Washington State Department of Ecology

Environmental Assessment Program

Standard Operating Procedure for Installation, Deployment, and Maintenance of Sensors Onboard the *Victoria Clipper IV* Ferry Vessel

EAP104

Version 1.0

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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 the Ecology uses an alternative methodology, procedure, or process.

SOP Revision History

Revision Date	Rev number	Summary of changes	Sections	Reviser(s)
04/13/2016	1.0	SOP development	All	Suzan Pool
09/06/2016	1.0	Final approval	All	Bill Kammin

Standard Operating Procedure for Installation, Deployment, and Maintenance of Sensors onboard the *Victoria Clipper IV* Ferry Vessel

1.0 Purpose and Scope

1.1 This document is the Environmental Assessment Program (EAP) Standard Operating Procedure (SOP) for the Marine Monitoring Unit's (MMU) field operations of near real-time sensors onboard the *Victoria Clipper IV* ferry vessel. The twice-daily ferry transits between Seattle and Victoria, B.C. carry MMU sensors to collect data of several parameters as described in the *Victoria Clipper IV* ferry monitoring program's Quality Assurance Monitoring Plan (Pool et al. 2015). The scope of this document covers installation, deployment, and maintenance of MMU sensors and equipment on the ferry vessel. More specific information on sampling methods, instruments, data collection, data repository, data processing, and procedures can be found in Pool et al. (2015).

1.2 Numerous components comprise the large, complex water monitoring system onboard the ferry vessel. Because the SOP is expected to be perused more often for routine maintenance (i.e., field servicing) than for installations and deployment, section 6.0 "Summary of Procedure" is organized to start the reader with routine maintenance instead of installations and deployment. Thus, for routine maintenance of the fluorometer, please go to Section 6.4 "Routine Maintenance" on page 15.

2.0 Applicability

2.1 This document will be followed during installation, deployment, and maintenance of MMU's sensors and equipment onboard the *Victoria Clipper IV* ferry vessel.

3.0 Definitions

3.1 1,3,6,8-pyrene tetrasulfonic acid tetrasodium salt (PTSA): A liquid standard for measuring and validating optical output used for detecting colored dissolved organic matter.

3.2 Alternating current (AC): Electric charge that changes current directions periodically.

3.3 American wire gauge (AWG): An industrial standard to define characteristics such as wire diameter and area, insulation, copper resistance, ampacity, and fusing current.

3.4 Colored dissolved organic matter (CDOM): Decaying organic matter in the water that is dissolved, absorbs light in the blue to ultraviolet spectrum, and can be optically measured.

3.5 Conductivity-temperature (CT): A sensor that measures conductivity and temperature sensor used in water quality monitoring.

3.6 D-Subminiature 9 pin (DB-9) connector: A type of electronic connector with 9 pins, either male or female, for connection with a RS-232 serial connector.

3.7 Dynamic Host Configuration Protocol (DHCP): A protocol on computer networks that assigns IP numbers

3.8 Ethernet: A type of technology created and used for data transmissions over a computer network.

3.9 Fluorescence: Light that is emitted by substance, molecules, or organisms after initial excitation.

3.10 Global positioning system (GPS): A system that uses satellites to provide coordinates of equipment or person.

3.11 Hypertext Transfer Protocol (HTTP): A communications protocol for connections between the internet or intranet and a server.

3.12 Internet Protocol (IP) numbers: Number or address assigned to electronic devices within a computer network.

3.13 Liquid standard: A chemical reagent in liquid form of known concentration. It is used to confirm validity of, or to calibrate a scientific instrument's measurement.

3.14 Media Access Control (MAC) address: Address which uniquely identifies electronic devices or machines from each other.

3.15 Nephelometric Turbidity Unit (NTU): A measurement of turbidity or amount of light scattered by suspended particles in water at specific optical wavelengths.

3.16 Non-external inductive conductivity (NXIC): Technology for measuring conductivity in seawater and used in thermosalinographs manufactured by Teledyne RD Instruments.

3.17 Parts per billion (ppb): Unit used in chemical reagents such as liquid standards.

3.18 Recommended Standard (RS-232): A type of port for serial communications between electronic devices.

3.19 Relative fluorescence unit (RFU): Type of unit measured by a sensor's fluorescence detection.

3.20 Secure Digital (SD) memory card: Electronic card used for portable storage of digital files.

3.21 Sea chest: A central recess below the vessel hull's water/draft line for admitting water into multiple piping systems for multiple purposes such as cooling engines. Some sea chests are protected by a strainer basket.

3.22 Solid secondary standard: A solid device for quick reference checks to validate a scientific instrument's measurements in between calibrations. For fluorescence sensors, this device is an encased fluorescent plastic.

3.23 Telemetry: The process of transmitting data from a remote sensor to a data collection point. Cables and cellular communication are used to record, upload, process, and post data in near real-time. The system includes communication cables connected from a sensor to a data logging system, cellular router, and power supply.

3.24 Turbidity: An optical characteristic of water expressed as the amount of light scattered by particles in the water. It is an indicator of water clarity or cloudiness.

3.25 Ultraviolet (UV) light: An invisible radiation within the light spectrum.

3.26 Uninterruptible power supply (UPS): Uninterruptible power supply, commonly a battery backup with power surge protection. It senses when electrical power fails or fluctuates and provides continuous power supply to electronic devices.

3.27 Universal Serial Bus (USB): A hardware interface for connections between electronic devices and for file transfers onto a portable file storage device.

3.28 Volts Direct Current (VDC): Constant voltage being passed through a wire.

3.29 Wi-Fi: Wireless local area network commonly used for connections between electronic devices and the internet. It is a wireless version of a wired Ethernet network.

4.0 Personnel Qualifications/Responsibilities

4.1 Installation requires at least two Ecology technicians and cooperation with ferry vessel staff to safely perform. Each technician must be capable of lifting or hoisting up to 50 lbs and climbing ladders or other structures as needed to reach and load/unload gear on the ferry vessel.

4.2 Training on the use, maintenance, troubleshooting, and calibration of sensors, cables, data logging system, software, field laptop, and power supply. Data logging system may include external data loggers, time-activated relay switchboard, power buses, fuses, connectors, and wires.

4.3 Training in telemetry and electronic communications, including, but not limited to wireless router, cellular modem, and creating/maintaining a secured wireless network.

4.4 Familiarity with voltmeters to test resistance, AC, VDC, and polarity. Use manuals that came with voltmeters or instructions online (e.g., https://learn.sparkfun.com/tutorials/how-to-use-a-multimeter).

4.5 Experience with seawater sampling, filtration, and preservation.

4.6 Training in safety procedures for working on floating structures, near/over open water (dock, pier, gangway), and on boats.

4.7 Experience working with hazardous chemicals.

4.8 Job classes are Natural Resource Scientist or Environmental Specialist.

5.0 Equipment, Reagents, and Supplies

5.1 Wire Diagrams

1. Because the water monitoring system on the ferry vessel is complex, wire diagrams are needed to assist Ecology technicians with the whereabouts and connections of all the numerous components. Wire diagrams include:
    a. General overview of entire water monitoring system.
    b. Location of sensors and equipment onboard the vessel.
    c. External data logging system and power supply.
    d. Future, planned upgrades.

5.2 Sensors

1. Table 1 lists sensors that are currently deployed.

Table 1. Sensors, manufacturers, model numbers, accessories, and parameters.

Sensor	Manufacturer, model, and accessories	Parameter
Fluorometer	Turner Designs C3 submersible fluorometer, model 2300-000 with optics for: 1) Chlorophyll *a*, 2) turbidity, 3) CDOM. Includes shade cap, cables, flow cap, wiper brush (not used), software, etc.	Chlorophyll *a* fluorescence, turbidity, CDOM, temperature, depth (not used)
Thermosalinograph	Teledyne RD Instruments Citadel thermosalinograph CT sensor with NXIC technology. Includes cables, power adapter.	Conductivity, temperature, salinity, sound speed
GPS	Garmin GPS 17x HVS	Position coordinates

5.3 Power Supply

1. Uninterruptible power supply (UPS) with high capacity to protect surges during switch between vessel power and shore power. In addition, it needs sufficient power to keep Ecology equipment running with continuous power and until their scheduled daily shut-down. The APC Back-UPS 700VA was selected for the current system.
2. Time-activated relay switchboard capable of handling two relays with capacity for two additional relays, if needed, and Wi-Fi and/or Ethernet capability. It also needs capability for a secure account and for setting the time zone. The switchboard that was selected for the current system is: National Control Devices, LLC Taralist time controlled relay, Web-i time activated relay 4-channel 5-amp SPDT with control by web. (SPDT = single pole, double throw switch; see https://learn.sparkfun.com/tutorials/switch-basics/poles-and-throws-open-and-closed).
3. Two power buses ruggedly built for marine vessel uses: Blue Sea Systems DualBus Plus 150A BusBar – ¼” – 20 stud 5 gang. Each bus has five screw terminals and two terminal studs.
4. Black and red wires of 18 AWG gauge.
5. Adjustable 6-12 VDC, 2.5 amp high-power AC adapter with a reversible polarity plug.
6. Fuses with 1 amp capacity. The current system has quick-acting cylindrical glass ceramic fuses (size AGC-1) which, in the near future, will be replaced with ATC or ATM fuses.
7. Waterproof holders for selected 1-amp fuse.
8. Butt and ring connectors.
9. Male and female quick disconnects.
10. Electrical splicing tape, preferably 3M Scotch Linerless Rubber Splicing Tape 130C, 3/4" width, 30 foot length.
11. Cable splicing kits of appropriate size needed for cable diameter. An example of a kit is an 3M Scotchcast Multimold Splice Kit.
12. Liquid electrical tape.

13. Heat shrinks large enough to enclose serial data communication cables, if needed.

5.4 Data Logging System

1. Three external data loggers with serial ports, power port, light indicators, and slot for a SD memory card with Wi-Fi capability. For loggers with a slot for a CompactFlash memory card, a CompactFlash card adapter for SD card could be used. Loggers should have capability for setting time zone, time stamps, handshaking, file names, and data appending. For the current system, the following were selected:
   a. Acumen Instruments DataBridge SDR2-CF data loggers were selected for the current system.
   b. 32 GB Toshiba FlashAir II Wireless SD cards that fit into a SD to CF Type II Adapter.
2. RS-232 extension cable (50 ft) with DB-9 female and male connectors for data transfer between sensors and external data loggers.
3. USB card reader.
4. Foam with about 1 ½" thickness and wide enough to support and cushion data logging system when ship sails over choppy, rough sea conditions.

5.5 Electrical Utility Boxes

1. Small, shallow plastic box to hold relay switchboard snugly along the edge with room for swapping out an Ethernet module with a USB module.
2. Metal, electronic box with ventilation and cable ports large enough to contain two power buses, fuse holders, relay switchboard inside its own plastic box, and wires.
3. Plastic box to hold external data loggers side-by-side. It should contain heavy duty Velcro tabs or similar to secure bottom of each logger within the box.
4. Bungee cord to secure boxes together, particularly for choppy, rough sea conditions.

5.6 Secured Wireless Network

1. Wireless router with a slot for a cellular modem and capability to establish a secure network. Router would also come with a proprietary power adapter. CradlePoint MBR1200B was selected for the current system.
2. Cellular modem that is compatible with the selected wireless router and carrier.
3. Ethernet cables.
4. List of network settings, including internet addresses, IP numbers, and account information.

5.7 Liquid Standards

1. Two 500-ml opaque, brown plastic bottles of Spectra Trace SH-P (PTSA), a liquid standard for validating CDOM measurements. One liter in two bottles at 100 ppb are purchased from Turner Designs, Inc. Lot number and expiration date are assigned by Turner Designs, Inc. Safety Data Sheet – http://www.turnerdesigns.com/t2/doc/MSDS/998-0127.pdf
2. Two 500-ml opaque, brown plastic bottles of turbidity standard, typically AMCO Clear turbidity standard, 100 NTU which is purchased in a gallon container. It has an absorbance at 455 nm (50 mm path length). Lot number and expiration date are assigned by GFS Chemicals, Inc. Safety Data Sheet – http://msds.gfschemicals.com/atn/AMCO%20CLEAR%c2%ae%20TURBIDITY%20STAN

DARD%2c%20100%20NTU%20FOR%20TURNER%20C3%20TURBIDIMETER_Default_SDS%20US.pdf

5.8 Solid Secondary Standards

1. Solid secondary standard cap specifically designed and manufactured for a Turner Designs C3 fluorometer.
2. Solid secondary standard for chlorophyll fluorescence.
3. Solid secondary standard for UV light.

5.9 Chlorophyll Samples

1. One 2-liter plastic bottle with a narrow rope for collecting seawater from a dock.
2. Two 1-liter brown, opaque plastic bottles with wide mouth.
3. Small cooler to hold one 1-liter bottle and several centrifuge tubes on ice.
4. Seawater filtration apparatus and related supplies.
5. See Ecology's Standard Operating Procedure for Seawater Sampling (Bos 2010) for additional information on needed supplies – www.ecy.wa.gov/programs/eap/quality.html

5.10 Tools, Hardware, and Safety Wear (Appendix B)

5.11 Log Sheets

1. Fluorometer Field Log Sheet (Appendix C)
2. Fluorometer Calibration Sheet (Appendix D)

5.12 Rugged Field Laptop

1. Laptop must be a reserved device on the wireless router's setting for Dynamic Host Configuration Protocol (DHCP).
2. Laptop should have SD card for backing up files, power adapter, 12 V power inverter, sensor communication software, terminal communication software (e.g., PuTTY), and internet browser.

