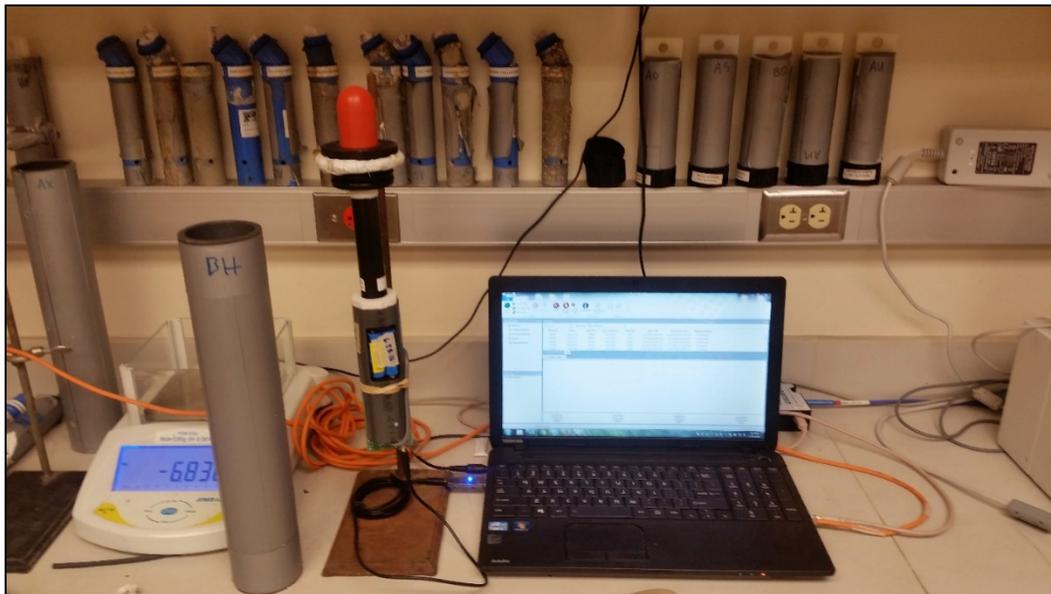


# ANEMONE sensor maintenance, calibration, and programming protocol

Aquatic Assessment Monitoring Team  
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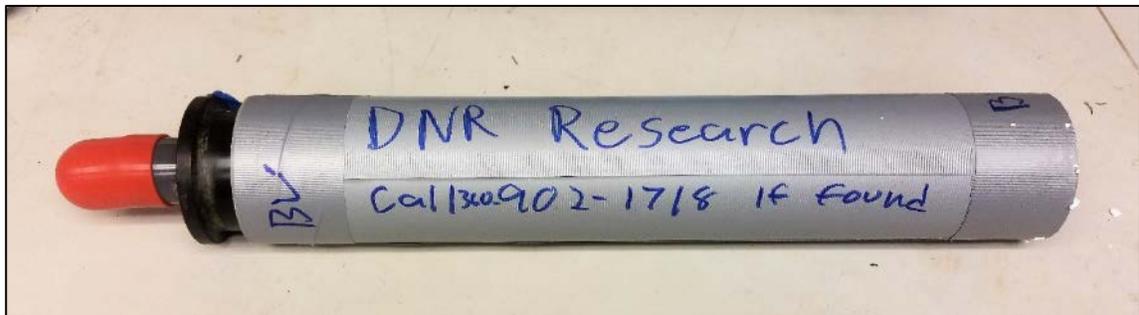
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Figure 1. pH sensor with vinyl tape and labeling



## Introduction

The ANEMONE sensor protocol describes the maintenance, calibration, and programming of pH, dissolved oxygen (DO), conductivity (CT), and chlorophyll (CHL) sensors. The Washington Department of Natural resources (DNR) Aquatic and Assessment Monitoring Team (AAMT) uses sensors to track long-term trends in Ocean Acidification (OA), to describe eelgrass's capacity to mitigate the effects of OA in nearshore environments and for short-term studies designed to address specific questions regarding near shore water chemistry, protected habitats/organism, and DNR land management. Proper maintenance, calibration, and programming are essential to the success of these projects.

This document provides the information needed to prepare ANEMONE sensors for field deployments and manage sensors/data after retrievals. It describes sensor and database organization, gives protocols for cleaning, maintenance, data downloads, calibration, and programming and outlines procedures to prepare and conduct sensor fieldwork. It is not a complete description of sensors. For specific details on the sensors, users should see manufacturer's manuals (links in Appendix II).

Figure 2. AAMT sensor arrays (pH, CHL, DO, and CT) see section x for details



## Sensor Labeling

Sensor codes are used to keep track of site deployments/retrievals, field data, sensor maintenance, and calibration data. Onset Hobo DO, and Odyssey Blue CT, and pH sensors are labeled with a two-digit alphabet codes. Codes correspond with the logger's serial number. Serial numbers and codes are written in a lab notebook (a sensor code spreadsheet will be made to reference codes and serial numbers). PME CHL and DO loggers use the serial number for the label. Sensor codes should also be written on the vinyl electric tape covering the sensor body.

