SEA-BIRD SCIENTIFIC

User manual

SeaFET™ V2 and SeapHOx™ V2

pH and optional CTD and DO sensor

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Version:	A
Software:	UCI 2.03

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Table of Contents

Section 1 SeaFET V2 and SeapHOx V2 quick start guide

This quick start guide gives the steps necessary to make sure that the SeaFET V2 or SeapHOx V2 sensor operates correctly and collects data before it is deployed.

- SeaFET V2 measures pH only
- SeapHOx V2 is a SeaFET with a SBE-37-SMP-ODO attached. It measures the added parameters of conductivity, temperature, pressure, and dissolved oxygen. The two sensors are integrated by the manufacturer.

The SeaFET V2 acts as a controller for the SBE-37, which sends the data it collects to the SeaFET V2. Because the SBE-37 pump operates before each burst of data collection, the manufacturer recommends that the shortest data collection interval is every two minutes for the SeapHOx. The shortest data collection interval for a SeaFET is 6 seconds. Use the battery endurance calculator in the software to determine the length of a deployment.

NOTICE

Do not let the sensing elements get dry. If the sensor will not be deployed immediately, put the wet cap in place and fill with clean seawater.

What's in the box:

SeaFET V2

- Flow cells and fittings
- Anti-fouling guard
- CD—has software, calibration files, documentation
- RS232 cable to connect to a PC
- SeaFET V2 toolkit and O-rings
- Hardware kit for boss seal

SeapHOx V2

- Flow cells and fittings
- Anti-fouling guard
- CD—has software, calibration files, documentation
- Y-cable to connect the SeaFET V2 and the SBE-37-SMP-ODO
- RS232 cable to connect the Y-cable to a PC
- 2.4 m cable to communicate directly with the SBE-37-SMP-ODO only
- SeaFET V2 toolkit and O-rings
- Mounting brackets (2) to attach the SBE-37 to the SeaFET V2
- Plumbing kit and Triton® X-100 to clean MicroCAT flow path.
- Hardware kit for boss seal

The SeaFET V2 has 12 size D alkaline batteries installed. The 12 lithium batteries for the SBE-37 are shipped separately.

1. **SeapHOx V2**: Install the manufacturer-supplied lithium batteries in the SBE-37 (refer to Lithium batteries on page 16 for details.)
   a. Remove the end flange of the SBE-37.
   b. Disconnect the battery holder and remove it from the sensor.
   c. Install new batteries.
   d. Connect the battery pack to the sensor again and install the end flange again.
2. **SeapHOx V2**: Remove the yellow protective label from the SBE-37 intake and exhaust ports.
3. **SeapHOx V2**:
   a. Connect the SeaFET V2 and SBE-37 with the manufacturer-supplied Y-cable.
   b. Connect the Y-cable to the manufacturer-supplied data I/O cable.
4. **SeaFET V2**:
   - Connect the sensor to the manufacturer-supplied data I/O cable.

5. Install the manufacturer-supplied software on a PC (refer to Set up sensor and verify function on page 15 for details.)
6. Connect the data I/O cable to the PC and double-click on **UCI** to start the software.
7. Push **Connect** in the software to turn on the sensor.
8. Set up the sensor for deployment (refer to Configure sensor with deployment wizard on page 20 for details.)
9. Verify that the boss seal on the SeaFET V2 is screwed in all the way.
   The sensor will flood if the plug is not screwed in all the way.
10. Immediately before the SeapHOx V2 is deployed, connect the plumbing to the SBE-37.
    a. Use a 5/32" hex key to remove the three screws that attach the wet cap to the pressure housing.
       The clean seawater in the wet cap will drain.
    b. Remove the two threaded plastic plugs and install the manufacturer-supplied flow cells with the wet cap (refer to Remove or attach wet cap on page 29 for details.)
    c. Install the flow cell again. Make sure the fitting is securely connected to the exhaust port on the MicroCAT.
    d. Secure the two plastic plugs into the wet cap again.
11. Connect a dummy plug to the Y-cable for deployment.

NOTICE

Make sure that the screw-in boss seal is tightened or the sensor will flood and void the warranty.