5.13 Company Internet Addresses (Appendix E)

6.0 Summary of Procedure

6.1 Cooperation and Coordination with Clipper Navigation

6.1.1 Current contacts at Clipper Navigation are:

John Jacoby, Director of Facilities
Brad Hartman, Port Engineer
Clipper Vacations
2701 Alaskan Way, Pier 69
Seattle, WA 98121-1199
www.clippervacations.com

6.1.2 Clipper Navigation engineers determine operations and scheduling needed for installations, deployments, repairs, and routine maintenance of Ecology equipment. The engineers also determine ideal equipment locations, engineering work, and plumbing needed to meet water flow requirements and marine transportation regulations. They will also provide access to the locked engine room. The best time for installations and any upgrades or cable replacements is while the ship is dry-docked during the vessel's annual maintenance (late Feb to early Mar). Vessel dry-dock is at Pacific Fishermen Shipyard (http://pacificfishermen.com). Finally, Clipper Navigation determines when the *Victoria Clipper IV* sails and occasionally makes this determination the morning of any scheduled work by Ecology staff who will reschedule accordingly.

6.1.3 Ecology staff should calculate and determine whether vessel speed and water flow requirements of sensors will be met in the proposed equipment locations. Ecology staff determine that sensors and equipment will be secured during rough sea conditions, particularly during storms and while crossing the Strait of Juan de Fuca. Staff should not touch vessel engines, cables, or other parts and instruments that Ecology does not manage. Finally, Ecology should respect that ultimate decisions are made by Clipper Navigation in regards to vessel operations (access, installations, activities, and schedules).

6.2 Schedule for Operations

6.2.1 The general schedule for various operations is listed in Table 2.

Table 2. General schedule of Clipper Navigation and Ecology activities on board the *Victoria Clipper IV*.

Operations	Day/Time	Note
Annual dry-dock maintenance	Late February to early March for two weeks.	Contact Clipper Navigation for exact dates. This time period can be used for Ecology equipment installations, upgrades, or replacements. Scheduling in advance is required for any of these activities.
Short-term vessel repairs	As determined by vessel needs; half day to two days.	Clipper Navigation occasionally, but rarely, needs to dock the vessel at Pier 69 or Pacific Fishermen Shipyard for immediate repairs.
Sailings	Daily, except most Tuesdays and Wednesdays. Two transects in winter and four transects in summer. The sailing schedule is at: www.clippervacations.com/schedules-fares/	Tuesday and Wednesday sails are determined in morning and common during: 1) rough sea conditions, 2) holidays, and 3) periods of heavy passenger loads.
Bilge pumping	Every morning before departure	Clipper Navigation runs the bilge pumps each morning before the vessel leaves the dock.
Availability for Ecology's routine maintenance of sensors	Most Tuesdays and Wednesdays between 8:00 a.m. and 2:30 p.m. Occasionally other days, depending on vessel needs.	Contact Clipper Navigation a few days in advance to schedule a tentative date for field servicing. Before departure from the Operations Center, confirm with Clipper Navigation (most times, Brad

		Hartman) between 8:00 a.m. and 8:15 a.m. for confirmation the ship is at Pier 69.
Frequency of routine maintenance of sensors	Every six weeks, dependent on vessel availability and Ecology technicians' schedules.	This frequency is necessary during late spring to early fall when biofouling of sensors is heaviest. Flexibility of the six-week frequency is required in case of the need to reschedule a week earlier or later.
Thermosalinograph calibrations	Annually.	Because of the thermosalinograph location in a water line, It may be required to remove the sensor during annual dry-dock.
Fluorometer calibrations	To be determined.	The methods and frequency to calibrate the fluorometer with a primary liquid standard are under development.

6.3 *Victoria Clipper IV* Ferry Vessel

6.3.1 The *Victoria Clipper IV* vessel is a ferry carrying passengers only between Seattle, WA, USA and Victoria, B.C., Canada. Its home port is Pier 69 in Seattle. According to Clipper Navigation, Inc.'s website (www.clippervacations.com), the 132-ft long vessel is a high-speed catamaran with twin hulls and speed up to 30 knots (Fig. 1). The ferry vessel has two engine rooms, one on each side of the hull. The port engine room is where the majority of Ecology equipment is located. The engine room generates heat up to about 34 °C (93 °F), and thus, fine oily vapors that cover surfaces, including Ecology equipment.

6.3.2 Ecology staff entrance to Pier 69 is on the north side of the building where the loading zone is marked for "Clipper Navigation" or "Clipper Vacations". Upon arrival, use the company doorbell to request whoever is meeting (usually Brad Hartman). They will provide access through the building, onto the docks, and to the vessel.

6.3.3 On the vessel, access into the port engine room is through a secured door (Fig. 2).

Figure 1. *Victoria Clipper IV* passenger-only ferry vessel in the harbor of Victoria, B.C., Canada. (Photo credit: Clipper Navigation, Inc. on company's website.)

Figure 2. Port side of the *Victoria Clipper IV* with arrow pointing to the door access leading into the port engine room.

6.3.4 Ecology equipment are located on both the deck and below deck levels of the engine room (Fig. 3 on next page). Through the door opening and several feet ahead, a metal shelf is where the power supply and data logging system are situated (Fig. 4). To the right and on the wall, a router with a plugged-in cellular modem is hung (Fig. 4). This area is at deck level and at the top of stairs which lead into the engine room below deck. Below deck, sensors and cables are under metal floorboards. The thermosalinograph is located several feet from the bottom of stairs and immediately aft of an oil pump system (Fig. 5). The fluorometer is immediately fore of the engine (Fig. 6).

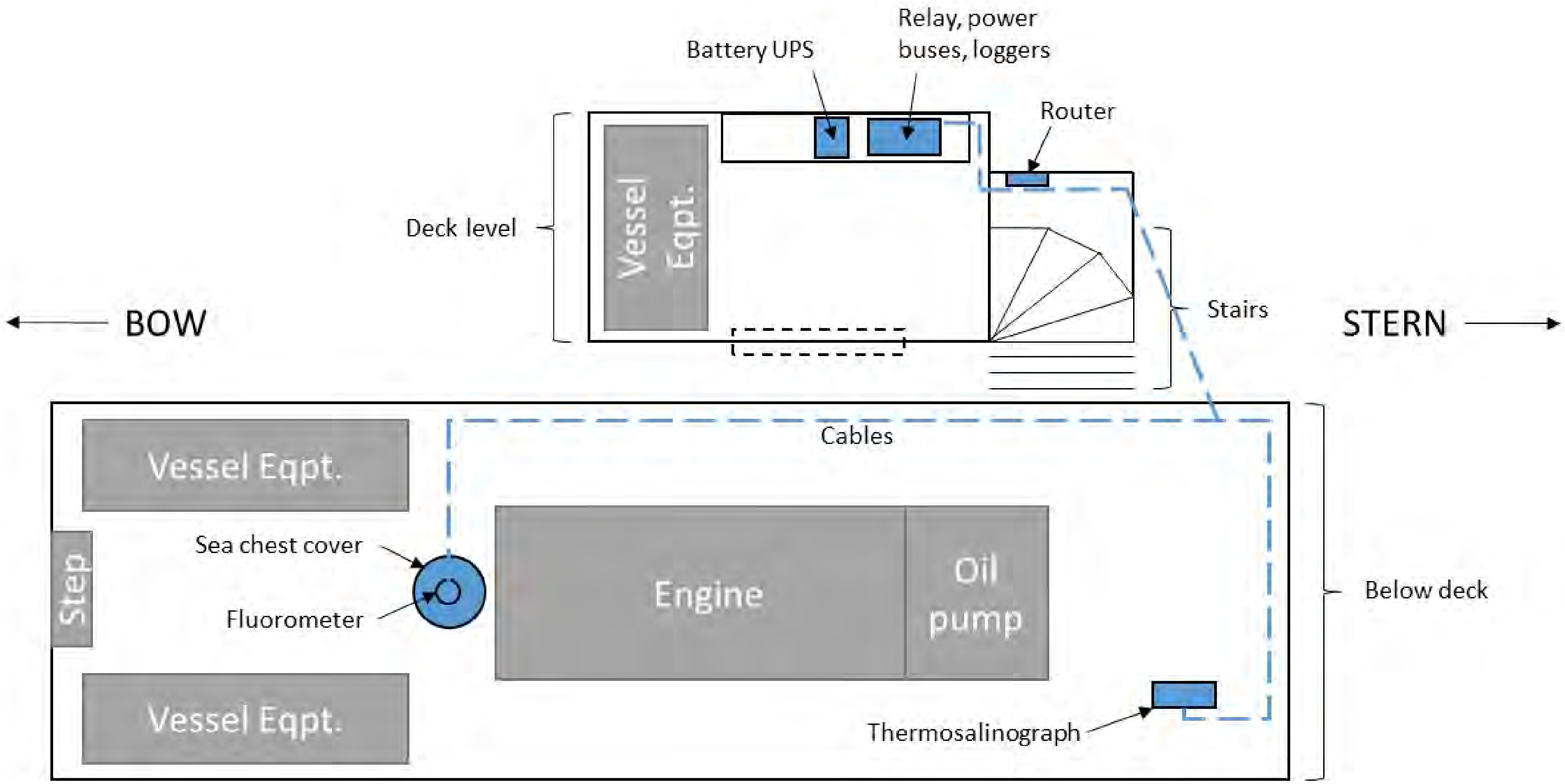


Figure 3. Floor plan of deck and below deck levels in the port engine room of the *Victoria Clipper IV*. Blue polygons and dashed lines (cables) are Ecology equipment.

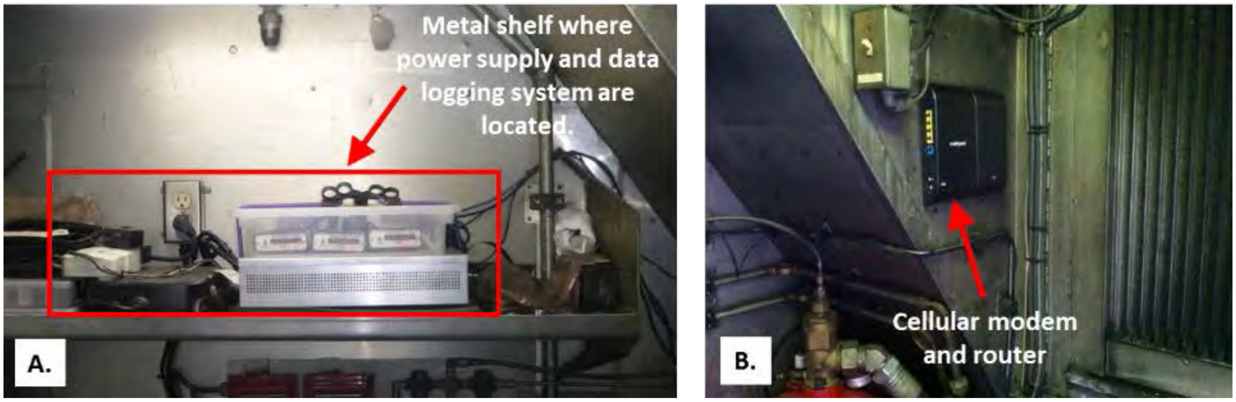


Figure 4. Location of electronic equipment near entrance into port engine room. A. Power supply and data logging system are located on a metal shelf. B. Cellular modem and router are hanging on a wall just to the right of the metal shelf.

Figure 5. Thermosalinograph (TS-NH) is installed in the port engine room and is connected to an impeller shaft line under the floorboard aft of the oil pump system.

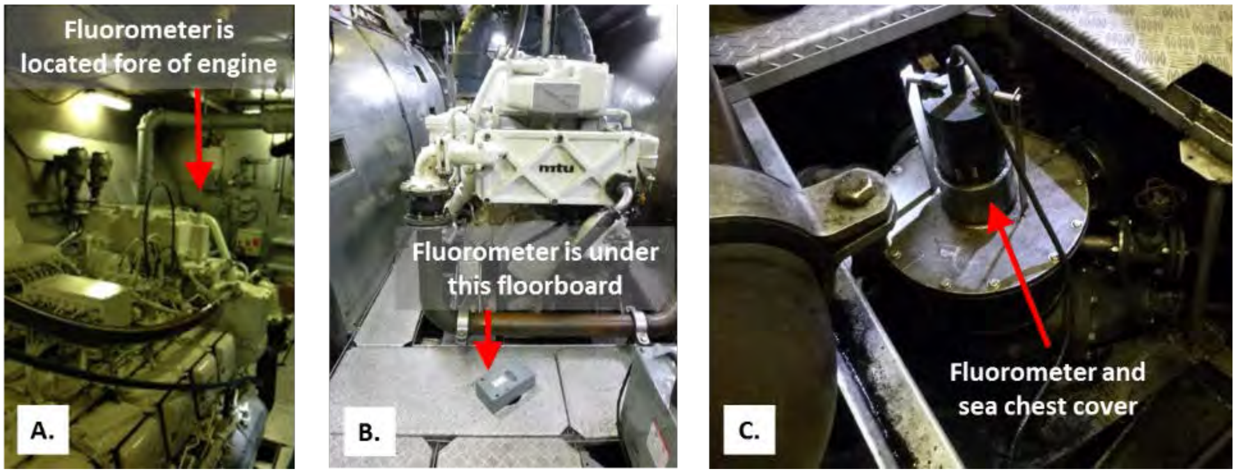


Figure 6. Location of fluorometer in port engine room. A. Fluorometer is installed immediately fore of the engine. B. Fluorometer is under the floorboard by the engine. C. With the floorboard removed, the fluorometer can be seen covering the vessel sea chest.

6.4 Routine Maintenance for Fluorometer

6.4.1 General Notes

1. It is **required** to record date and times that Ecology technicians board ship, close valves, reopen valves, and depart the ship. See the Fluorometer Field Log Sheet for highlighted entries to record (Appendix C). This documentation is necessary to show accountability and responsibility in any incidents that may occur with the *Victoria Clipper IV*.
2. **Important –** Do not attempt to remove fluorometer from the custom sea chest cover. Do not attempt to rotate the fluorometer within the custom cover.
3. Do not touch fingers onto inside of flow cap or optical end. This is necessary to prevent disturbance of measuring biofouling effects for eventual data adjustments as described in the program's Quality Assurance Monitoring Plan (Pool et al. 2015).
4. Estimated ranges of expected calibration measurements are listed on the Fluorometer Field Log Sheet (Appendix C) and copied in Figure 7. The estimates are updated every several months to ensure consistency in methods and fluorescence measurements. If readings are significantly outside the expected ranges, this indicates that the test methods were modified, a liquid or solid standard needs replacement, or that the sensor has a serious issue needing a repair by the manufacturer.