Table 1: Location of sensor codes on sensors

Sensor	Make	Code type	Code Placement	Back up label
<b>pH (built in house)</b>	Honeywell Durafet II	Two-digit alphabet codes	Circuit board	N/A
<b>Conductivity</b>	Odyssey Blue	Two-digit alphabet codes	Sensor housing	Round plate covering the circuit board
<b>DO</b>	Hobo Onset	Two-digit alphabet codes	Sensor housing	N/A
<b>DO</b>	PME miniDot	Serial number	Circuit board	N/A
<b>Chlorophyll</b>	PME Cyclops 7	Serial number	Sensor housing	SD card located on the circuit board

## **Sensors data storage and transfer protocol**

The AAMT lab's laptop computer (LPT) is the primary interface with the sensors. The LPT is used to download and store sensor data and to share data. Data are shared by using the Dropbox ANeMoNe (\Dropbox\ANeMoNe\) folder. Two data types are stored on the LPT: calibration data and field collected data.

### **Calibration data storage**

**pH data:** Data are used to create a relationship between sensor voltage and pH data (see appendix I pg 21 for details)

1. Calibration data are stored on the LPT desktop in the SENSOR CALIBRATIONS folder\pH sensor calibrations subfolder
  - a. In the subfolder, create a new folder labeled with the date, sensor type and data type (example 12.30.16\_pHcalibration)
2. Save all calibration data downloaded on the same day in the new folder
3. Label the file with sensor code, date, and data type (example AU\_12.30.16\_calibration)
  - a. see pH data download section for download instructions pg. 7
4. Copy calibration folder to \Dropbox\ANeMoNe\Unsorted data

**CHL data:** Calibration data are stored on the logger's SD card, the file saved on the LPT is a backup log.

1. Calibration data are stored on the LPT desktop in the SENSOR CALIBRATIONS folder\CHL sensor calibrations subfolder
  - a. In the subfolder, create a new folder labeled with the date, sensor and data type (example 12.30.16\_CHLcalibration)
2. Save all calibration data downloaded on the same day in the new folder
3. Label the file with sensor code, date, and data type (example SN99\_12.30.16\_calibration)
  - a. see CHL calibration section for download instructions pg. 10
4. Copy calibration folder to \Dropbox\ANeMoNe\Unsorted data

### **Field data storage**

1. Field data are stored on the LPT desktop in the pH\_Field\_data\_folder
2. Create a retrieval subfolder
  - a. Label folder with the month(s) and year of retrieval
3. Follow data download protocols for sensors and save data from all sensors to the file
4. Copy calibration data folder to \Dropbox\ANeMoNe\Unsorted data
- 5.

### **Deployment and Calibration Log**

The log is stored as an Excel file in the \Dropbox\ANeMoNe folder\ Deployment and calibration log.xlsx. The file has two tabs a deployments and calibrations tab. The calibration tab is used for the pH sensors and is updated by ANEMONE lead scientist. Staff programming the sensors and setting up the sensor arrays should update the deployment tab. See sensor array protocol pg. 18 for details

## Sensor cleaning protocol

Sensor cleaning occurs after each field deployment. The instructions in this section outline the general steps taken for cleaning ANEMONE sensors and describe additional cleaning needs for each sensor. Steps may be modified as needed.

### Equipment

- Wire Brush
- Pipe cleaning brush
- Forceps
- Cotton swab
- Bronze wool
- Distilled vinegar
- Deionized (DI) water
- 0.01M HCL (HCL)
- Silicone Grease
- Vinyl electric tape
- Plastic tub

Figure 3. Sensor cleaning supplies



### General Cleaning Protocol

1. Create a list noting sites and habitats where sensors were deployed and the codes for each sensor
  - a. Use table as a reference to label downloaded data files
2. Remove sensors from PVC/rebar mounting frame (if needed)
  - a. Using a flat head screw driver to loosen stainless steel hose clamps
3. Inspects sensors to assess level of cleaning
  - a. If sensors have excess mineral growth, remove vinyl electric tape
4. General Cleaning
  - a. In lab sink, run warm water and use wire brush to remove dirt/mud and mineral growth
  - b. In difficult to reach areas, use forceps and an appropriately size piece of bronze wool
  - c. If growth cannot be removed, soak sensors in vinegar, DI water, or HCL
  - d. Set clean sensors on paper towels to dry
  - e. Clean lab sink with paper towels and sweep floor after sensors have been cleaned
5. Replace vinyl electric tape (if needed)
  - a. Label sensors with sensor codes, and contact information (figure 1)

## **Additional cleaning requirements for sensors**

### **pH**

1. Unscrew PVC tube at sensor head, remove plumbers tape around threads, clean and set aside to dry
2. Thoroughly cleaned and remove organic matter from sensor head area
  - a. Gently clean around the pH sensor's sensor located in the center of head
    - i. Clean sensor area with cotton swab
  - b. Use bronze wool and forceps to clean hard to reach areas along sensor head (threads and plastic posts around sensor)
  - c. If dirt/growth cannot be removed fill sensor head with vinegar, DI water, or HCL
    - i. Place sensor upright to soak head