12. Transmit and process data that is stored in the sensor to the PC (refer to Transmit and process data on page 25for details):
    a. Connect the sensor to the UCI software and PC and start the software.
    b. Push **Transmit Data** in the Dashboard of the software.
    c. Select "All Data" or "Sample Number Range" in the Data Transmit Options area.
    d. Select either "UTC" or "Local" time stamp in the CSV Format Options area.
    e. Enter a new file name or use the automatically generated file name.
    f. Push **Transmit**.
       The software copies the data to the PC in both a raw **.sbsdat** format and a converted **.csv** format.
13. Immediately after the SeaFET V2 or SeapHOx V2 is recovered from a deployment (refer to Recover sensor from deployment on page 23 for details):
    a. Use the software to turn off the sensor.
    b. Disconnect the fittings from the flow cell, fill the flow cell with clean seawater and secure the two red plugs to keep fresh water out of the flow cell.
    c. Rinse the sensor with fresh water.
    d. **SeapHOX**: Disconnect the Y-cable and remove the SBE-37 from the mounting bracket.
    e. **SeapHOx**: Clean the flow path of the SBE-37.
14. Dry and lubricate the bulkhead connectors. Refer to Clean bulkhead connectors on page 37 for details.
15. Attach the protective dummy plugs and lock collars.
16. Refer to Prepare sensor for storage on page 38 for details to prepare the sensor for short- or long-term storage.

Section 2 Specifications

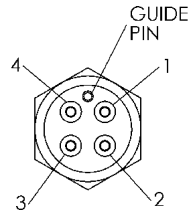
2.1 Mechanical

2.1.1 SeapHOx V2

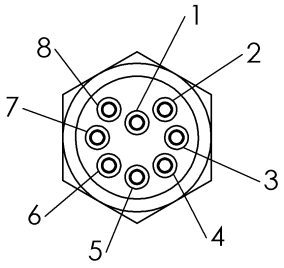
	SeaFET	**37-SMP-ODO**
Rated depth	50 m	20, 100 m
Weight	5.45 kg	3.4 kg (air)
Length	55.88 x 28.25 cm	55.5 cm
Diameter	11.4 cm	N/A
Temperature range, operation	0–50 °C	-5–45 °C
Temperature range, storage	2–55 °C	—

2.1.2 Bulkhead connectors

2.1.2.1 SBE-37-SMP-ODO connector

Contact	**Function**	**MCBH-4-MP**
1	Ground	
2	RS232 RX	
3	RS232 TX	
4	Voltage in	

2.1.2.2 SeaFET V2 connector

Contact	**Function**	**MCBH-8-MP**
1	Voltage in	
2	Ground	
3	No connect	
4	CTD/pump V out (12 V, 650 mA, optional)	
5	TXD/D+	
6	RXD/D-	
7	CTD TXD	
8	CTD RXD	