Rough Estimate of Ranges (RFU)		*5 Apr 16*
Fluor	**Turb**	**CDOM**
DI Water Blanks		
10-22	15-55	5-22
1° Liquid Standards		
na	1800-1990	1230-1290
2° Solid Standards		
90-125	na	95-110

Figure 7. Rough estimates of measurements to expect during calibrations of fluorescence (Fluor), turbidity (Turb), and CDOM.

6.4.2 Seawater Collection

1. Using a 4-L carboy, collect ambient seawater from the dock.
2. Mix and pour seawater into two 1-L brown, wide-mouth Nalgene bottles.
3. Reserve one bottle of seawater for servicing the fluorometer. Store on ice until ready to use.
4. Immediately use second bottle for filtering seawater to collect three replicates of discrete chlorophyll samples following the Standard Operating Procedure for Seawater Sampling (Bos 2010). A minor exception is that acetone preservation and sample storage in freezer will be done immediately upon return to the laboratory.

6.4.3 Close Valves

1. Close main water valve to sea chest. This is the most important valve to shut, and therefore, the first one to shut (Fig. 8). It is about 2 feet forward of the sea chest. To crank it, use a pipe wrench or similar tool on the hand wheel.

Figure 8. Photograph of the main water valve to close in a clockwise direction.

2. Under the floorboard, there are five valves around the sea chest. One valve is for emergency bilge suction – **do not close** this one (Fig. 9). Close other four valves as illustrated (Figs. 10-11). It is okay if one valve remains open which will have a little water flow back into the sea chest from the engine cooling system, but it is preferable to close all four valves.

Figure 9. Photograph showing part of a valve for the emergency bilge. It is located starboard of the sea chest.

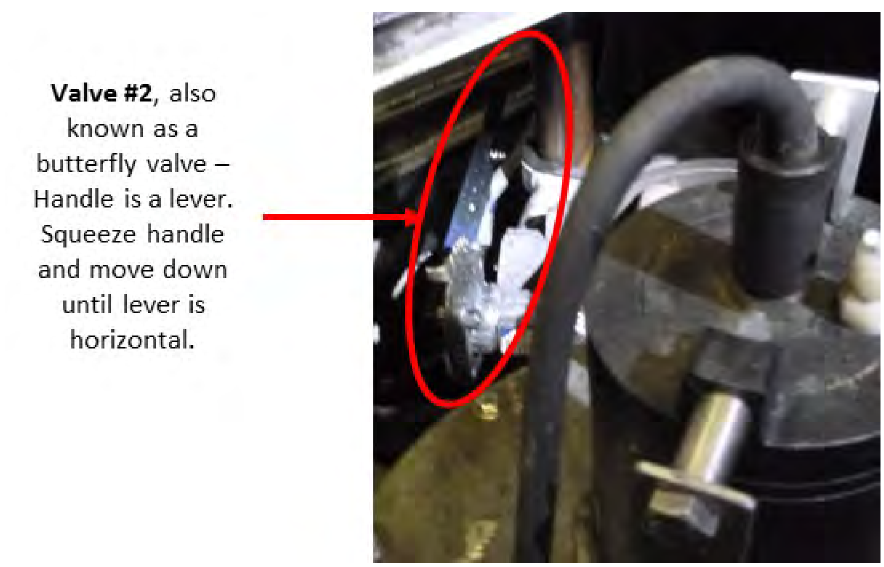


Figure 10. Photograph showing the horizontal and open position of the butterfly valve between the engine and sea chest where fluorometer is located. The valve handle is pulled up to close the valve.

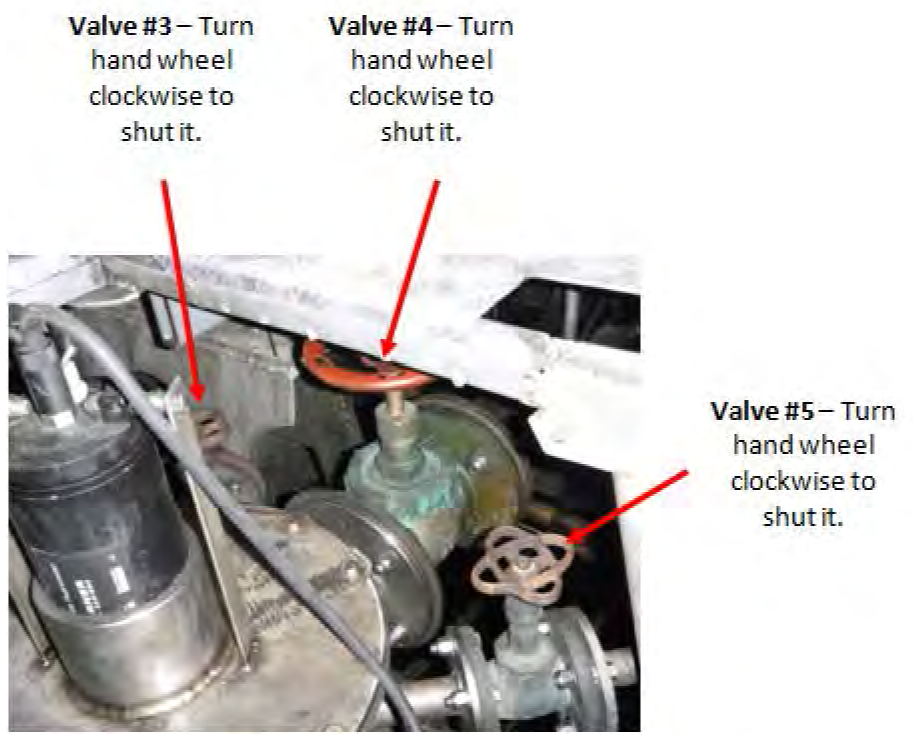


Figure 11. Photograph of three valves to close in a clockwise direction.

6.4.4 Open Sea Chest

1. To access the sensor's optical lenses, the custom sea chest cover with sensor (thereafter called "cover-sensor unit") needs to be removed.
2. The fluorometer cable can remain connected to the sensor bulkhead. For non-routine maintenance, it may be necessary to disconnect the cable, cover cable end, and insert 5-pin female plug onto the bulkhead.
3. Stainless steel nuts and bolts around the cover and sea chest fit a ½" socket or other hand tools. Remove bolts, nuts, and washers. Suggestion is to use a small plastic beaker or similar to contain the hardware so they do not drop into the belly of the vessel where they may be difficult to retrieve.
4. Don safety goggles with UV light protection. One of the fluorometer's optical lenses emits UV light.
5. Remove the cover-sensor unit from the sea chest and place inverted onto mouth and slightly to side of a 5-gal bucket. Ensure that the cable is not crushed, entangled, or overly bent so as not to compromise the cable, splice, or sensor bulkhead (Fig. 12).

Figure 12. Fluorometer is inverted with shade cap screwed on and outside of bucket. (Note: Photograph shows an old cable splice since redone and moved.)

6. Check cabling 2 to 3 feet aft and port of sensor and verify that:
   a. Cable splice is well sealed.
   b. No wire is cut.
   c. Sealed power adapter is looped nearest the floorboard, not on the bottom of the cable loop (Fig. 13).

Figure 13. Cable splice is shown inside the red oval.

6.4.5 Biofouling and Debris Documentation

1. Put on nitrile laboratory gloves. Latex gloves are too slippery when touching oil and water.
2. Record onto field log sheet and camera the contents of sea chest water to document potential fouling that could have affected sensor measurements (Fig. 14).
3. Remove metal mesh strainer from sea chest and document additional contents not already recorded (Fig. 15).

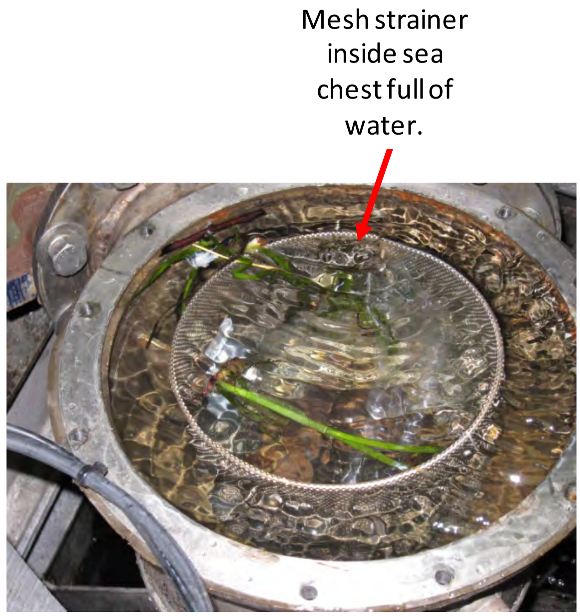


Figure 14. Uncovered sea chest with water, strainer basket, and seagrass.

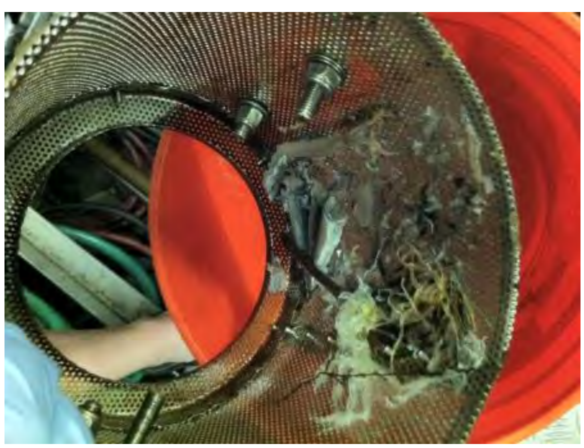


Figure 15. Strainer basket with biofouling.

4. Remove debris from chest water and strainer using tongs or hands. Strainer can also be cleaned with a scrub pad.
5. Reposition cleaned metal strainer into sea chest.
6. Unscrew shade cap over the optics. Do <u>not</u> look at the lights! Continue to wear UV light protection glasses.
7. On the optical end of the fluorometer, there are a thermistor and three optical lenses which measure (Fig. 16):
    a. Optic 1 = Fluorescence
    b. Optic 2 = Turbidity
    c. Optic 3 = CDOM – Do <u>not</u> look at UV light!

Figure 16. Optical end of fluorometer showing thermistor (temperature sensor) and lenses. Each lens is identified by parameter and type of fluorescing light being emitted.

8. Record any debris caught in thermistor (Fig. 17) and any obvious biofilm on lenses and inside of shade cap (Fig. 18).

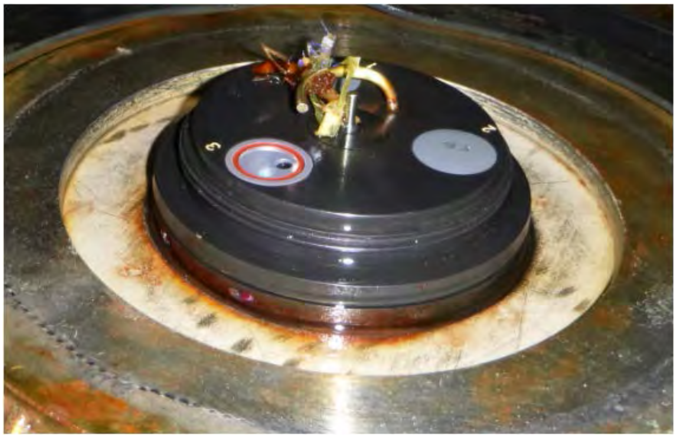


Figure 17. Example of debris caught in the thermistor.

Figure 18. Inside of shade cap covered with biofilm.

6.4.6 Shade Cap Cleaning

1. Remove biofilm from shade cap using absorbent paper towel.
2. Rinse cap with DI water and set aside.

6.4.7 Laptop Setup

1. Connect the field laptop with the internet via the router's wireless network.
2. Enter secured web address for accessing the "DATA-C3" folder on the SD card assigned to the fluorometer. Refer to technical note of network settings or field servicing for folder's network address.
3. When list of data files appear, note today's file name and then enter secured web address for accessing the specific file. Refer to technical note of network settings or field servicing for file's network address.

6.4.8 Pre-cleaning Calibrations

1. Screw on flow cap with its covered hose barb near the plate.
2. Ambient seawater pre-cleaning calibration
   a. Mix reserved seawater several times and slowly pour into the flow cap while ensuring that no air bubbles form and until water reaches top of thread of flow cap.
   b. Screw on flow cap lid with its covered hose barb (Fig. 19).

Figure 19. Flow cap and lid with covered hose barb screwed onto fluorometer.

   c. Record data logger's start time, wait 2 minutes, and record end time.
   d. Refresh webpage of data file and scroll to measurements where the logger's time stamps match recorded start and end times.
   e. Estimate and record averages of fluorescence, turbidity, and CDOM for those 2 minutes. Column headings are shown at beginning of file and clarified in Figure 20.