### **PME cyclops 7 CHL and Onset HOB0 DO**

1. Unscrew the sensor head guard
  - a. Be careful not to unscrew the PVC housing protecting sensor internals
2. Gently clean around the sensor head
3. Use a soft bristle brush to clean the interior of the guard

### **PME miniDoT DO**

1. Be careful when cleaning the sensor head; film covering the optic sensor (center of head) can peel or flake
  - a. If film is damaged, sensor will need to be sent to manufacturer for service (see warranty information pg. 23)

### **Odyssey Blue CT**

1. Use cotton swab to clean waterway through center of salinity cell, vertical and horizontal tube

## Sensor data download, maintenance, calibration, and programing protocols

The following protocol outlines the necessary steps to download, maintain, calibrate, and program ANEMONE sensors. For additional sensor and software information, follow the links provided in appendix II (pg. 23).

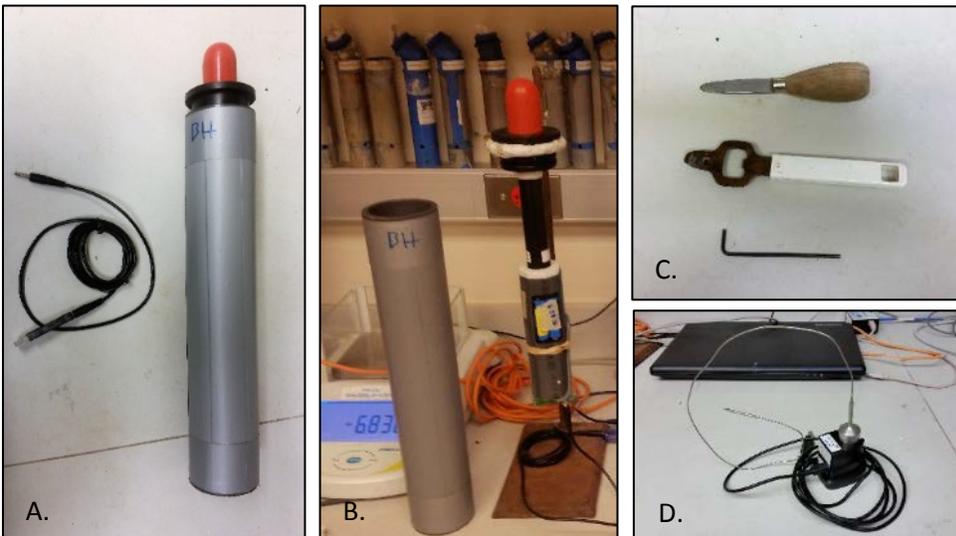
### pH sensor (Honeywell/MadgeTech custom built sensor)

Data download, calibration and programing

#### Equipment

- 3/32 Allen wrench
- bottle opener
- metal wedge
- 3" lab equipment stand
- Threaded PVC cap with plumbers tape on threads
- Orange rubber cap
- Tris buffer solution
- Masking tape
- Thionyl nickel chloride Lithium AA Batteries 3.6v (if needed)
- MadgeTech IFC200 data logger 3.5mm headphone jack to USB interface cable
- MadgeTech HiTemp140-PT temperature logger

Figure 4. A. pH sensor and download cable. B. Housing removal tools (metal wedge, bottle opener, Allen wrench). C. pH sensor seated in lab stand. D. Temperature logger.



## Data Download

1. Sensor should be clean and dry before data download begins
2. Remove pH sensor body from PVC housing
  - a. Use Allen wrench to remove Allen bolt from top of sensor
    - i. Clean Allen bolt and set aside to dry
    - ii. Place in receptacle located in the drawer labeled pH sensors equipment
  - b. Gently use bottle opener and metal wedge to remove sensor by placing tools under lip of body
    - i. Be careful not to mar the edges of the housing with tools
  - c. Check the O-rings on sensor body for damage and lubrication
    - i. If dry use silicone grease to lubricate rings
    - ii. If cracked replace rings
3. Download
  - a. Place pH body in equipment stand
  - b. Connect sensor to computer using headphone/USB cable
    - i. pH sensor connection is located on the bottom of the circuit board
  - c. MadgeTech software
    - i. The software should recognize the sensor
      1. If it doesn't, under the devices tab, click on the "refresh devices" button
  - d. Data download
    - i. Under the devices tab highlight sensor information
    - ii. Click on the "stop logging" icon
    - iii. Click on the "download" icon
      1. Downloading data can take 20-30 min
4. Label file
  - a. Once data is download, MadgeTech software prompts you to name the data file
    - i. Name the file: by the year and month sensor retrieval occurred, site name, the sensor type, deployment habitat ((B)bare, (E)eelgrass), and sensor ID
      1. Example: 201610WBEpHCH
5. Inspect graphed data
  - a. Graph (x=time y=volts)
  - b. pH sensor logs four channels of data, check to make sure data is within an acceptable range
    - i. V1: pH: between 0.05 to 0.12v
    - ii. V2: positive battery power: very close to .036v
    - iii. V3: negative battery power: very close to -.036v
    - iv. V4: temperature: about 0.02 to -0.02v
6. Export data to excel
  - a. Under the report tab click on the "export to excel" button
  - b. Data will be exported in tabular format to excel
  - c. Do not export graphic data
  - d. Save data with the same file name as the graphic data

