until diver removes all of the submerged u-bolts.
10. When the divers finish removing their bolts you will remove the top u-bolt. Before you do this, have a boat deckhand take control of the boom vang from the boat.
11. Remove the last u-bolt and send it to the boat in the previously described method.
12. Undo the binder holding the i-beam to the nav-aid limb and pry the i-beam/standoffs loose from the barnacle buildup. While you are doing this the deckhand should be adjusting the tension on the boom vang to take the weight off of the bio-buildup that is hanging on to the standoffs and controlling the tether line that is attached to the bottom standoff.
13. After the i-beam is loose and hanging, retake control of the boom vang from the deckhand have them focus on preparing to haul the bottom end of the i-beam in.
14. Uncleat the boom vang and lower the i-beam into the water until the floats relieve some of the weight on the boom vang. (If it sinks at an angle it is ok)
15. With the bitter end of another hank of line (at least 25 ft. long), set a bowline knot around the top standoff (behind the i-beam) and belay it to the ladder. This will become your control line when the i-beam is released from the boom vang. Make sure you tie a knot that will be easy to untie while under the weight of the i-beam
16. Uncleat the boom vang and slowly release the i-beam until the control line has taken the weight. Next remove the boom vang rigging from the i-beam and prepare the deckhand(s) for hauling in the submerged end of the i-beam.
17. Have the deckhands haul in the submerged end of the i-beam. Once they have control of the end, release your control line and (if the floats can handle the weight without you holding tension on the line) toss the loose end of the line to the deckhands. Have them secure the i-beam to the side of the boat or as Brian wants it attached. Note: For 2010 retrieval, the I-beam was not floated, simply fixed to the side of the workboat.
18. Clean up and board the boat.

Appendix 2

SBE 37 Fixed Deployment and Rescue Plans

Deployment Plan for SBE 37 CTD package at Bay Center, MMU.

7/28/2010, Christopher Krembs

Text contributions and Review provided by:

David Mora and Ashley Carle

1. Strategic Advantage:

An important component of Marine Monitoring Unit/Marine Waters (MMU/MW) strategy is to support NANOOS, the Northwest Association of Networked Ocean Observing System, and the understanding of what is going on in our oceans and estuaries. The NANOOS Visualization System provides an interface for users to access real time telemetered data that is received from MMU stations.

Right now we are failing to meet our commitments to provide real time data feeds from Willapa Bay. Shellfish growers regularly ask for timelines regarding when we will have a functional system in place. Our single remaining mooring deployment at Bay Center Willapa Bay is a near surface and floating. Our existing instrument package is attached to a NavAid Station piling. The floating package is mounted on an I-beam track that moves up and down on the track with waves and tides. Getting data from a moving instrument package and posting the data real time has proven to be technically challenging. We have been promised assistance from the University of Washington but it has yet to materialize.

Rather than try to post data from a moving CTD package at Willapa Bay we propose deploying a second CTD package that is held in a fixed subsurface position. From our Puget Sound mooring deployments we are well versed in how to set up telemetry transmissions from instruments deployed in a fixed position. We propose utilizing a proven deployment configuration for Willapa Bay CTD deployments, encasing the chained instrument (SM-37 with pressure sensor) in PVC piping and then chaining the PVC piping to the NavAid piling.