Logger's date-time stamp (PST)	Fluorometer's date-time stamp (PST)		Chlorophyll fluorescence (RFU)	Turbidity (RFU)	CDOM (RFU)	Depth (m)	Temperature (°C)
02/18/2016 06:19:18.077	Date	Time	Chlorophyl	Turbidity	CDOM	Depth	Temp C
02/18/2016 06:19:24.648	2/18/16	6:16:57	141.60	84.40	50.80	9.99	11.18
02/18/2016 06:19:29.649	2/18/16	6:17:02	106.40	60.44	3.60	9.99	11.18
02/18/2016 06:19:34.648	2/18/16	6:17:07	100.92	60.68	5.92	10.07	11.18
02/18/2016 06:19:39.648	2/18/16	6:17:12	96.56	60.56	4.72	9.99	11.18
02/18/2016 06:19:44.649	2/18/16	6:17:17	90.48	60.60	4.36	9.99	11.18
02/18/2016 06:19:49.650	2/18/16	6:17:22	92.88	60.32	4.92	9.99	11.18
02/18/2016 06:19:54.650	2/18/16	6:17:27	87.20	60.32	5.36	10.07	11.18
02/18/2016 06:19:59.649	2/18/16	6:17:32	85.96	60.32	7.08	9.99	11.17
02/18/2016 06:20:04.649	2/18/16	6:17:37	82.44	60.08	3.12	9.99	11.18
02/18/2016 06:20:09.650	2/18/16	6:17:42	81.36	59.88	3.84	9.99	11.17
02/18/2016 06:20:14.649	2/18/16	6:17:47	76.88	60.56	5.04	9.99	11.18
02/18/2016 06:20:19.649	2/18/16	6:17:52	72.96	60.36	3.52	10.07	11.17
02/18/2016 06:20:24.649	2/18/16	6:17:57	72.48	60.28	5.64	9.99	11.17
02/18/2016 06:20:29.650	2/18/16	6:18:02	68.72	60.20	7.04	10.07	11.17
02/18/2016 06:20:34.649	2/18/16	6:18:07	67.48	60.12	6.72	10.07	11.17
02/18/2016 06:20:39.649	2/18/16	6:18:12	67.48	60.00	4.28	9.99	11.17
02/18/2016 06:20:44.650	2/18/16	6:18:17	68.92	59.92	4.44	9.99	11.17
02/18/2016 06:20:49.650	2/18/16	6:18:22	69.32	60.44	2.24	10.07	11.17
02/18/2016 06:20:54.650	2/18/16	6:18:27	68.72	60.16	3.80	10.07	11.17

Figure 20. Fluorometer data output at beginning of a file. Blue column labels are added to figure for clarity of data output.

f. Remove lid and pour waste seawater into bucket.

g. Rinse flow cap and optical lenses with DI water.

3. <u>DI water pre-cleaning calibration</u>

a. Repeat step 2 substituting DI water for seawater.

6.4.9 Optical Surface Cleaning

1. Remove flow cap and rinse with DI water.
2. Without touching the optics, use an absorbent paper towel and cotton swab(s) to clean the black plastic around each lens.
3. Use lens paper and intermittent DI water rinse to clean optical lenses. Dry lenses with lens paper.

6.4.10 Post-cleaning Calibrations

1. Screw on solid secondary standard cap.
2. <u>Fluorescence solid secondary standard and temperature ambient air calibrations</u>

a. Insert solid standard for chlorophyll fluorescence and position it over optical lens 1 (Fig. 16).

b. Record logger's start time, wait 2 minutes, and record end time.

c. Refresh webpage of data file and scroll to measurements where data logger's time stamps match recorded start and end times. Expected measurement is ~100 RFU.

d. Remove solid standard for fluorescence.

e. Estimate and record average of fluorescence and temperature for those 2 minutes. (See Figure 20 on page 24 for sample data output.)

3. CDOM solid secondary standard calibration

a. **Important**: ***Do not expose** standard to UV light for more than **30 seconds**!*** This is the manufacturer's recommendation based on tests and conversations with customers. Therefore, the following steps must be done efficiently and quickly.

b. Position opening for CDOM over optical lens 3 (Fig. 16).

c. Insert UV solid secondary standard, record start time, wait **30 seconds**, record end time and **immediately remove** standard.

d. Refresh webpage of data file and scroll to measurements where data logger's time stamps match recorded start and end times. Expected measurement is ~100 RFU.

e. Estimate and record average of CDOM for those 30 seconds. (See Figure 20 on page 24 for sample data output.)

2. Remove solid secondary standard cap.

3. Screw on flow cap with its covered hose barb near the plate.

4. DI water calibration

a. Mix DI water several times and slowly pour into the flow cap while ensuring that no air bubbles form and until water reaches top of thread of flow cap.

b. Screw on flow cap lid with its covered hose barb.

c. Record data logger's start time, wait 2 min, and record end time.

d. Refresh webpage of data file and scroll to measurements where the data logger's time stamps match recorded start and end times.

e. Estimate and record averages of fluorescence, turbidity, and CDOM for those two minutes. (See Figure 20 on page 24 for sample data output.)

f. Remove lid and pour waste DI water into bucket.

5. Ambient seawater calibration

a. Repeat step 4 substituting seawater for DI water.

b. Rinse flow cap and optical lenses with DI water.

6. CDOM liquid standard calibration

a. Check that the PTSA liquid standard is not past expiration date and record standard type, lot number, and expiration date.

b. Swirl PTSA standard and slowly pour into flow cap while ensuring that no air bubbles form and until standard reaches top of thread of flow cap.

c. To remove any air bubbles from quartz optical lens 3, use a long-handled cotton swab to very gently touch bubbles.

d. Screw on flow cap lid with its covered hose barb.

e. Record data logger's start time, wait 2 minutes, and record end time.

f. Refresh webpage of data file and scroll to measurements where the logger's time stamps match recorded start and end times.

g. Estimate and record average of CDOM for those 2 minutes. (See Figure 20 on page 24 for sample data output.)

h. Remove lid and pour waste standard into bucket.

i. Rinse flow cap, lid, and optical lenses with DI water.

7. Turbidity liquid standard calibration

j. Record standard type, lot number, and expiration date.

k. Swirl turbidity standard (i.e., AMCO Clear) and slowly pour into flow cap while ensuring that no air bubbles form and until standard reaches top of thread of flow cap.

l. To remove any air bubbles from optical lens 2, use a long-handled cotton swab to very gently touch bubbles.

m. Screw on flow cap lid with its covered hose barb.

n. Record data logger's start time, wait 2 min, and record end time.

o. Refresh webpage of data file and scroll to measurements where the data logger's time stamps match recorded start and end times.

p. Estimate and record average of turbidity for those 2 minutes. (See Figure 20 on page 24 for sample data output.)

q. Remove lid and pour waste standard into bucket.

r. Rinse flow cap, lid, and optical lenses with DI water.

8. Remove flow cap.

6.4.11 Re-deployment

1. Screw on cleaned shade cap.

2. Check position of rubber gasket on inverted cover-sensor unit so that gasket holes line up with those on the cover.

3. Position cover-sensor unit into sea chest and ensure that:

a. Rubber gasket is well positioned between the cover and sea chest for a watertight seal.

b. Cover-sensor unit bolt hole marked by an arrow on the exterior is aligned with the sea chest's bolt hole nearest the fore valve with large red wheel (Fig. 21).

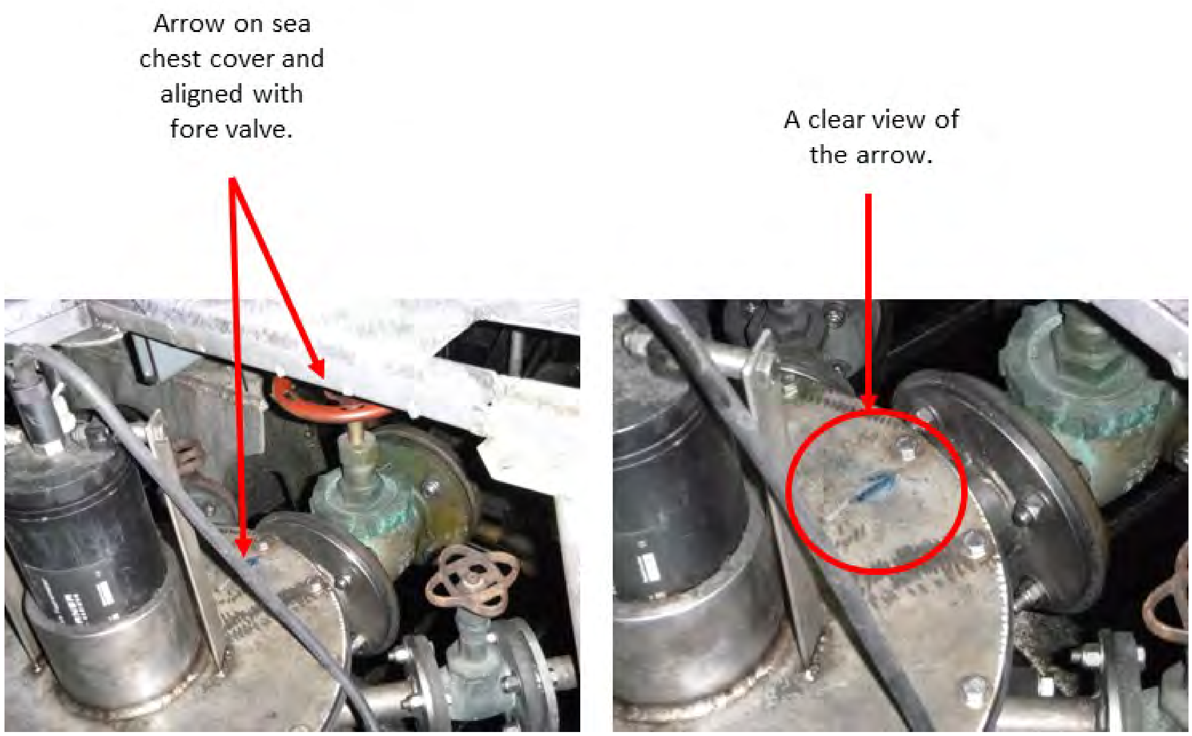


Figure 21. Blue arrow on custom sea chest cover points to alignment of cover's bolt hole with sea chest's bolt hole by the fore seawater valve.

4. Secure cover-sensor unit to sea chest with stainless steel bolts, nuts, and washers one at a time and following an alternating and opposing bolt hole pattern (Fig. 22). Suggestion is to insert bolts from underside rather than on topside for ease of retaining nuts and washers.

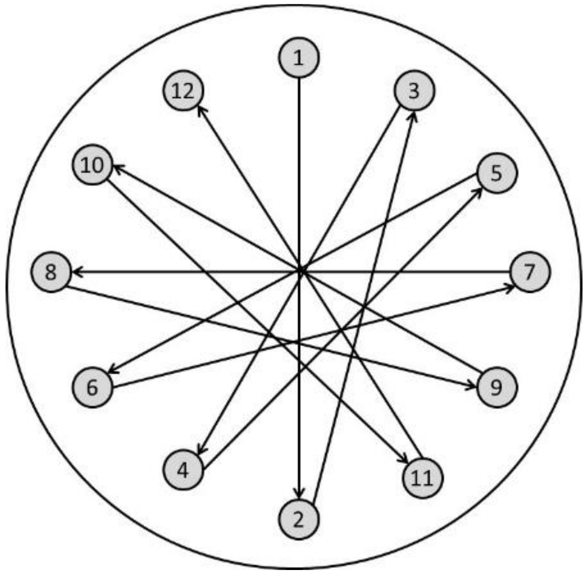


Figure 22. Example of stress-balancing method for tightening bolts 1 to 12 when securing cover to sea chest.

6.4.12 Open Valves

1. Open valves 2, 3, 4, and 5 around sea chest (Figs. 23-24).

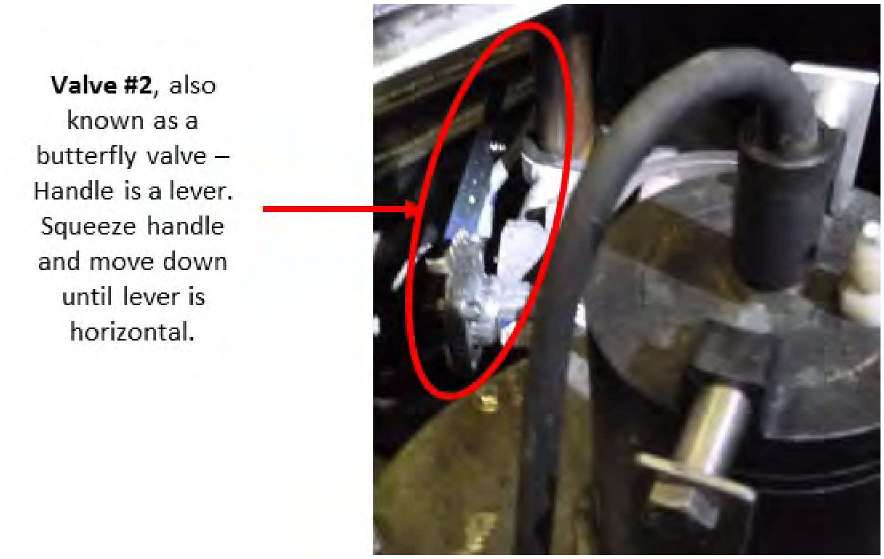


Figure 23. Photograph showing the horizontal and open position of the butterfly valve between the engine and sea chest where fluorometer is located.

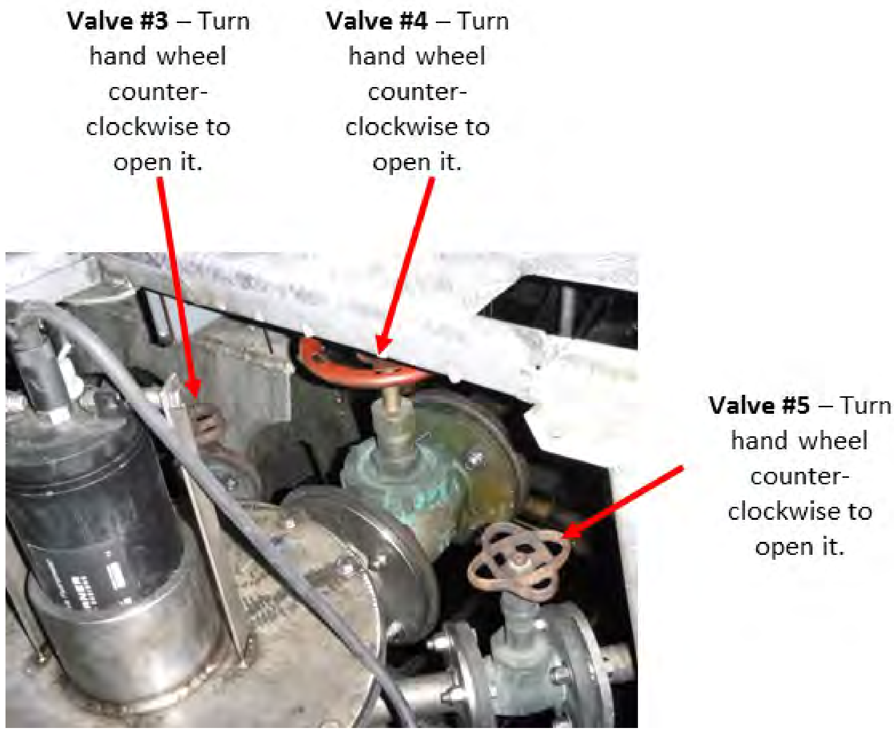


Figure 24. Photograph of three valves to open in a counter-clockwise direction.