- e. Save data on the desktop in folder labeled 'field data' and in the \Dropbox\ANeMoNe\Unsorted data folder (see Sensors data storage and transfer protocol pg. 3 for details)
7. Check excel file to make sure data was exported correctly
8. Close and save MadgeTech data file
9. Click on "Reset" to delete all data from sensor
10. If sensor is going to be calibrated move to calibration section
11. If sensor is going to be stored
  - a. Disconnect sensor from computer
  - b. Remove battery power pin from circuit board
  - c. Loosely place sensor body in PVC housing
  - d. Screw on clean PVC tube to sensor head
  - e. Fill head with Tris
  - f. Place rubber cap on PVC tube
  - g. Use a piece of painters tape and Label sensor as "needs to be calibrated"
  - h. Store sensor in clean, dry location

Figure 4. pH sensor circuit board. Red arrow points to battery power pin



### Calibration/battery maintenance

Note: for more information on sensor calibration see appendix I pg. 21

1. Sensor head must be filled with Tris buffer solution for at least 72hrs prior to calibration
2. Check date label on AA batteries
  - a. If batteries are more than 6 months old change batteries
  - b. Label replaced batteries with date
3. Connect sensor to computer
  - a. Start MadgeTech software
4. Check sensor data
  - a. In the device tab click on "real time start"
  - b. Set to log every second
  - c. Check real-time log to determine if sensor data outputs are within range
    - i. Batteries channels V2 and V3
      1. If battery voltage is below 0.035 or above -0.035 change batteries
    - ii. Check V1, pH output should be between 0.05 and 0.12v
    - iii. Check V4, temperature output should be between 0.02 and -0.02v
    - iv. If pH and temperature are out of range label the sensor with the variable out of range
      1. Notify ANEMONE Sensor maintenance lead of damaged sensor
5. Program sensor for calibration
  - a. Click on the "custom start" button
  - b. Set sensors to log for 10 min
  - c. Set a start logging time
    - i. Logging time should be set so that all sensors start at the same time
6. MadgeTech Temperature logger
  - a. Logger uses the same programming software as pH sensors

- b. Connect logger to base and base to computer
7. To program logger, follow the “Program sensor for calibration” instructions in step 5 of the pH calibration section
8. Calibration process
  - a. Place sensors and temperature logger in a cooler with tap water
    - i. Cooler fits about 8 sensors
  - b. Leave rubber cap on head
  - c. Make sure sensor head is filled with tris buffer solution
  - d. Place weight on sensor to keep sensors below the water line (they float)
  - e. Leave sensor in the cooler, in the lab, for at least 24hours (48hr or longer is ideal)
  - f. Put cooler in freezer (DNR building 6<sup>th</sup> floor freezer) for another 24hours (again, 48hr or longer is ideal)
  - g. Follow data download instruction to download data and reset device
  - h. Place downloaded data in pH calibration folder on the laptop’s desktop and in the \Dropbox\ANeMoNe\Unsorted data folder (see data storage section pg. x)

### **Programing**

1. Connect sensor to computer (or keep connected)
  - a. Start MadgeTech software
2. To program logger Follow the ‘Program sensor for calibration’ instruction in step 5 of pH calibration section
  - a. Logging time should be set so that all sensors start at the same time after sensors deployment
3. Insert sensor in housing
  - a. Align bolt holes as best as possible
  - b. Push sensor head down past the two O-rings
  - c. Leave about 1 cm between top of PVC housing and sensor body
  - d. Replace Allen screw in one of the available holes
  - e. Make sure rubber nipple is covering PVC head and that sensor head is filled with Tris

## **PME cyclops 7 chlorophyll logger**

Data download, calibration and programing

### **Equipment**

- Philips head screw driver
- SD card reader
- 3.5mm headphone jack to USB Communication cable (generic cable with black headphone jack cable and silver and blue USB cable (cables connect with an RS232 serial cable interface)
- Rhodamine dye 440ppb
- Calibration containers (2)
- C-cell batteries (if needed)

Figure 4. A. CHL sensor and download cable. B. Calibration containers



### **Data Download**

1. Unscrew chlorophyll sensor from PVC housing
  - a. Check the O-rings on the sensor head for damage and lubrication
    - i. If dry, use silicone grease on rings
    - ii. If ring is cracked replace
2. Press white/translucent button near off switch to save data logged within the last 24hrs
3. Switch sensor to off
4. Remove Philips head screws
5. Remove SD card
  - a. Place card in SD card reader
  - b. Connect reader to computer
  - c. Logger data is stored on SD card in the data folder
6. Create new folder in the retrieval subfolder folder (see Sensor data storage and transfer protocol pg. 3 for details)
  - a. Label folder by the year and month sensor retrieval occurred, site name, the sensor type, deployment habitat (bare, eelgrass), and sensor ID
  - b. Example: 201610WBECLSN090
7. Move data from SD card (data folder) to retrieval subfolder
8. Delete data off card
9. Replace SD card and Philips head screws into sensor circuit board
10. Turn the sensor on