2.1.3 Illustrations

Figure 1 SeaFET V2 dimensions

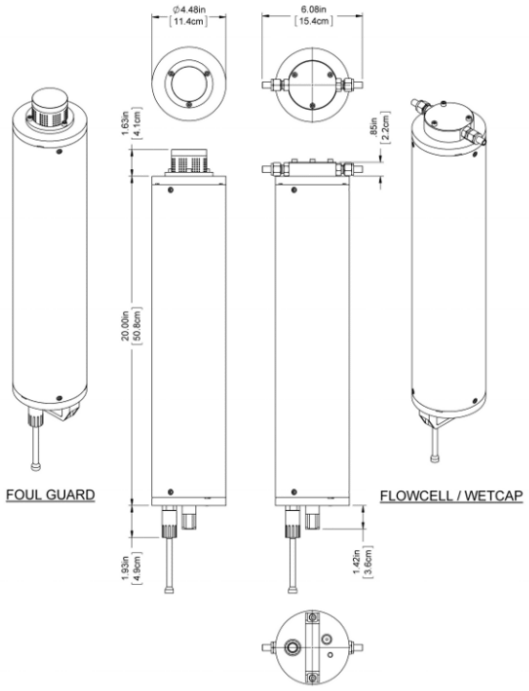


Figure 2 SeapHOx V2 dimensions

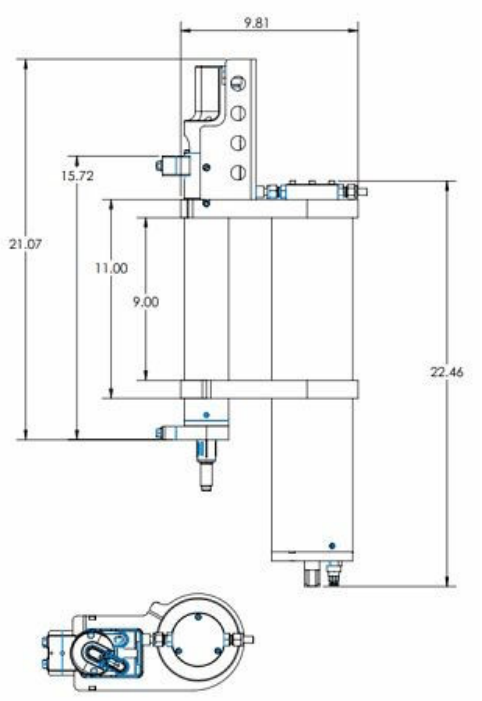
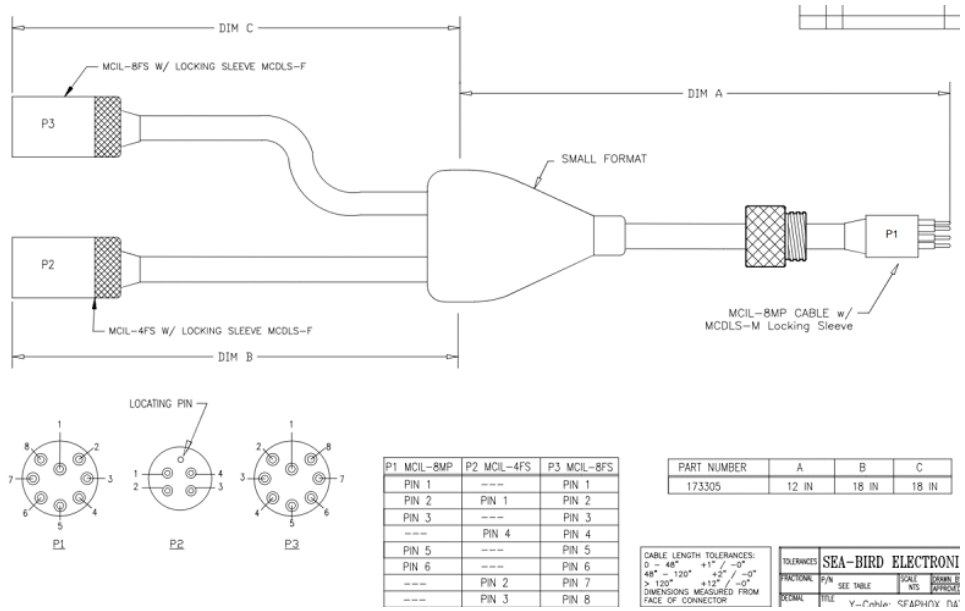


Figure 3 "Y" cable for SeapHOx V2



P1 MCIL-8MP	P2 MCIL-4FS	P3 MCIL-8FS
PIN 1	---	PIN 1
PIN 2	PIN 1	PIN 2
PIN 3	---	PIN 3
---	PIN 4	PIN 4
PIN 5	---	PIN 5
PIN 6	---	PIN 6
---	PIN 2	PIN 7
---	PIN 3	PIN 8

PART NUMBER	A	B	C
173305	12 IN	18 IN	18 IN

CABLE LENGTH TOLERANCES:
0 - 48" +1" / -0"
48" - 120" +2" / -0"
> 120" +12" / -0"
DIMENSIONS MEASURED FROM FACE OF CONNECTOR