2. Open main valve (Fig. 25).

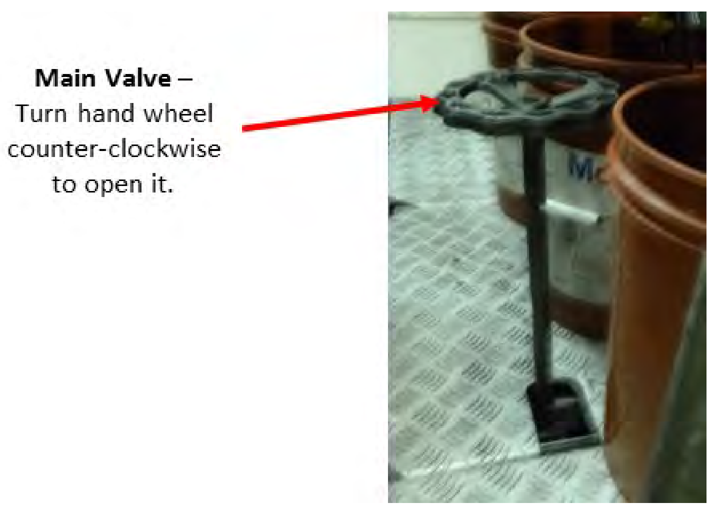


Figure 25. Photograph of the main water valve to open in a counter-clockwise direction.

6.5 System Configurations and Testing

6.5.1 General Notes

1. Because the water monitoring system is complex with numerous components, it is strongly recommended to build, configure, and test the entire system in the laboratory before installation on the ferry vessel.
2. Peruse manufacturer's manuals for software use and instructions for each equipment.
3. It is critical to record and document all final configurations for sensors, GPS, network, and electronic components. In addition, completely document wire diagrams so that the system can be replicated elsewhere, updated for any equipment upgrades, or mounted on one motherboard. Configurations to document include:
    a. Phone number assigned to the cellular modem
    b. Network name
    c. Administrative user names and passwords
    d. IP addresses for router, relay switchboard, and server
    e. Port numbers
    f. DHCP reservations
    g. Internet addresses for external and internal access and for router administrative login page
    h. MAC address
    i. Virtual servers being allowed (e.g., HTTP and remote desktop)
    j. Inbound filters
    k. Access control selection
    l. Activation dates of modem and network
    m. Event names, relay numbers, and on/off times on relay switchboard. Current configurations are:

Event	Time (PST)	Relay
AcumenBus – On	5:45 AM	1
SensorBus – On	6:15 AM	2
SensorBus – Off	10:00 PM	2
AcumenBus – Off	10:30 PM	1

    n. Configurations established on SD cards for remote access

6.5.2 Connections and Configurations

1. See Appendix A for a detailed wire diagram of the data logging system which show connections to make.
2. Activate the cellular modem that will be inserted into wireless router. Configure router to block all incoming IP addresses except for those assigned to field laptop, SD cards with Wi-Fi capability, relay switchboard, and cloud server. To incorporate the external data loggers and relay switchboard, assemble components and configure:
    a. Data loggers
    b. SD cards with Wi-Fi capability

c. Relay switchboard

3. Configure sensors and GPS for 5-sec sampling frequency and for serial data communication to an external data logger. Sensors and GPS require proprietary software to make the configurations. Data loggers require using the PuTTY open source software (http://www.putty.org).

4. Connect sensors, GPS, wireless network, relay switchboard, and external data loggers with power buses, UPS backup, and external power supply. Follow manufacturers' wiring specifications for any pigtail cable connections to power and/or RS-232 serial connectors.

5. Run tests on power supply and wireless network. Refine configurations and assembly until data flow and power supply meet expectations.

6. Next, run tests to ensure that the wireless network is properly set to send data files from external data loggers to a file server and that it meets security and data transmission requirements. The loggers will store data files onto a SD card with Wi-Fi capability and this card is inside the CF card adapter. Server will contact the wireless network and upload data files that are not already uploaded.

6.5.3 Electrical Utility Boxes

1. Secure and protect equipment by using electrical utility boxes to neatly contain them and to protect them from fine, dusty oil vapors. Use zip ties, electrical tapes, or Velcro tabs to keep components in place.

2. Relay switchboard is to be placed snugly into a small plastic box. They are then placed into a metal box along with two power buses, an Ethernet cable, two fuse holders, and wires (Fig. 26).

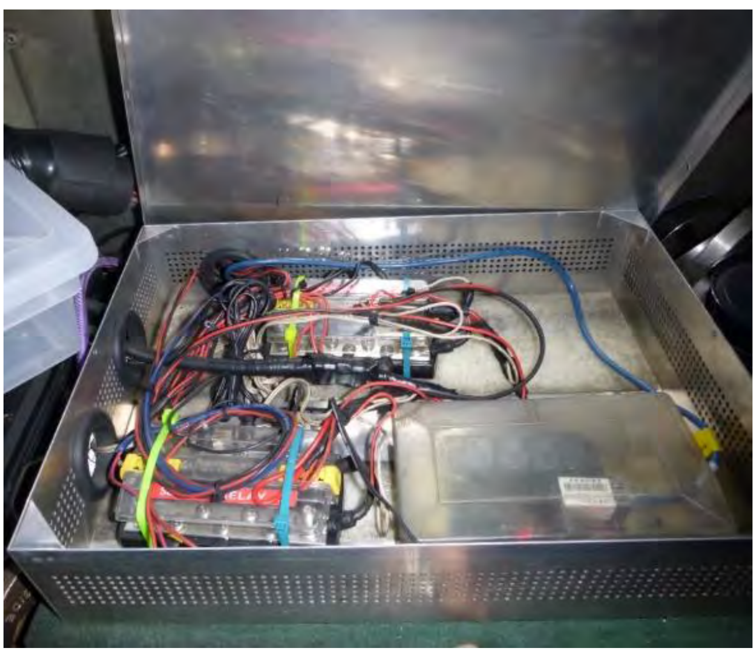


Figure 26. Two power buses, a relay switchboard within its own plastic box, fuse holders, and wires are tidied into metal utility box. The lid for the metal box is in background.

3. The external data loggers are to be positioned inside a large plastic box with a cut-out in the back for cables to enter (Fig. 27). Each logger is positioned with room in the rear for inserting/removing cables and in front for inserting/removing CF card adapters. Finally, each logger is secured on the bottom with heavy duty Velcro tabs.

Figure 27. Three external data loggers are positioned inside a plastic box with a cut-out in back for power and communication cables and with room in front for changing record mode or removing/inserting CF cards adapters.

6.6 Installations

6.6.1 General Notes

1. Before finalizing installations on the vessel, test the entire system, including splices for extended cables, with shore, vessel, and backup power supply. Cable splices must be tested for proper power connections to sensors and GPS. The splices must also be tested for data transmissions from sensors and GPS to external data loggers. Objectives are to ensure that cable splicing and connections are proper and data are stored as expected.
2. Vessel locations of all equipment are designated and approved by Clipper Navigation engineers. More information are stated in section 6.1.2 on page 10.
3. Installation of the fluorometer over the sea chest occurred in April 2010. Installation of the GPS was determined in late 2009 and installed in April 2010. Finally, installation of the thermosalinograph was done in May 2012. Thus, this subsection refers to the current setup and locations of all equipment, and can be modified when the need arises.

4. After all tests are determined successful, finalize positions of components, wires, cables, and sensors.

6.6.2 Power Supply, Network, and Data Loggers

1. Set up UPS backup and box with power buses and relay switchboard in their designated locations. Leave space for adding power and data communication cables from sensors and GPS.
2. Set up router in their designated location, connect it with assigned power bus, and connect Ethernet cable between router and relay switchboard. Confirm that wired and wireless network are active and configurations remain unchanged.
3. Set up external data loggers and their plastic box. Leave room for data communication cables from sensors. Connect power to the data loggers. On the router, confirm that SD cards in the loggers are listed as active devices connected to the network.

6.6.3 Power and Data Extension Cables

1. Run and secure (e.g., zip ties) cables from sensors and GPS to vessel location designated for the UPS backup, power buses, and external data loggers. In the engine room, cables from sensors are routed under the floorboards and then up the wall and stairs to the deck-level room. The GPS is located above deck and on the stern, thus, cables are routed into the engine room differently.
2. For pigtail cables, splice them appropriately with power and/or data extension cables, following manufacturer's wiring specifications determined during laboratory testing. When cable splices are determined properly connected, temporarily seal them with Scotch Linerless Rubber Splicing Tape.

6.6.4 Custom Sea Chest Cover

1. **Important – Do not attempt** to remove fluorometer from the custom sea chest cover. **Do not attempt** to rotate the fluorometer within the custom cover. Either attempt will damage the sensor. These statements are also emphasized in section 6.4.1 on page 15.
2. The fluorometer is deployed on and in the vessel's sea chest. A custom sea chest cover was manufactured by Pacific Fishermen Shipyard to: 1) provide and maintain a watertight seal and 2) position the fluorometer in the center of the cover. The custom cover only fits in one position onto the sea chest and cannot be rotated.
3. To fit the fluorometer, the custom cover has a metal cylinder several inches high and two flat, vertical bars (Fig. 28). A rubber gasket is placed inside between the cylinder and fluorometer. The optical side of the fluorometer is inserted through the cylinder until the thread for shade cap is past the other side and until nylon ports are accessible by the sensor manufacturer for repairs, a highly critical requirement (Figs. 29 and 30). Bolts secure the vertical bars to the fluorometer on its bulkhead side (Fig. 28).

Figure 28. Custom sea chest cover and fluorometer are installed under the floorboard of the port engine room.

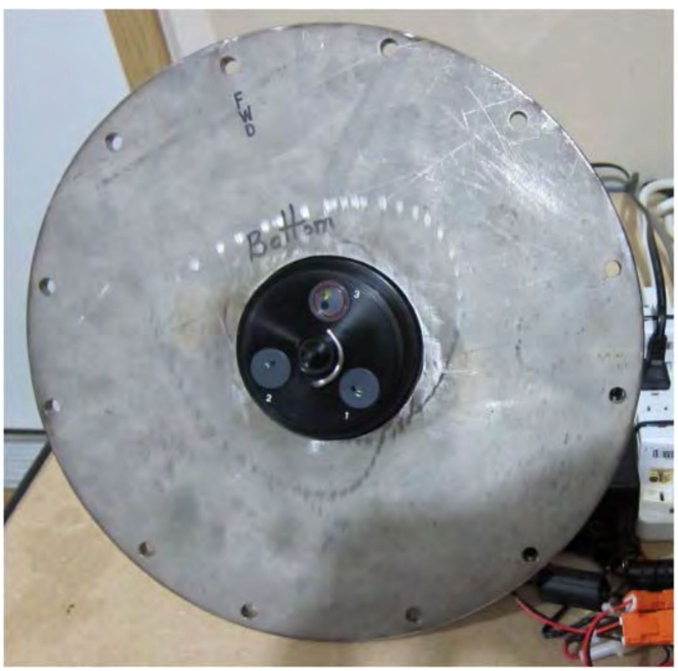


Figure 29. Bottom of custom sea chest cover with optical lenses and thermistor of fluorometer visible.

Figure 30. Thread and one of two nylon ports on the fluorometer's optical end are inserted past the bottom of the sea chest cover.

6.6.5 Fluorometer

1. Close main water valve to sea chest. This is the most important valve to shut, and therefore, the first one to shut (Fig. 31). It is about 2 feet forward of the sea chest. To crank it, use a pipe wrench or similar tool on the hand wheel.

Figure 31. Photograph of the main water valve to close in a clockwise direction.

2. Under the floorboard, there are five valves around the sea chest. One valve is for emergency bilge suction – **do not close** this one (Fig. 32). Close other four valves as illustrated (Figs. 33-34). It is okay if one valve is left open which will have a little water flow back into the sea chest from the engine cooling system, but it is preferable to close all four valves.

Figure 32. Photograph showing part of a valve for the emergency bilge. It is located starboard of the sea chest.

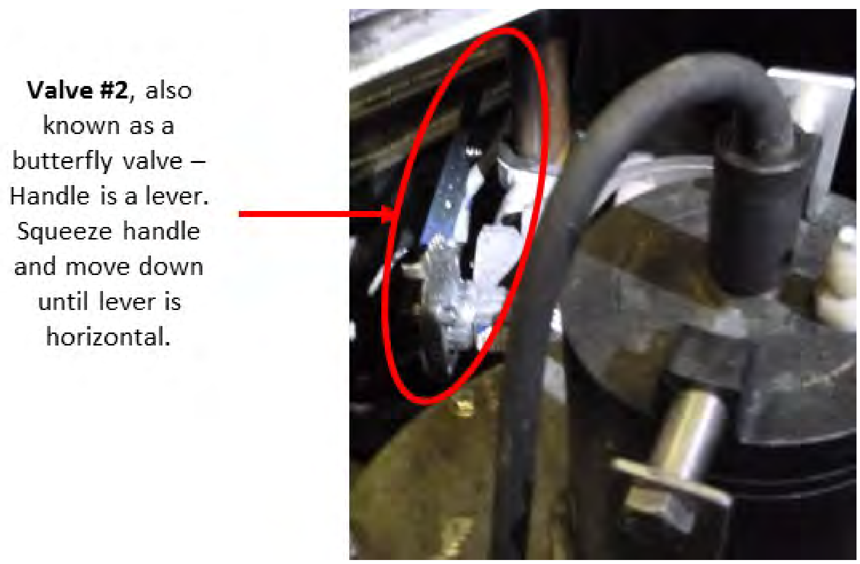


Figure 33. Photograph showing the horizontal and open position of the butterfly valve between the engine and sea chest where the fluorometer is located. The valve handle is pulled up to close the valve.