- a. Green light should flash once
- b. If light flashes multiple times, check manual for error codes (see pg. 23 for manual link)

### **Battery maintenance**

1. Check data to determine if more than 30,000 samples were taken since last changed
2. Change batteries when more than 30,000 samples have been logged

### **Calibration**

1. Fill one container with tap water, fill the other with 400ppk solution
  - a. Make sure liquid in containers will submerge the sensor head but not displaced liquid above the sensor board
2. Connect the logger to the laptop with communication cable
3. Turn the sensor on
  - a. Small green light next to the off switch should be glowing solid green
4. Open the Cyclops7 calibration program
  - a. Program is located on the desktop under the folder labeled CHL sensor stuff
5. Select com port
6. Connect to the logger
  - a. Once connected, a warning will appear regarding time, Disregard warning
7. Enter Rhodamine dye solution parameters
  - a. Unit of measure (ppb)
  - b. Calibration value (440)
8. Put sensor in water
  - a. Click on the "calibrate" button
  - b. Follow prompts
9. Put sensor in Rhodamine dye solution
  - a. Follow prompts
10. Once sensor has been calibrated save results (see data transfer pg. 3)

### **Programing**

1. Sensor programing occurs in the same software as calibration
2. Program sensor to log every 10 minutes (sample interval box)
3. There is not start timer
  - a. Sensors will need to be started manually before field deployments (see field deployment pg. 19)

## **PME miniDoT Dissolved Oxygen (DO) logger**

Data download, calibration and programming

### **Equipment**

- Mini USB cable
- Lithium AA batteries (if needed)
- Masking tape

### **Data Download**

1. Unscrew DO sensor from PVC housing
  - a. Check the O-rings on sensor head for damage and lubrication
    - i. If dry use silicone grease on rings
    - ii. If ring is cracked replace
2. Switch sensor to halt position
3. Connect the logger to the laptop
  - a. Small green light next to the off lever should be glowing solid green
  - b. Computer recognizes logger as an external drive
    - i. Open the folder associated with the logger
4. Create new folder in the retrieval subfolder folder (see Sensors data storage and transfer protocol pg. 3 for details)
  - a. Label folder by the year and month sensor retrieval occurred, site name, the sensor type, deployment habitat (bare, eelgrass), and sensor ID
  - b. Example: 201610WBEDOSN090
5. Move data from the data folder on the sensor to the retrieval subfolder
6. Delete data folder in sensor storage

Figure 5.  
miniDoT DO  
sensor and  
download  
cable.



### **Battery maintenance**

1. At 10min samples batteries will last a year
2. Change batteries as needed
  - use masking tape to label batteries with the changed date

### **Calibration**

1. Manufacturer performs calibration of miniDoT sensors. When logger reaches 500,000 samples it needs to be sent to PME for calibration
2. Check maintenance log for number of samples taken or estimate based on past data logs

## **Programing**

3. Connect sensor to LPT (miniDoT data download section)
4. The logger is recognized by the computer as an external drive
5. Open miniDoT control software in external drive
  - a. Connect to logger
6. Program sensor to log every 10 minutes (sample interval box)
7. There is not start timer - Sensors will need to be started manually before field deployments (see field deployment pg. 19)

## **Onset HOBO DO Logger**

Data download, calibration and programing

### **Equipment**

- HOBO optic USB base station (Base-U-4) coupler
- Sensor cap
- Calibration boot and sponge

Figure 6. Onset HOBO DO Logger and optic USB base station coupler



### **Data Download**

Unscrew DO logger cap

- c. Check the O-rings on cap for damage and lubrication
  - i. If dry use silicone grease on rings
  - ii. If cracked replace
11. Connect the sensor to the optic base station
  - a. Make sure readout pins and alignment notches are inline
12. Open the HOBOWare software program
  - a. Under the devices table click on “readout”
  - b. You will be prompted to Label file
    - i. Label folder by the year and month sensor retrieval occurred, site name, the sensor type, deployment habitat (bare, eelgrass), and sensor ID
    - ii. Example: 201610WBEDOAJ
  - c. In plot set up screen check boxes for DO, Temp, and end of file, and highlight dissolved oxygen assistant option
  - d. Click on the “plot” option
13. View plot to assess data are in range
14. Export table
  - a. In file tab, click “export table”
  - b. Check boxes for DO, Temp, and end of file
  - c. Export date
  - d. Name file as in 12-b above
    - i. Save to appropriate folder (see data transfer protocol pg. 3)

## Battery maintenance

1. Battery status is viewed by clicking on the “status” icon under the device tab
  - Sensor cap expiration date is also in the programing screen
  - Batteries should last three years or more
2. Logger will report a bad battery reading at 3.2 V and another at 3.1 V
  - At 3.1 V logger should be returned to Onset for replacement