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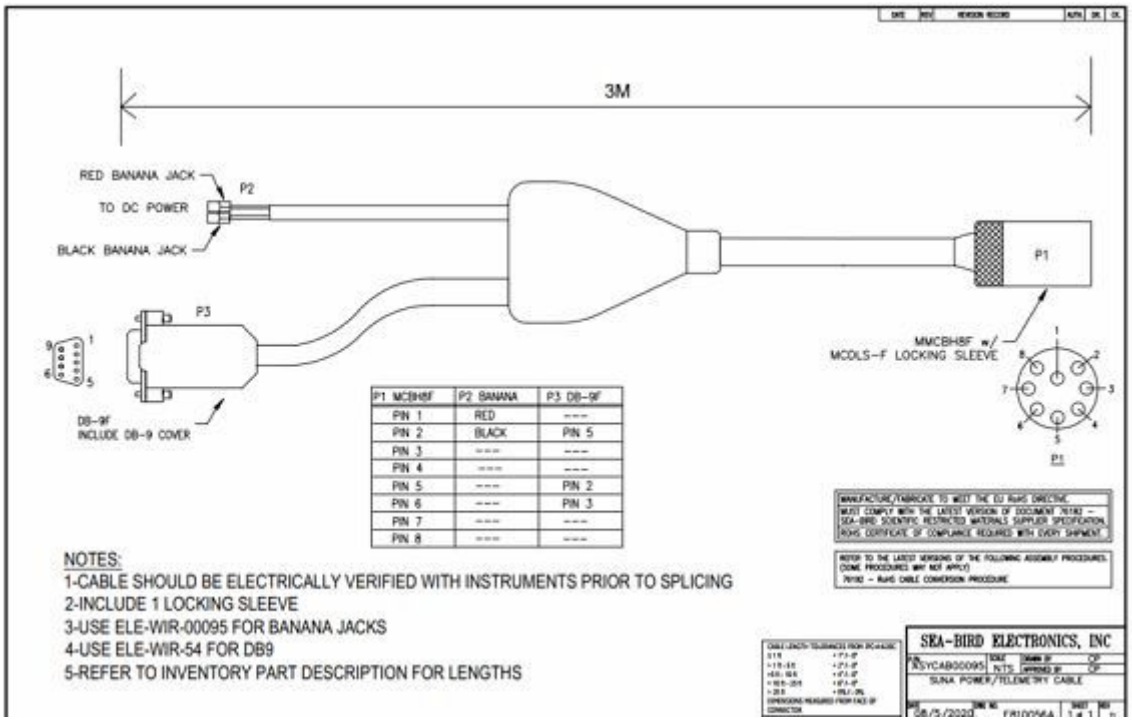
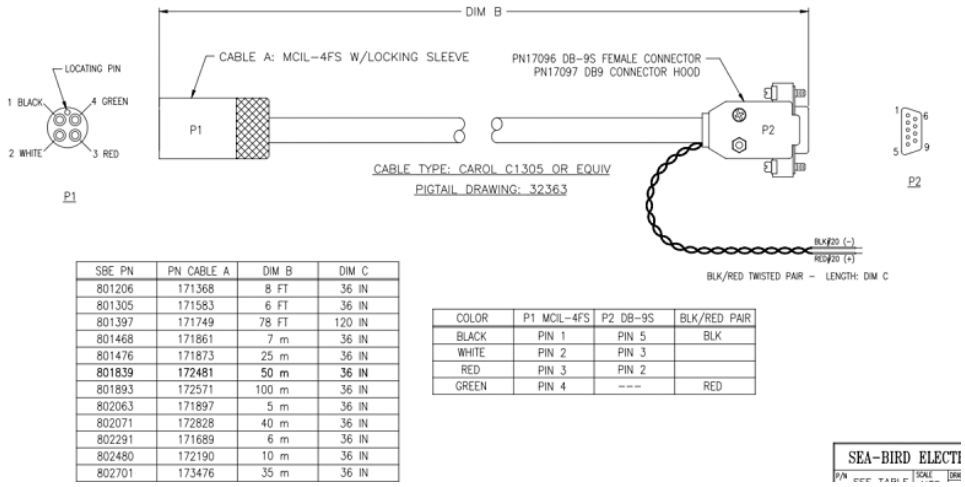
Figure 4 Data I/O cable



P1 MCBH8F	P2 BANANA	P3 DB-9F
PIN 1	RED	---
PIN 2	BLACK	PIN 5
PIN 3	---	---
PIN 4	---	---
PIN 5	---	PIN 2
PIN 6	---	PIN 3
PIN 7	---	---
PIN 8	---	---

Figure 5 SBE-37-SMP-ODO-only test cable



SBE PN	PN CABLE A	DIM B	DIM C
801206	171368	8 FT	36 IN
801305	171583	6 FT	36 IN
801397	171749	78 FT	120 IN
801468	171861	7 m	36 IN
801476	171873	25 m	36 IN
801839	**172481**	**50 m**	**36 IN**
801893	172571	100 m	36 IN
802063	171897	5 m	36 IN
802071	172828	40 m	36 IN
802291	171689	6 m	36 IN
802480	172190	10 m	36 IN
802701	173476	35 m	36 IN