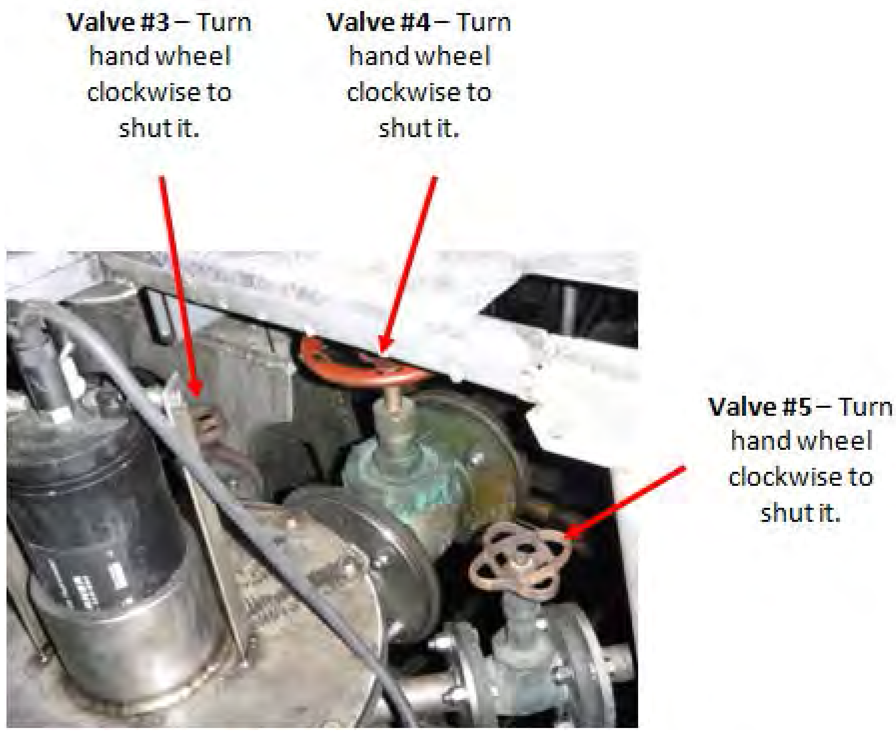


Figure 34. Photograph of three valves to close in a clockwise direction.

3. Stainless steel nuts and bolts around the cover and sea chest fit a ½” socket or other hand tools. Remove bolts, nuts, and washers. Suggestion is to use a small plastic beaker or similar to contain the hardware so they do not drop into the belly of the vessel where they may be difficult to retrieve.
4. Remove the original cover from the sea chest and set aside.
5. Don safety goggles with UV light protection. One of the fluorometer’s optical lenses emits UV light.
6. Check position of rubber gasket on custom sea chest cover with fluorometer and its shade cap (cover-sensor unit) so that gasket holes line up with those on the cover.
7. Position cover-sensor unit into sea chest and ensure that:
    a. Rubber gasket is well positioned between the cover and sea chest for a watertight seal.
    b. Cover-sensor unit bolt hole marked by an arrow on the exterior is aligned with the sea chest’s bolt hole nearest the fore valve with large red wheel (Fig. 35).

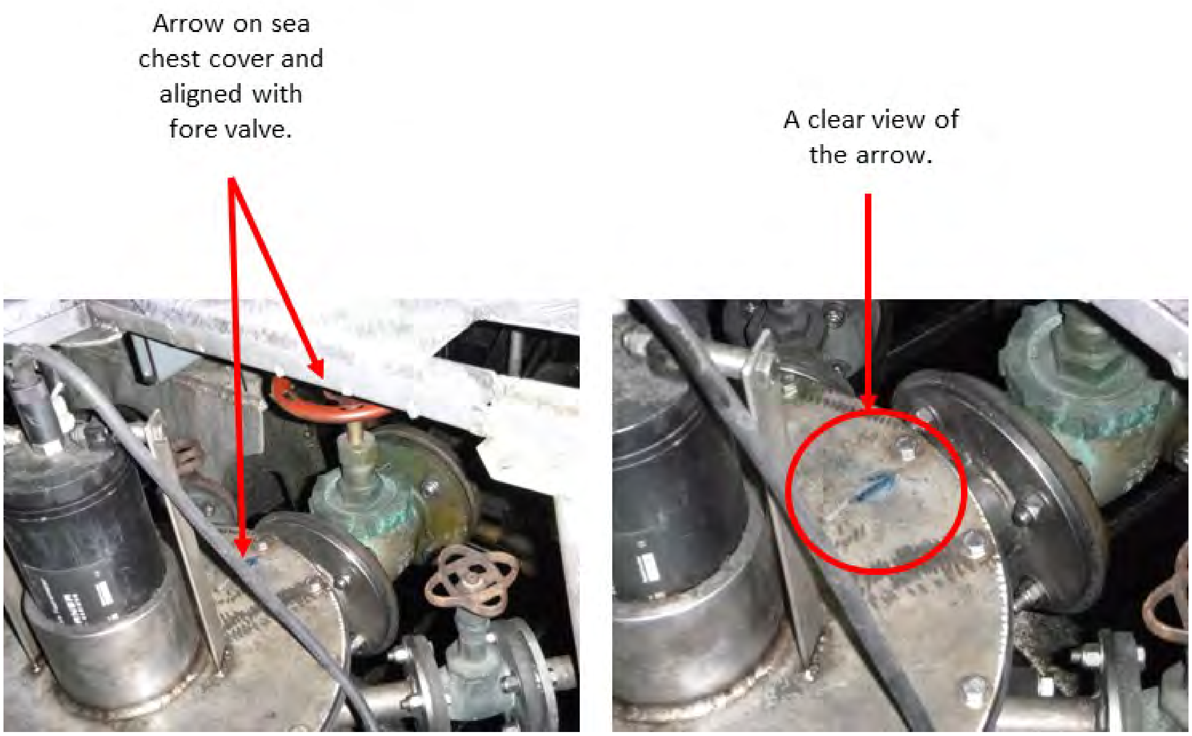


Figure 35. Blue arrow on custom sea chest cover points to alignment of cover's bolt hole with sea chest's bolt hole by the fore seawater valve.

8. Secure cover-sensor unit to sea chest with stainless steel bolts, nuts, and washers one at a time and following an alternating and opposing bolt hole pattern (Fig. 36). Suggestion is to insert bolts from underside rather than on topside for ease of retaining nuts and washers.

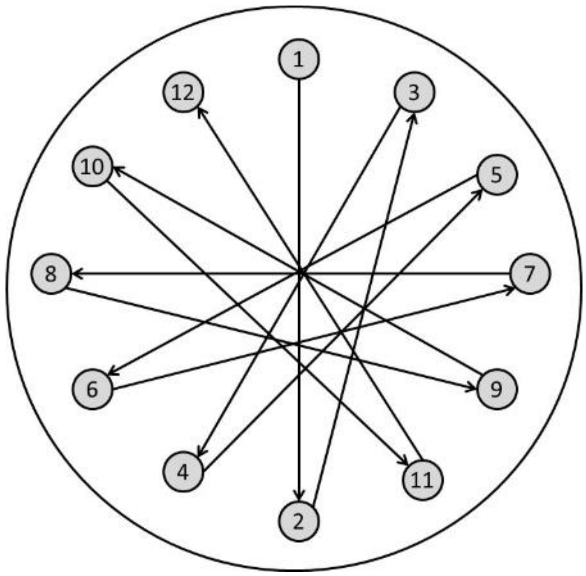


Figure 36. Example of stress-balancing method for tightening bolts 1 to 12 when securing cover to sea chest.

9. Open valves 2, 3, 4, and 5 around sea chest (Figs. 37-38).

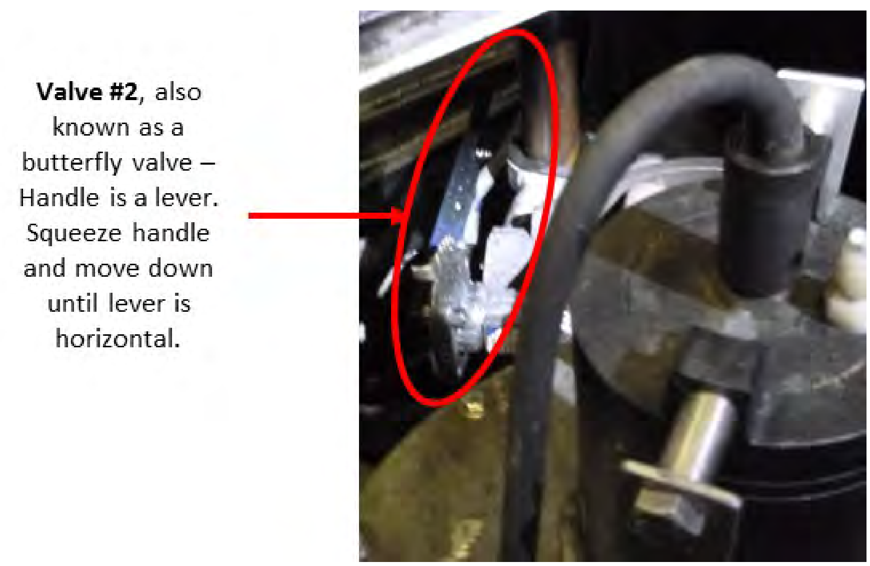


Figure 37. Photograph showing the horizontal and open position of the butterfly valve between the engine and sea chest where fluorometer is located.

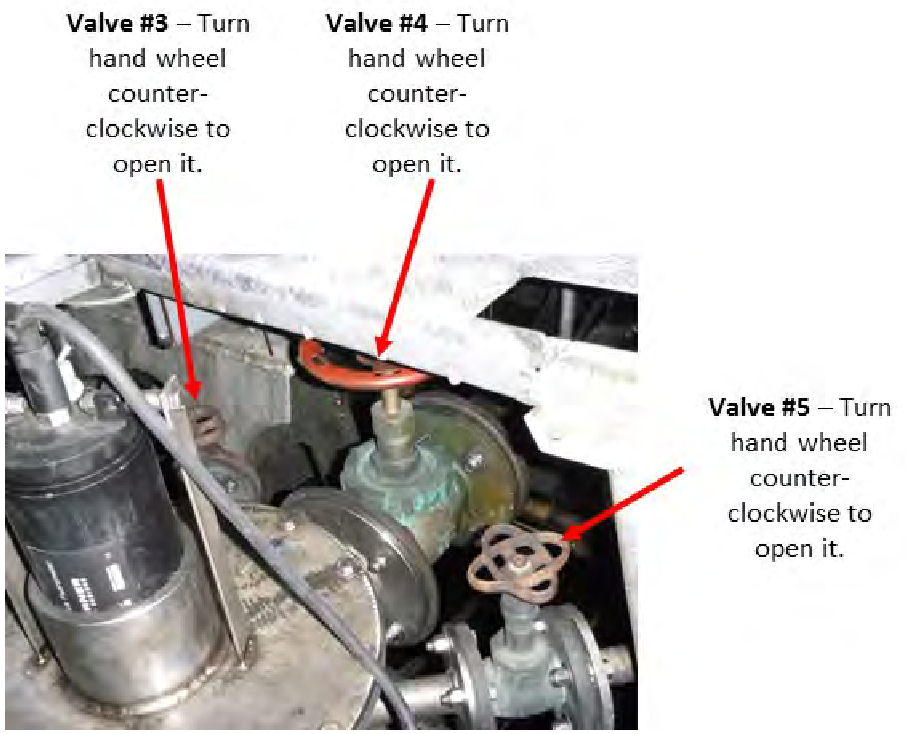


Figure 38. Photograph of three valves to open in a counter-clockwise direction.

10. Open main valve (Fig. 39).

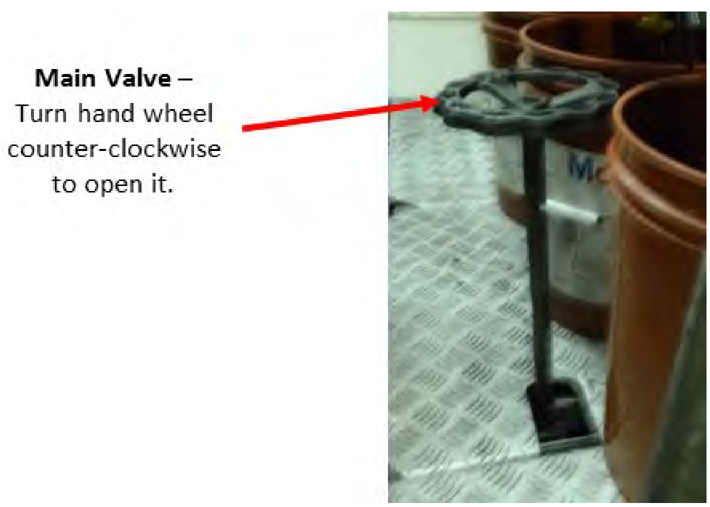


Figure 39. Photograph of the main water valve to open in a counter-clockwise direction.

6.6.6 Thermosalinograph

1. The thermosalinograph has a manifold with a hose barb on each end for flow-through operation. Clipper Navigation engineers install a length of sturdy, seagoing hose on each hose barb, secured with two stainless steel hose clamps. They also connect the hose with appropriate stainless steel plumbing joints and nuts in the impeller shaft line (Fig. 40).

Figure 40. The thermosalinograph (TS-NH) has hoses on each end of its manifold and is installed into the impeller shaft line.

2. To support the thermosalinograph, particularly during rough sea conditions, it is hung from a subflooring frame using heavy duty zip ties on each end of the sensor's manifold.

6.6.7 GPS

1. The GPS is installed above deck on the stern of the ferry vessel and secured for withstanding any sea conditions. A hole through the metal sheeting allows the GPS to be connected with a cable underneath (Fig. 41).

Figure 41. Ecology's GPS is installed above deck and on the stern of the vessel.

2. Cable is routed from under the GPS into the deck-level part of the engine room where the power buses and data loggers are located.