## Sensor cap maintenance

1. Sensor cap expires 7 months after initiation
  - a. Logger reads 888mg/l after expiration
  - b. Sensor cap expiration date can be viewed if you click on the “status” icon under the device tab
2. Replacing cap - See page 2 of the HOBO dissolved oxygen logger (U26-001) manual for additional details (Instructions below are form manual)
  - a. Unscrew protective guard covering the DO sensor
  - b. Remove the red dust cap that protects the sensor during shipping
  - c. Take green sensor cap out of the canister
  - d. With the flat part of the sensor pointing down and the green sensor cap oriented with the arrow up, slide the sensor cap over the sensor until it snaps in place. The cap should be snug against the logger housing without any gaps
  - e. Initiation occurs automatically after cap has been replaced

## Calibration

### Notes

- Calibration occurs before each field deployment and after replacing the sensor cap
  - Sensor cap should be replaced when preparing sensor for a field deployment, not after it has been retrieved for the field.
- 0% sodium sulfite calibration isn't necessary for our purposes
- Local parametric pressure will be needed

### Protocol

1. Set out logger, water, boot and sponge long enough for them to reach room temperature
2. Connect logger to computer and HOBOWare
  - a. From the device menu, click “lab calibration”
3. 100% saturation
  - a. Enter barometric pressure at your location
  - b. Make sure sensor guard is installed
  - c. Wet small sponge with water and squeeze out excess
    - i. Place sponge in calibration boot
  - d. Insert logger in the calibration boot so that there is 1cm of overlap between the end of the boot and the body of the logger

- e. Wait approximately 15min until the logger reaches temperature equilibrium
- f. Click "Get DO value" from the logger
  - i. Can click more than once to check if values are constant
- g. Click the "next" button
4. 0% saturation (this step is only for water less than 4mg/l)
  - a. Click skip step (see manual if sensor will be deployed in low DO waters)
5. Finish
  - a. Click "Send calibration to logger" to save results
  - b. Click "close" to cancel calibration

### **Programing**

1. Connect device to computer as described in the data download section
2. Under the device tab click "Launch device"
3. Check the dissolved oxygen concentration and temperature icons
4. Set to log 10 min
5. Set date and time
  - a. Logging time should be set so that all sensors start at the same time after sensors will be deployed at the site
6. Click on "delayed start"

## **Odyssey Blue CT Sensor**

Data download, calibration and programing

### **Equipment**

- headphone jack to RS232 serial head with a RS232 to USB converter labeled digits
- Odyssey proprietary batteries (if needed)
- Masking tape

Figure 7. Odyssey Blue Sensor and connection cable



### **Data Download**

1. Unscrew sensor top to expose circuit board cover
2. Plug in sensor to laptop (white 3.5 headphone jack to RS232 serial head with a RS232 to USB converter labeled digits)
3. Open Odyssey software
  - a. In “site files” column
    - i. Find the file that corresponds to the most recent deployment of the sensor
    - ii. If needed use deployment and calibration log as reference (see data transfer section pg. 3)
  - b. Site summary window
    - i. Confirm serial number matches the sensor’s serial number
    - ii. Click on “stop logger” and save data file
  - c. Save data to PC
    - i. Label folder by the year and month sensor retrieval occurred, site code, deployment habitat ((B)bare, (E)eelgrass), sensor type, and sensor ID
    - ii. Example: 201610WBECTAI

### **Battery maintenance**

1. At 10min samples batteries will last about a year
2. Change batteries as needed
  - a. Use masking tape to label batteries with change date
3. Change batteries
  - a. Unscrew the two Allen head bolts on the circuit board cover using a 3/32 Allen wrench
  - b. Be careful not to lose the washers
  - c. Remove the circuit board cover

- Batteries are soldered to the cover
- d. Install new batteries
- e. Screw in Allen bolts and washers
- f. Circuit board should blink red for a few seconds when connected

### **Calibration**

1. Calibration occurs once when sensors are new. Calibration files are stored on the laptop. Files are associated to the sensor's serial number.
2. When sensor is connected to computer make sure the serial number is correct
  - a. No further calibration is required

### **Programming**

1. New site file
  - a. Click on the "new site file" icon
  - b. Name the file with site code, deployment habitat ((B)bare, (E)eelgrass), Date (year-month) sensor type, and sensor ID
  - c. Example: WBE201610CTAI
  - d. Site number=1
  - e. Label serial number appropriately
  - f. Select "temperature and salinity" in the sensor type drop box
  - g. Select linear calibration in the drop box for both conductivity and temperature
  - h. Site file identification = site name
  - i. Click on "Okay" to close
  - j. New file appears in the site file column
2. Program sensor
  - a. Select recently created file in the site file column
  - b. In the site summary window click on the "set up and start logger" icon
  - c. Confirm logger serial number
  - d. Set scan time to 10min
  - e. Chose delay start
    - i. Set logger to start on the date they will be deployed at a time later than the assumed swap time

## Sensor array description/protocol

Sensors are generally deployed bundled together in sensor arrays. Sensor arrays consist of a PVC/rebar framework; stainless steel hose clamps secure sensors to framework. Sensor array configurations can be adjusted for each project. Deployments generally consist of arrays deployed at two habitats, eelgrass and bare. Each habitat has two pH sensors and a DO sensor; bare habitats include a CHL and CT sensor.