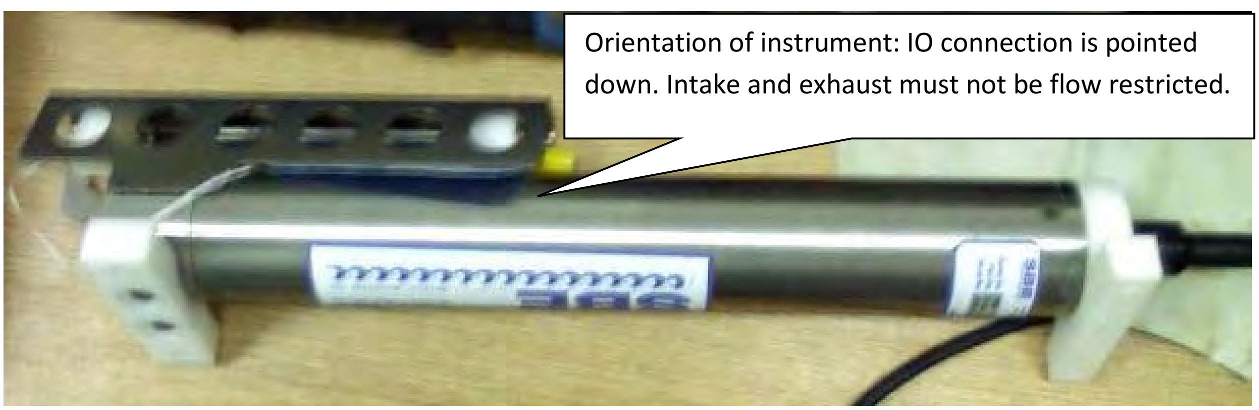

Figure 1. SBE 37SM with pressure sensor.

2. Site specific objectives:

Site specific objectives include:

- The deployment will support our commitment to provide high quality real time data to our stakeholders, e.g., shellfish growers.

- Telemetry transmissions from our SM37 will help assure data quality through continuous monitoring of instrument performance and troubleshooting as needed.
- Telemetry helps us understand when events are happening in Willapa Bay, and gives us the heads up of what to look for at other stations, and provides real time context toward oceanic observations.
- Deployment of a second mooring package at this station (WPA13) helps us prevent data gaps from occurring should one instrument or the other fail to operate as expected. By comparing data from both instruments we are in a better position to assess data quality.
- Deployment of a second mooring package at a different depth helps us better understand what is happening throughout the water column at WPA 13 not just what is happening at a single depth.
- Personnel safety at Willapa Bay deployments.
- Equipment protection for the Willapa Bay, Bay Center fixed position deployment.

3. Infrastructure and logistic support:

The deployment location will be at station WPA13, Bay Center at Willapa Bay on the same piling (opposite side) as the I-beam deployment figures 2-4. To protect the instrument the SM37 will be placed in a 6" x 30' PVC pipe bound by chain binders to the interior side of the piling. The PVC pipe will be spaced off of the piling with plastic spacers so that the I-beam u-bolts can potentially be removed without necessarily removing the PVC pipe.

The upper end of the PVC piping will be approximately the same height as the upper end of the I-beam. The SM37's conductivity tube has an intake and exhaust. Restrictions in flow can cause the instrument to read artificially low. Therefore the slots or holes will be placed in the pipe around these areas to allow flow. Any extended portions of the instrument below the intake will be protected by the pipe.

The SM 37 will be placed within the tubing attached to a 3/8" chain. The instrument comes with plastic attachment points. The chain will be attached to these points using small stainless steel shackles. The telemetry cable will follow the chain and be attached to the chain with cable ties.

Prior to deployment, the required length of the chain will be verified and marked so the SM 37 is suspended to the correct depth. Because of the potential for shifting sand bars, the instrument will be placed 2 meters from the bottom surface rather than 1 meter as is more typically done in mooring deployments. The support chain will be extended through a 1" hole in the cap placed at the upper end of the PVC pipe. To protect the pipe cap and the telemetry cable, hosing or layers of electrical tape will be placed around the contact area between the cap and the chain.

The upper portion of the support chain will be attached to a carabiner that is attached to a sling at the bottom grating of the NavAid platform (see figure 4).

For maintenance the cap will be removed prior to retrieving the instrument. During retrieval a rope can be placed through one of the chain lengths so that the chain can be lifted with better leverage.

Figure 2. Willapa Bay NavAid station and pilings.

Figure 3. Back side of piling.