6.7 Sealing Cable Splices

1. Double-check that sensors and GPS are installed properly for consistent power supply and for successful data transmissions to loggers before putting on final seal of cable splices.
2. To prevent corrosion of copper wires or electrical prongs under the engine room's floorboards, it is required to seal cable splices. Organic solvents that are used in the engine room will slowly soften and disintegrate cable insulations and splice seals. Thus, the splice covering needs sporadic replacement to prevent water from reaching and corroding the internal wires beneath cable insulation.
3. Seal the cable splices with either of:
    a. Several layers of brush-on liquid electrical tape for marine use over linerless rubber splicing tape such as 3M Scotch Linerless Rubber Splicing Tape 130C.
    b. A cable splice kit such as 3M Scotchcast Multimold Splice Kit.
4. When dried, use zip ties or similar to position sealed cable splices closest to the underside of floorboards. This position will further protect the splices from organic solvents as described in step 2.

6.8 Deployment

1. Relay switches will activate electronics and instruments before passengers board the vessel and deactivate at the end of the day.
2. If equipment are installed as described earlier, the expectation is that data will be recorded daily and subsequently uploaded into a data repository. Currently, data are stored and processed on the DigitalOcean cloud server.
3. There is no manual deployment or retrieval to perform except for routine maintenance and calibrations and for troubleshooting failed data records/transfers or data logging upgrades.

6.9 Sensor Calibrations

1. The fluorometer is calibrated by Ecology technicians following the manufacturer's manuals and recommendations.
2. The thermosalinograph is calibrated by the manufacturer annually.
3. The GPS will be calibrated as needed.

6.10 Sensor Repairs

1. Sensor repairs are done by the manufacturer.
2. With the fluorometer inserted in the sea chest cover, Turner Designs, Inc. in Sunnyvale, CA does not have a large enough a pressure chamber to accommodate the sea chest cover and would need to send it to Deep Sea Power & Light in San Diego, CA for an extra charge.

7.0 Records Management

7.1 Each time a sensor is newly installed, re-installed, or removed, record when, where, and how.

7.2 Record how and when a data logging system was installed or upgraded. Information include, but are not limited to, wire diagrams, list of components, technical configurations, and photographs.

7.3 Record and maintain data collected during routine maintenance:

1. Field log sheets will be used to record observations and activities during each field servicing (Appendix C).
2. Observations and estimates of sensor data recorded on the log sheets will be input into Excel files with field servicing dates in file names. The files will be stored in a designated subfolder of the main “Victoria Clipper” folder on a secured network server. The observations and data estimates will be input into the “Log sheet” spreadsheet (Appendix D).
3. Using the entire day’s raw sensor data file, a subset of sensor measurements during routine maintenance will be put into the “Data” spreadsheet of the Excel file designated for that day’s field servicing.
4. For each ambient and standard measurement, medians of parameters will be calculated for the recorded time periods and calculated from the subset of data in the “Data” spreadsheet. For example, the field log sheet indicates that the post-cleaning ambient measurement of seawater was collected from 12:06:30 to 12:08:30. Medians of data are calculated from 12:06:30 to 12:08:25, excluding 12:08:30. This calculation method was established in 2010 and will be maintained for consistency in results.
5. The medians will be input into the “Log sheet” spreadsheet of the designated Excel file.
6. The field log sheets and printed “Log sheet” spreadsheets containing both data estimates and calculated medians will be stored in a designated three-ring binder.
7. Observations and results are also input into a relational database in Access designed solely for servicing records of:
    a. Servicing date
    b. Times technicians boarded vessel, closed valves, reopened valves, and departed
    c. Technicians
    d. Sea chest debris
    e. Start and end times of fluorometer pre-cleaning and post cleaning measurements, both ambient and standard
    f. Fluorometer data estimates and calculated medians
    g. Solid secondary standards and their purchase dates
    h. Liquid standards and their purchase dates, types (e.g., PTSA or AMCO Clear), expiration dates, and lot numbers
    i. Comments about general observation/activity and specific calibration measurements
    j. Chlorophyll sample bottle, tube numbers, and laboratory results
8. The database contains user-designed, automatically generated temporal charts of fluorometer servicing measurements to provide a quick overview of how individual lens and thermistor are performing. The charts are a useful tool in determining whether a sensor repair by the manufacturer is required.

8.0 Quality Control and Quality Assurance Section

8.1 At all wire junctions in sensor cable splices or data logging system, securely seal junctions to prevent corrosion from salt air and exposure to fine, dirty engine oil vapors and degreasers.

8.2 Position data logging system inside electronic boxes or plastic totes to prevent corrosion from salt air and exposure to fine, dirty engine oil vapors and degreasers.

8.3 Verify routine maintenance data entries in electronic files by comparing them against paper field log sheets and correct any data entry errors.

8.4 Check field calibrations over time with established control charts and if trends are unreasonable or graphs show outliers, consider resolutions such as, but not limited to:

1. Rechecking data entries against field and calibration log sheets.
2. Rechecking calculations of medians of pre- and post-cleaning measurements.
3. Reviewing this SOP for field servicing day in question to ensure that all steps were followed. If a discrepancy is found, take action to resolve and/or clarify for future servicings.
4. Expiration dates of liquid standards, especially the PTSA standard used to check the CDOM measurements.
5. Age of solid secondary standards and whether to purchase a new one.
6. Sending a sensor in for repairs by the manufacturer.

9.0 Safety

9.1 Laboratory testing and field servicing activities require the use of hands and power tools. Follow guidelines established in the EAP Safety Manual for “Using Hand or Power Tools” (Washington State Department of Ecology, 2015).

9.2 Spectra Trace SH-P (PTSA) has health hazards, but no flammability or reactivity hazards. The health hazards are: 1) may be harmful if swallowed, 2) causes skin irritation, 3) causes serious eye irritation, and 4) may cause respiratory irritation. It is required to wear laboratory gloves and safety glasses when dealing with PTSA during field servicings. Also, PTSA should not be emptied into drains or aquatic environment. Safety Data Sheet – http://www.turnerdesigns.com/t2/doc/MSDS/998-0127.pdf

9.3 AMCO Clear has no physical, health, or environmental hazards. However, it is strongly recommended to wear laboratory gloves and safety glasses when dealing with this turbidity standard in the laboratory and during field servicings. Also, this chemical contains less than 0.1% styrene divinylbenzene polymer beads and thus, it is strongly recommended not to dispose of the chemical into drains or aquatic environment. Safety Data Sheet – http://msds.gfschemicals.com/atn/AMCO%20CLEAR%c2%ae%20TURBIDITY%20STANDARD%2c%20100%20NTU%20FOR%20TURNER%20C3%20TURBIDIMETER_Default_SDS%20US.pdf

9.4 Working with cable splices, wiring, and custom wiring systems are prone to electrical shocks. Before adding or replacing wire connections, cable splices, or sensor cables, properly shut off power and verify by any light indicators not being lit and/or by using a volt meter.

9.5 A Turner Designs C3 fluorometer’s CDOM optical lens emits UV light which can be harmful to the naked eyes. Therefore, always wear safety glasses with UV light protection.

9.6 Docks and vessel decks can be slippery when wet. Ensure good footing with each step and take caution not to slip and fall.

9.7 Typical access to the *Victoria Clipper IV* is by climbing the vessel's external ladder from the dock. Access to the below-deck level of the engine room requires climbing down a built-in ladder with steps inserted into a wall. Occasional vessel access is via a pier ladder, gangplank, or shipyard scaffolding with narrow and steep ladders. On all these structures, ensure good hand and foot holds. In addition, follow guidelines established in the EAP Safety Manual for "Fall Protection" (Washington State Department of Ecology, 2015).

9.8 The engine room can be extremely warm and unbearable from unventilated heat generated during engine operations. There are a few ways to deal with the heat:

1. Never work alone.
2. Take frequent breaks outside on deck, drink plenty of fluids, and wear comfortable clothing.
3. Monitor heat stress by following guidelines established in the EAP Safety Manual for "Preventing Heat-Related Injuries" which will be similar to working outdoors (Washington State Department of Ecology, 2015).
4. Deck-level bulkhead door can remain open throughout Ecology technicians' field operations. Routinely gain approval from Clipper Navigation staff to open the fore bulkhead door in the engine room to allow air circulation and slight cooling. Opening this door depends on non-Ecology activities that occasionally occur during Ecology's routine maintenance. Before departing the vessel, close both bulkhead doors.

9.9 Before opening the sea chest to install or service a sensor, double-check that all water valves, especially the main valve, are closed. Otherwise, if the valves, especially the main valve, remain open, sea water will flood the engine room. Avoid this at all costs to prevent loss of lives or sinking of ferry vessel.

9.10 Likewise, when done working with the sea chest, double-check that all nuts, bolts, and washers are properly installed and secured and that all water valves are open. This is necessary to prevent any damage to the ferry vessel engine.

10.0 References

10.1 Bos, J. 2010. Standard Operating Procedure for Seawater Sampling. Washington State Department of Ecology, Environmental Assessment Program Publication No. EAP025. 15 pp. http://www.ecy.wa.gov/programs/eap/quality.html

10.2 Pool, S., C. Krembs, and J. Bos. 2015. Quality Assurance Monitoring Plan: Puget Sound Temperature, Salinity, In Situ Fluorescence, Turbidity, and Colored Dissolved Organic Matter, Marine Water Monitoring using the *Victoria Clipper IV* Ferry Vessel. Washington State Department of Ecology Publication No. 15-03-115. 48 pp. https://fortress.wa.gov/ecy/publications/SummaryPages/1503115.html.

10.3 Washington State Department of Ecology. 2015. Environmental Assessment Program Safety Manual. March 2015. Washington State Department of Ecology. 193 pp.

11.0 Appendices

11.1 Appendix A – Wire Diagrams

11.2 Appendix B – Field Gear List

11.3 Appendix C – Fluorometer Field Log Sheet

11.4 Appendix D – Fluorometer Field Calibration Sheet

11.5 Appendix E – Companies and their Internet Addresses

Appendix A – Wire Diagrams

Figure A-1. Wire diagram of Ecology's entire ferry monitoring system.

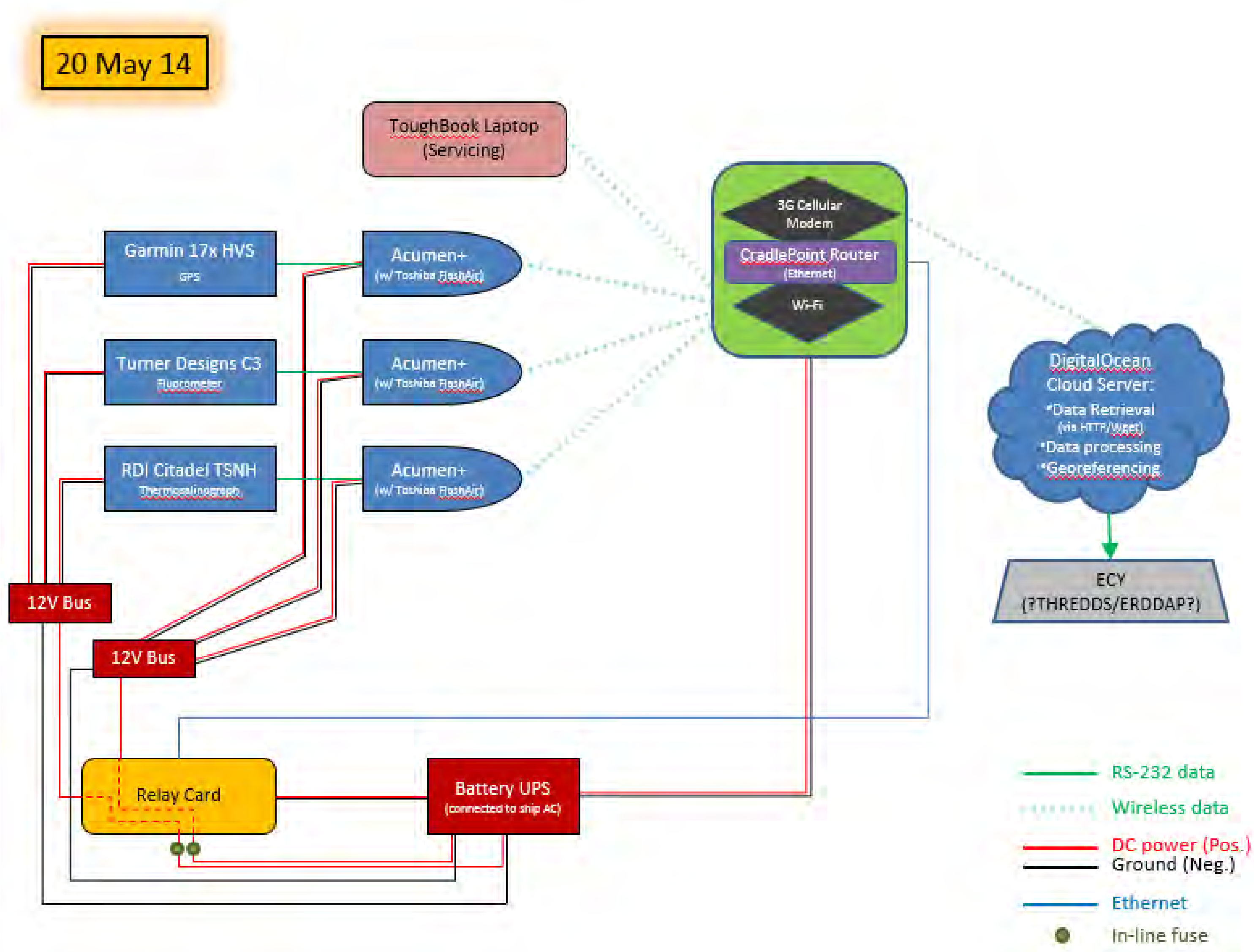
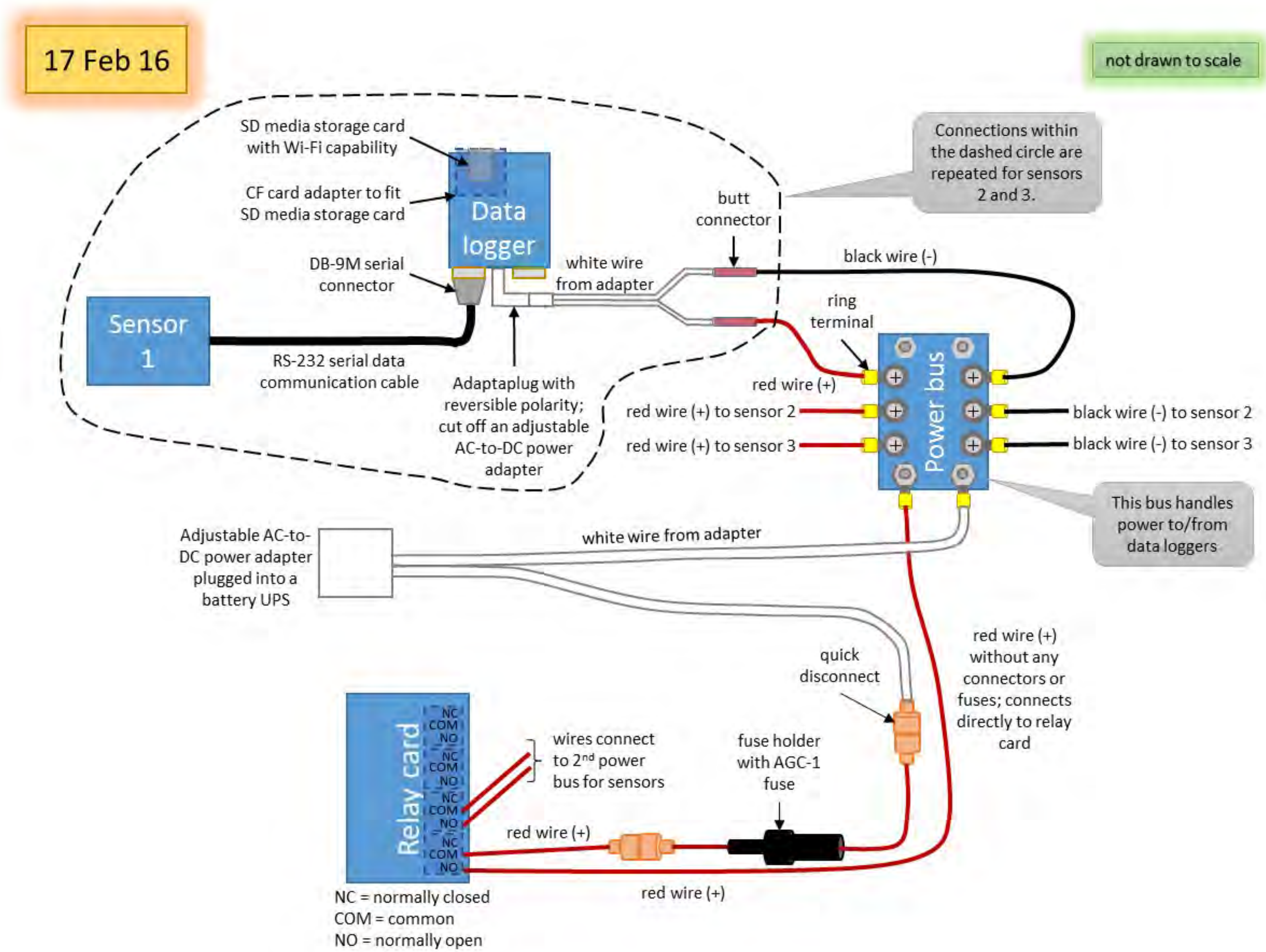