### Protocol

1. In most cases, hose clamps will already be attached to PVC/rebar housing
  - a. If they are not, attach clamps as needed
2. pH sensors
  - a. Each sensor array uses two pH sensor
  - b. Attach pH sensor to opposite ends of framework
  - c. Safety latch
    - i. Run a zip tie around the framework and around the pH sensor's Allen bolt (Figure 8)
3. Attach other sensors to any available spot using hose clamps
4. Group sensor arrays in lab by site (1 eelgrass, 1 bare per site)
  - a. Use sticky or masking tape to label groups with site information
5. Transfer site, sensor codes and programing parameters to Deployment and Calibration Log:  
\Dropbox\ANeMoNe folder\ Deployment and calibration log.xlsx.

Figure 8. pH sensor with attached zip ties



## Sensor swap fieldwork protocol

### Equipment

Screw driver, pliers (use to unscrew D-ring attachment if it is stuck), towel (use to dry off sensors and to protect car from sensors), headlamp, floodlight, waders.

### Sensor arrays

- Two arrays are placed at each site; one in Eelgrass the other in bare habitat
  - Eelgrass array consists of three sensors: 2 pH, 1 DO
  - Bare array consists of 5 sensors: 2 pH, 1 DO, 1 Chlorophyll, 1 conductivity
- The DO and Chlorophyll sensor will have to be set to start logging before conducting the swap (bellow)
- Take the orange rubber cap and PVS sensor tube off the pH sensors before swapping.

### DO Sensor

1. Unscrew the cap
  - a. If needed loosen the hose clamp with flat head screwdriver
  - b. Be careful not to let sensor internals or desiccant packet get wet
2. Flip the lever to the record position
  - a. Light should flash green
3. Screw the cap back on
  - a. Make sure to leave the black rubber guard off the sensor head

### Chlorophyll (Similar to DO):

1. Unscrew the cap
  - a. If needed, loosen the hose clamp with flat head screwdriver
  - b. Be careful not to let sensor or desiccant packet get wet
2. Flip the switch to the on position
3. Screw the cap back on

Figure 10. Sensor arrays



Figure 11: DO sensors, arrow point to hose clamp and logging lever



Figure 12: Chlorophyll sensor, blue arrow point to on-off switch



## Sensor swap fieldwork protocol (continued)

### Sensor swap

1. Locate the sensors deployed in the field
  - a. Sensors have buoys attached
    - i. Use flood light if needed
  - b. If buoys aren't visible type in GPS coordinate to you phone's navigation
2. Sensor swap
  - a. Sensors are attached to a screw anchor via a rope and locking carabiner
  - b. Unscrew the carabiner
    - i. Use pliers if needed
  - c. Replace old sensor array with new array
  - d. Wipe of sensors with towel
  - e. Towel can be used wrap around sensors to minimize dirt in car during transport

Table 1: GPS coordinates, Type the appropriate coordinate into your phone to navigate to sensor locations

Site	Site code	Habitat	Lat	Long
Cherry Point	CP	B	48.8970137	-122.78194
	CP	E	48.8966694	-122.78281
Fidalgo Bay	FB	B	48.481691	-122.58353
	FB	E	48.481342	-122.58353
Nisqually Reach	NR	B	47.10164	-122.7269
	NR	E	47.10174	-122.7267
Maury Island	MI	B	47.3336927	-122.49076
	MI	E	47.3338235	-122.49118
Willapa Bay	WB	B	46.49586	-124.02586
	WB	E	46.49508	-124.02652
Port Gamble	PG	B	47.8425475	-122.58426
	PG	E	47.8481565	-122.58329
Case Inlet	CI	E	47.3584391	-122.79645
	CI	B	47.3579367	-122.79576
Skokomish	SK	E	47.35397	-123.15613
	SK	B	47.35523	-123.1572

## Appendix I

### Calibration details

WA DNR sensors are calibrated before and after each deployment in order to determine two sensor-specific properties: 1) the standard potential ( $E^*$ ) of the Durafet electrode, and 2) the temperature dependence of that standard potential ( $E^*_T$ ). When these properties are known, pH can be calculated from Durafet voltage using the following equation (Martz et al. 2010):

$$\text{pH} = (\text{Durafet voltage} - E^* - E^*_T \times T) / (R \times (T + 273.15) \times \ln(10)/F) \quad (\text{Eq. 1})$$

Where R is the gas constant:  $8.3145 \text{ J} \times \text{K}^{-1} \times \text{mol}^{-1}$

T is temperature in Celsius

And F is the Faraday constant  $96485 \text{ C} \times \text{mol}^{-1}$

For calibration, Tris-buffered synthetic seawater is prepared following SOP 6a in Dickson et al. (2007). A cap filled with roughly 30mL of this synthetic seawater is then placed over the Durafet sensor. Sensors are left for 72 hours to equilibrate to matrix salinity of 35. Sensors are then programmed to log at 10-minute intervals, and fully immersed in a water bath at room temperature (between 19 and 21 degrees Celsius), where a precise thermometer is taking contemporaneous measurements at 10-minute intervals. The water bath is intended to provide thermal mass. Sensors are left at room temperature for at least 24 hours, and then moved to a refrigerator that maintains a temperature between 1 and 3 degrees Celsius. After at least 24 hours at the colder temperature, sensors and thermometer are removed from the water bath, and data are downloaded.