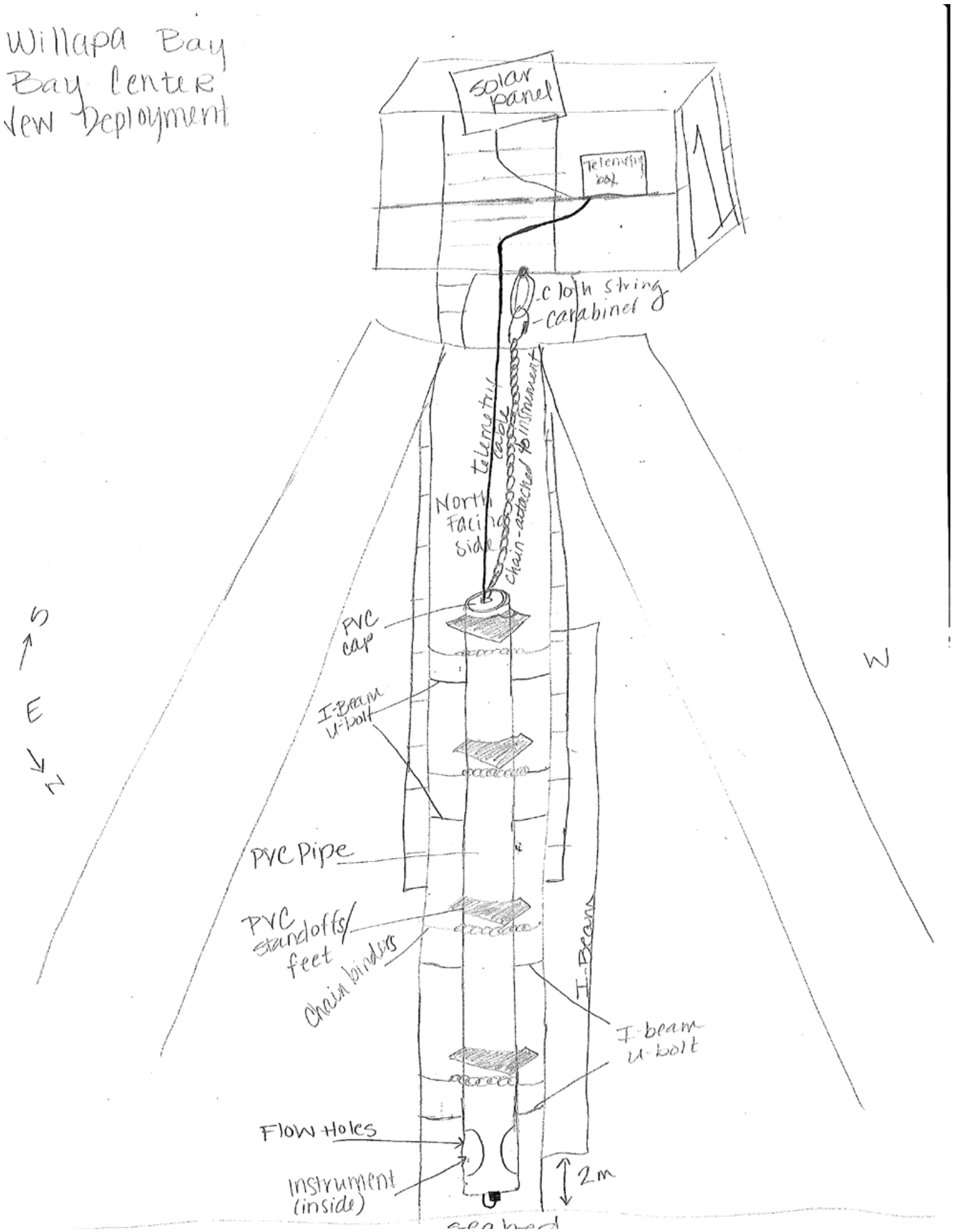

Figure 4. Deployment drawing.

The MMU is determined to ensure sufficient security measures to protect its instruments. PVC piping will be attached using seasoned EPA divers. A pinger will be attached to the instrument to assist retrieval if necessary.

Last year we pulled down the existing blue tooth/free wave telemetry system/solar panel. This system will be replaced by a new set of components. The solar panel will be connected to the railing structure using u-bolts. The utility box will be connected to the NavAid grating using cloth straps and bolts. Transmission of telemetered data will be achieved using an ATT digi device (cellular modem). This device has already been tested at other mooring locations.

4. Report on deployment and securing of SBE 37 instrument:

Approximately 30 days after the initial deployment we will return to retrieve the instrument and evaluate biofouling. At this time any problems noted in the deployment or retrieval will be reported as a follow-up to this deployment plan. Because the instrument telemeters data every 15 minutes, a failed transmission of data may be indicative of a problem. Should this happen we will attempt to schedule a maintenance visit sooner.

We believe that the proposed deployment can be done safely, effectively, and with minimal risk to equip the deployment. As a follow-up to this initial deployment plan we will include a discussion on our success of meeting our stated objectives (Section 2).