COLOR	P1 MCIL-4FS	P2 DB-9S	BLK/RED PAIR
BLACK	PIN 1	PIN 5	BLK
WHITE	PIN 2	PIN 3	
RED	PIN 3	PIN 2	
GREEN	PIN 4	---	RED

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2.2 Electrical

2.2.1 SeaFET V2

Input	6–18 VDC
Internal batteries	12 D-cell 1.5 V alkaline
Main battery pack	12 V, 13420 mA-hours
Isolated battery	6 V
Real-time clock drift	2 ppm (0–40 °C)
Communication interface	RS232: 9600–115200 baud; Default: 19200 baud
Data storage	32 Mb (over 1240000 samples)
Current draw, operation	
CTD OFF, data transmit OFF	17.3 mA (2.5 sec sample time)
CTD OFF, data transmit ON	17.0 mA (2.7 sec sample time)
Current draw, idle	3.4–4.0 mA
Current draw, quiescent	Main battery: 70 µA; Isolated battery: 200 µA @ 12 V

2.2.2 SeapHOx

Input	6–18 VDC
Internal batteries	12 D-cell 1.5 V alkaline
Main battery pack	12 V, 13420 mA-hours
Isolated battery	6 V
Current draw, operation	
CTD OFF, data transmit OFF	18.9 mA (2.5 sec sample time)
CTD OFF, data transmit ON	21.1 mA (2.6 sec sample time)
CTD ON, data transmit OFF	21.7 mA (7.2 sec sample time)
CTD ON, data transmit ON	23.1 mA (7.2 sec sample time)

Current draw, pump	10 mA
Current draw, idle	3.4–4.0 mA
Current draw, quiescent	Main battery: 70 µA; Isolated battery: 200 µA @ 12 V
Real-time clock drift	2 ppm (0–40 °C)
Communication interface	RS232: 9600–115200 baud Default: 19200 baud
Data storage	32 Mb (over 1240000 samples)

2.2.3 SBE-37-SMP-ODO

Input	9–24 VDC
Internal batteries	12 AA-cell 3.6 or 3.9 V lithium
Current draw, operation	0.29 watts
Current draw, low power	30 µA
Current draw, communication	4.3 mA

2.3 Analytical

2.3.1 SeaFET V2

Measurement range	6.5–9.0 pH
Salinity range	20–40 psu
Accuracy	±0.05 pH
Precision	0.004 pH
Resolution	0.0001 pH
Stability	0.003 pH/mo

2.3.2 SeapHOx™ V2

	Conductivity	**Temperature**	**Depth**	**Oxygen**
Measurement range	0–70 mS/cm	-5–45 °C	20, 100 m	120% surface saturation
Accuracy	±0.003 mS/cm	±0.002 °C (-5–35 °C); ±0.01 °C (35–45 °C)	±0.1% full scale range	±0.1 mg/L or ±2%
Resolution	0.0001 mS/cm	0.0001 °C	0.002% full scale range	0.2 µmol/kg
Stability	0.003 mS/cm/mo	0.0002 °C/mo	0.05% full scale range/yr	sample-based drift <1 µmol/kg/100,000 samples @20 °C

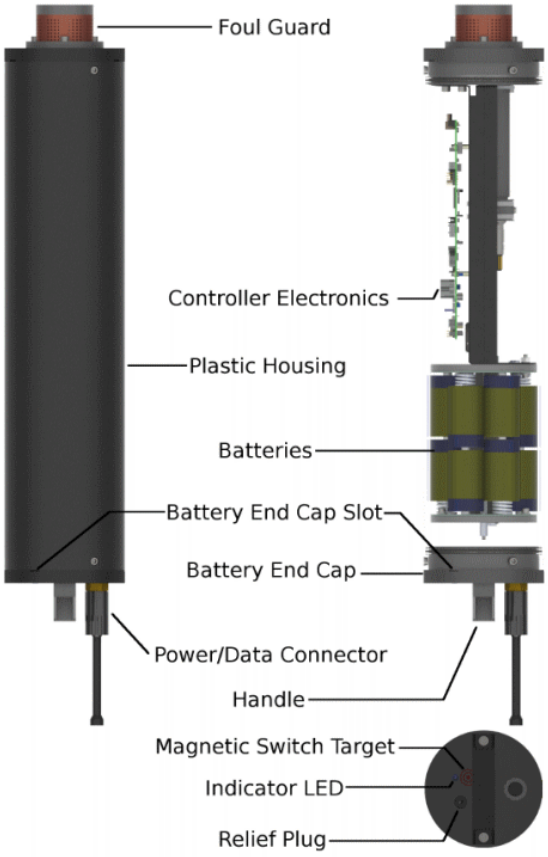
NOTICE

When sensor is not in use, make sure that the wet cap is in place and is filled with clean seawater. Do not put the sensing elements in fresh water: it may cause data to be unstable and damage to the sensor.