The pH of the Tris-buffered synthetic seawater is calculated across the calibration period from thermometer observations following the equation from Dickson et al. (2007):

$$\text{pH} = ((11911.08 - 18.2499 \times S - 0.039336 \times S^2) \times 1/(T + 273.15)) - 366.27059 + 0.53993607 \times S + 0.00016329 \times S^2 + ((64.52243 - 0.084041 \times S) + \log(T + 273.15)) - (0.11149858 \times (T + 273.15))$$

Where T is as in equation 1

and S is the salinity of the Tris-buffered synthetic seawater (35)

Durafet voltage is then regressed against temperature:

$$\text{Durafet voltage} - (R \times \ln(10) \times (T + 273.15) \times \text{pH}) / F = T \quad (\text{Eq. 3})$$

Where R, T, and F are as in equation 1

and  $pH$  is the calculated  $pH$  of the Tris-buffered synthetic seawater

$E^*$  is the intercept and  $E^*_T$  the slope of the resulting model. The date of calibration and the calculated  $E^*$  and  $E^*_T$  for each sensor are recorded and compared against previous calibration results to evaluate sensor drift and accuracy of observations in the field.

## Appendix II

Manual links

Table 2: Links to manufacturers sensor, software and warranty information for sensors used in AAMT Ocean Acidification research.

Sensor type	Sensor	Sensor documents	Software	Software user guides	Tech support/Warranty phone number	Warranty	Address
pH (built in house)	Honeywell Durafet II	<a href="http://ftp.sccwrp.org/pub/download/DOCUMENTS/TechnicalReports/861_CCAN_Durafet_Best_Practices_Manual.pdf">http://ftp.sccwrp.org/pub/download/DOCUMENTS/TechnicalReports/861_CCAN_Durafet_Best_Practices_Manual.pdf</a>	MadgeTech	<a href="http://www.madgetech.com/software-download">http://www.madgetech.com/software-download</a>	800- 822-7673	N/A	1250 West Sam Houston Parkway South, Houston, TX 77042
CT	Odyssey Blue	<a href="http://odysseydatarecording.com/download/Odyssey%20Conductivity%20Logger.pdf">http://odysseydatarecording.com/download/Odyssey%20Conductivity%20Logger.pdf</a>	Odyssey software	<a href="http://odysseydatarecording.com/download/Odyssey%20Data%20Logging%20Software.pdf">http://odysseydatarecording.com/download/Odyssey%20Data%20Logging%20Software.pdf</a>	64 3 358 8979	<a href="http://odysseydatarecording.com/index.php?route=information/information&amp;information_id=5">http://odysseydatarecording.com/index.php?route=information/information&amp;information_id=5</a>	Dataflow Systems Limited Unit 3, 54 Wordsworth Street, Christchurch 8023, New Zealand.
DO	Hobo Onset	<a href="http://www.onsetcomp.com/files/manual_pdfs/15603-F%20MAN-U26x.pdf">http://www.onsetcomp.com/files/manual_pdfs/15603-F%20MAN-U26x.pdf</a>	HOBOWare pro 3.3.1	<a href="http://www.onsetcomp.com/files/manual_pdfs/12730-V%20HOBOWare%20User%27s%20Guide.pdf">http://www.onsetcomp.com/files/manual_pdfs/12730-V%20HOBOWare%20User%27s%20Guide.pdf</a>	508-759-9500	<a href="http://www.onsetcomp.com/files/374-K_Warranty_Support-war-WEB.pdf">http://www.onsetcomp.com/files/374-K_Warranty_Support-war-WEB.pdf</a>	Onset Computer Corporation, 470 MacArthur Boulevard, Bourne, MA 02532
DO	PME miniDoT	<a href="http://pme.com/wp-content/uploads/2014/07/Manual2.pdf">http://pme.com/wp-content/uploads/2014/07/Manual2.pdf</a>	Software is internal to instrument/runs on computer after plug-in	Same as sensor documents	(760) 727-0300	<a href="http://pme.com/warranty">http://pme.com/warranty</a>	1487 Poinsettia Ave. Suite 129 Vista, California, USA 92081
CHL	PME Cyclops 7	<a href="http://pme.com/wp-content/uploads/2014/07/Manual-2014SEP21-Interchangeable.pdf">http://pme.com/wp-content/uploads/2014/07/Manual-2014SEP21-Interchangeable.pdf</a>	Cyc7Calibration	Same as sensor documents	(877) 316.8049	<a href="http://pme.com/warranty">http://pme.com/warranty</a>	1995 N. 1st Street San Jose, CA 95112