Willapa SBE37 Rescue Plan

Background

At the Willapa Bay, Bay Center, NavAid 1 station, we deployed a SBE37 CTD. The CTD is suspended on a chain inside a 30 foot x 6 inch PVC pipe. The depth of the CTD varies with tides ranging from 4 to 8 meters in depth. The CTD is connected to a telemetry cable and cellular modem for real time data transmission. We retrieve the CTD for maintenance by pulling the chain up through the PVC pipe.

Problem #1: Cannot Retrieve CTD

During our June 2011 servicing we were unable to pull up and retrieve the CTD through the PVC pipe. The cause is unknown. However, we believe that the plastic foot of the instrument may be lodged against the PVC pipe or the connector.

Problem #2 Telemetry Failure

We believe that the telemetry failure was caused by an over application of silicon grease to the connector. However, the cable connection was showing signs of wear back in June and may need to be replaced.

Problem #3: CTD Producing Poor Quality Data

Under the existing deployment set up, we have experienced difficulty in collecting quality data from this CTD. The CTD conductivity cell is prone to being clogged by sediment, and reading low of true values. During storm events high sediment loads appear to outweigh the capacity for water flow to push sediment through. Two options are available to remedy this problem: 1) either we decrease sediment coming in by increasing concealment of the instrument or 2) we expose the instrument to increased flow and improve sediment removal capacity.

Prior to February 9, 2011, we believe the CTD was obstructed by sediment and reporting erroneous values. Subsequently, after we inadvertently lowered the CTD to its current position and exposed it to greater currents and possible turbulent agitation, the instrument appears to be functioning correctly. This implies that the instrument will perform better if exposed to more water flow. See time series data below, before and after CTD exposed to water flow.

In February of 2011 we placed a perforated cap over the end of the PVC tube in the hopes sediment trapping within the sensor would diminish. Upon retrieval of the instrument it was determined that sediment was still being trapped in the conductivity cell. As a next step we deployed a sensor with pumped sampling, i.e., still within the PVC tube. Because of the telemetry failure we will not be able to evaluate the success of this deployment regarding data quality until after the instrument is retrieved.

Objectives:

1) Safety
2) Routine servicing of surface floating CTD
3) Recovery of CTD Trapped inside PVC pipe

Remove from field DIGI cellular modem and batteries.

Proposed Sequence

Jan 30, 2012

Transit to hotel, overnight stay, check in with divers.

Jan 31, 2012

08:00	Meet at Tokeland Dock to load equipment
09:00	Depart to Bay Center NAVAID station
10:00-13:00	Arrive at Bay Center tie up to NAVAID stations. Ecology team completes servicing of near-surface sensor package includes sampling, cleaning, and calibration checks. Ecology team sets up retrieval swing. Ecology team recovers DIGI cellular modem and batteries. Divers prep for dive, Ecology climbers prep for climb and surface retrieval (set ropes to instrument etc.)
13:30-15:00	Dive operations tides predicted slack at around 14:00. Note: Due to tidal currents, it may be difficult or unsafe to dive much outside of this window.

- Divers assess and report cause for inability to retrieve. See diagram of deployment configuration, and possible chain angles.
- Divers assist CTD retrieval from PVC pipe (see drawing)
    a. Assisted normal retrieval up through PVC pipe. Divers might only need to lift CTD so that it is aligned with pipe, then Ecology surface team may raise the instrument through the pipe. Lift and manipulate by placing arm in pipe and grabbing instrument.
    b. Divers may need to cut strapping and remove perforated PVC cap. We may be able to provide some support from above if cap needs to be pushed off using notched poles.
    c. If unable to remove from above but can be lowered through pipe. Telemetry cable rs-232 connection will be encased in electrical tape and lowered through pipe along with the deployment chain. Deployment chain will be fixed to retrieval rope.
    d. With assist from divers surface team retrieves rope and chain and removes telemetry cable and instrument from chain.

15:00	Divers return to vessel. Ecology surface crew retrieves lines and prepares for departure.
16:00	Return to Tokeland.

Figures

Figure 5. PVC Pipe Configuration

Figure 6. Climber Assist Position

Figure 7. Climber Assist Position Close-up. Climber can raise or lower chain from this position.