Figure A-2. Wire diagram of data logging system



Appendix B – Field Gear List

Victoria Clipper Field Gear Check List

updated 17 Mar 16

Before departure*, text Brad (or John, if Brad is out) for confirmation that the VCIV is in and to give ETA.*

Computer Bag

1) Laptop (moorings Toughbook) with SD card inserted for backing up files
2) Power adapter
3) Power inverter with 12 V adapter
4) Ethernet cable
5) Camera
6) Clipboard with log sheet
7) C3 fluorometer servicing SOP (not available yet)
8) Field servicing technical notes
9) Network settings
10) Troubleshooting guide

Blue Plastic Tote

<u>*Electronics*</u>

1) 9-pin male to 9-pin female cable
2) Dummy 5-pin female plug for C3 fluorometer
3) C3 interface cable (in Turner Designs bag)
4) C3 power adapter
5) C3 pigtail cable (purchased for 2^{nd} C3); aka Submersible pigtail assembly (in Turner Designs bag)
6) C3 data continuous cable
7) Power and interface cables for Acumen data loggers
8) SD card adapter with USB plug
9) USB module for relay card
10) Desiccant, small bags for metal and plastic boxes
11) Volt meter
12) Electrical outlet tester
13) Standard electrical tape, various colors and black
14) Stretchable electrical tape for splicing, 2 rolls
15) Cable ties, various sizes
16) Fuses, various sizes
    a) Cooper Bussmann fuses, 1 amp GMA-1A
    b) Bussmann AGC-1, 1 amp
17) Silicone lube spray (one recommended by WET Labs – 3M Silicone Lubricant Spray without hydrocarbon solvents)
18) Cable cutter (for removing wire insulation, etc.)
19) Pliers
20) Heat shrinks, including ½" one for large cable splices)
21) Soldering pen and wire
22) Liquid electrical tape (with brush; for sealing cable splices)

Black Toolbox

Supplies for Sea Chest Cover and C3

1) Small plastic beaker for holding bolts, nuts, and washers
2) ½" socket and spare
3) Socket wrench to fit socket identified in #2
4) ½" manual nut driver
5) Spare *stainless steel* nuts, washers, bolts
6) Socket extension for drill

Supplies for Cleaning

1) Scrubbing pad or metal brush for cleaning mesh basket
2) Trash bags
3) Gloves (XS, S, M, L, XL in own ziplock bags)
4) Absorbent paper towels
5) Kimwipes (*do not use* for optics!)
6) Q-tips, including long ones
7) Plastic tongs

Solid Standards, Chemicals, and Accessories

1) Solid chlorophyll standards (1 new and 1 old)
2) Solid UV standard
3) Solid secondary standard cap
4) Special small, green screwdriver for solid standards
5) Flow cap with end caps (aka calibration cup)
6) Lens paper (for wiping C3 optics)

Other, but also Important Supplies

1) Pens and pencils
2) Lab tape, 2-3 rolls
3) Sharpie
4) Magnet pen
5) Wire cutter

Chlorophyll Sampling in Transparent Blue Tote

1) 6 x 65 ml brown, opaque sample bottles
2) Hand pump with tubing
3) Plastic vacuum flask
4) GF/F filters, 25 mm diameter
5) Small 65 ml squeeze bottle of $MgCO_3$
6) Filter cup for 25 mm diam filters – funnel, screen, gasket, base, stopper
7) 6 x 15 ml plastic test tubes (resistance to acetone; 1 labeled "FB1" for field blank with FSW and 1 labeled "LB1" for DI blank; 1 spare tube)
8) Forceps
9) Parafilm
10) Foil
11) Lab mats

12) Filtered seawater setup
    a) GF/F filters, 47 mm diameter
    b) Filter cup for 47 mm diam filters – funnel, screen, gasket, base, stoppers
    c) 0.5 L FSW wash bottle

Cleaning and Liquid Storage Bucket

1) Blue bucket labeled for Victoria Clipper
2) Empty 4 L carboy with a thin line attached (for seawater collections)
3) DI water in large wash bottle
4) 2 x 1 L transparent Nalgene sample bottles
5) 2 x 1 L brown Nalgene sample bottles
6) 2 L DI water, enough for pre- and post-cleaning
7) Liquid 0.5 L turbidity standard (AMCO Clear, 100 NTU)
8) Liquid 0.5 L CDOM PTSA standard (100 ppb)

Small Ice Chest (Lunchbox Size)

1) Sufficient ice for chl tubes to fit inside

Tools not in Black Toolbox

1) Battery-powered drill (n = 2)
2) Folding step stool
3) Knee pads
4) Dolly (sediment team's dolly is available, except in April and June each year)
5) 2 bungee cords to secure field gear to dolly

Others to add to list??

Ethanol and steel wool for cleaning sensor cable connections at female/male ends

For Cable Splices (occurs infrequently, pack only when needed)

1) Paint-on liquid electrical tape (ex. West Marine Liquid Electrical Tape, 4 oz.)
2) Spray can of liquid tape
3) Stretchable splicing tape (check electronic box/tote)
4) Silicone lube spray without hydrocarbon solvents, specifically for use on sensor bulkheads (one recommended by WET Labs – 3M Silicone Lubricant Spray)
5) Electrical cleaning solvent (do *not* use on sensor's bulkheads or cables)
6) Extra paper towels or clean rags

Appendix C – Fluorometer Field Log Sheet

Highlighted entries are emphasized to document times Ecology technicians board ship, close sea chest valves, reopen valves, and depart ship.

Record all times in PST

Turner Designs C3 Calibration

Date:	
Techs:	
Seawater collection time:	
Debris types in sea chest:	
Photo(s) of sea chest:	Yes/No
Online C3 file name(s):	

Take salinity sample before C3 servicing
Record discrete samples on next page

Accountability	Time (hh:mm)
On ship:	
Valves closed:	
Valves opened:	
Off ship:	

Use logger times (1st column)

	Start time hh:mm:ss	End time hh:mm:ss	Temperature	RFU Estimates Fluor	Turb	CDOM	Comment
Pre-Cleaning							
Ambient							
seawater:							
DI water:							
Post-Cleaning							
Solid standards - for CHL, use 2013 every time; check with 2010 every few months							
2010 Chl Std:							
2013 Chl Std:							
**30 sec!! CDOM Std:							
Ambient							
air temperature:							
DI water:							
seawater:							
Liquid standards							
CDOM Std (100 ppb):							
Type (PTSA, quinine), exp date, lot #:							
Turbidity Std (100 NTU):							
Type (AMCO Clear, others), exp date, lot #:							

Before leaving vessel:	Completed?	Comment
Check time drift on relay card:		
Replace desiccant in electronic boxes:		
Clean/rinse calibration cup and chl filt. supplies:		
Inspect TSNH for corrosions, etc.:		
Check cables for engine cleaners, salts, etc.:		

Rough Estimate of Ranges (RFU) *5 Apr 16*

Fluor	Turb	CDOM
DI Water Blanks		
10-22	15-55	5-22
1° Liquid Standards		
na	1800-1990	1230-1290
2° Solid Standards		
90-125	na	95-110

General Servicing Notes:

Page 1 of 2

Record all times in PST

Thermosalinograph

Sea chest water collection time:	
Salinity sample bottle number:	

Chlorophyll samples

Chl filtration tech:	
General sampling/filtration comment:	

	Bottle #	Tube #	Acetone Added	Sample comment
Sample 1				
Sample 2				
Sample 3				
Field blank				
Lab blank				

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Appendix D – Fluorometer Field Calibration Sheet

Record all times in PST

Turner Designs C3 Calibration

Date:	
Techs:	
Seawater collection time:	
Debris types in sea chest:	
Photo(s) of sea chest:	
Online C3 file name(s):	

Take salinity sample before C3 servicing
Record discrete samples on next page

Accountability	Time (hh:mm)
On ship:	
Valves closed:	
Valves opened:	
Off ship:	

Use logger times (1st column)

	Start time hh:mm:ss	End time hh:mm:ss	Temp Estimate	Temp Exact	Fluor Estimate	Fluor Exact	Turb Estimate	Turb Exact	CDOM Estimate	CDOM Exact	Comments
Pre-Cleaning											
Ambient											
seawater:											
DI water:											
Post-Cleaning											
Solid standards - for CHL, use 2013 every time; check with 2010 every few months											
2010 Chl Std:											
2013 Chl Std:											
**30 sec!! CDOM Std:											
Ambient											
temperature:											
DI water:											
seawater:											
Liquid standards											
CDOM Std (100 ppb):											
type (PTSA, quinine), exp date, lot #:											
Turbidity Standard (100 NTU):											
Type (AMCO Clear, others), exp date, lot #:											

Before leaving vessel:	Completed?	Comment
Check time drift on relay card:		
Replace desiccant in electronic boxes:		
Clean/rinse calibration cup and chl filt. supplies:		
Inspect TSNH for corrosions, etc.:		
Check cables for engine cleaners, salts, etc.:		

General Servicing Notes:

Page 1 of 2

Record all times in PST

Thermosalinograph

Sea chest water collection time:	
Salinity sample bottle number:	

Chlorophyll samples

Chl filtration tech:	
General sampling/filtration comment:	

	Bottle #	Tube #	Acetone Added	Sample comment
Sample 1				
Sample 2				
Sample 3				
Field blank				
Lab blank				

Appendix E – Companies and their Internet Addresses

Company	Product	Internet Address
Acumen Instruments Corporation	Manufacturer of data loggers, with or without enclosure	http://www.acumeninstruments.com
Blue Sea Systems	Manufacturer of power buses, fuse boxes, etc. for marine use	https://www.bluesea.com
Clipper Navigation (aka Clipper Vacations)	Passenger ferry and travel service; Ecology sensors on *Victoria Clipper IV*	http://www.clippervacations.com
Cradlepoint	Manufacturer of wireless routers	http://cradlepoint.com
Garmin	Manufacturer of GPS	http://www.garmin.com
GFS Chemicals	Source for AMCO Clear turbidity standard	http://www.gfschemicals.com
National Control Devices, LLC	Manufacturer of various electronic boards, including time-activated relay switchboards	https://www.controlanything.com
Ocean Innovations	Supplier of thermosalinograph pigtail cables	http://ocean-innovations.net
Pacific Fishermen Shipyard	Shipyard that Clipper Navigation uses for annual maintenance and repairs; company also manufactured custom sea chest cover	http://pacificfishermen.com
PuTTY open source software	Terminal software to communicate with Acumen data loggers	http://www.putty.org
Teledyne RD Instruments	Manufacturer of thermosalinograph	http://www.rdinstruments.com
Turner Designs, Inc.	Manufacturer of C3 fluorometer and accessories; source for PTSA standard	http://www.turnerdesigns.com