NOTICE

Do not let the potassium chloride (KCl) gel or the wet cap filling solution freeze. This will damage the DuraFET and void the warranty.

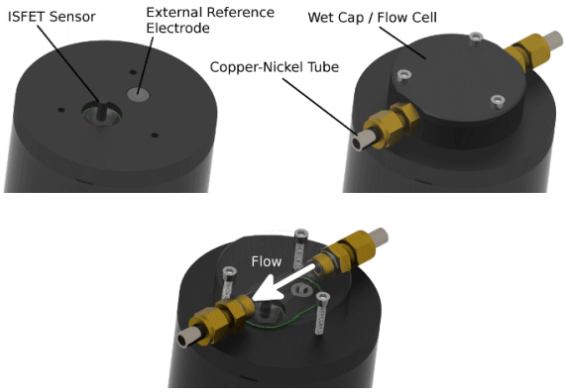
The sensor uses ion-sensitive field effect transistor (ISFET) technology to measure pH in marine environments at depths to 50 meters. The sensor has internal memory and an internal battery pack so that it can operate autonomously for a long-term deployment.



When an SBE-37-SMP-ODO is attached to the SeaFET, the system operates in SeapHOx mode, which also measures salinity, temperature, depth, and oxygen, and has an internal pump. The SeapHOx uses a manufacturer-attached "Y" cable to connect the SeaFET and SBE-37-SMP-ODO.

The manufacturer-supplied software lets the user set up the sensor, monitor graphical data in real time, upload stored data, and process that data.

The end flange with the ISFET sensor and the external reference electrode must be covered with a seawater-filled cap during storage. This cap is also used with flow cells when the SeaFET is connected to the SBE-37-SMP-ODO.



3.1 Ion-sensitive field effect transistor (ISFET)

The primary sensor element of the SeaFET™ is the ISFET, a solid-state sensor that senses pH in marine environments. The ISFET has two reference electrodes: an internal reference and an external reference, that give separate reference potentials to the ISFET and show separate pH values (pH Internal and pH External). After the corrections for temperature and salinity are applied, the values from the internal and external are similar, and let the user verify the validity of the sensor's measurements.

Internal reference

The internal reference electrode inside the DuraFET® is immersed in a bath of saturated potassium chloride (KCl) gel and is physically separated frm the environment. The KCl gel exposes the Ag/AgCl internal electrode to a relatively constant chloride concentration. The sensor can therefore measure pH regardless of environmental salinity. If accurate salinity and temperature data are not available, the internal cell is generally more accurate.

External reference

The external reference electrode has a Ag/AgCl reference electrode in direct contact with seawater. The potential of this electrode varies with pH and chloride concentration, so unless the chloride concentration is known, the external reference is not stable. To correct this, salinity can act as an approximation of chloride concentration. If accurate salinity data is available, it can be applied to the pH external data and significantly reduce measurement errors, and give the most accurate and stable pH data.

3.2 LED status indicator and batteries

The LED near the magnetic power switch shows the status of the sensor, so you can determine if the sensor is in operation or ready to be deployed. To see the status of the sensor, swipe the manufacturer-supplied magnet across the red circle at the top of the magnetic switch. If the LED does not flash, verify that new batteries are installed and the memory is configured. None of the settings on the SeaFET are affected when you use the magnet to look at the status.

Table 1 LED status flashes

No flash	Sensor batteries or memory not ready for deployment	• RTC battery is below 2.5V • Isolated battery is below 4.0V • Main battery or external power supply is below 7.0V • Memory is full
Red flash	Sensor has not received a command to collect data	• The sensor is in standby for a command to begin data collection • Push **Start** to start data collection. ("startnow" or "startlater" in a terminal program.)
Green flash	Sensor is in operation	Logger-controlled (polled) data collection occurs. The sensor has received a "Start," "startnow," or "startlater" command.

The internal batteries must be installed in the SeaFET at all times for the preservation of the sensing element. If the internal batteries are removed, the sensor must be "re-conditioned" before or at a deployment, which can take up to 24 hours.

SeaFET V2 batteries

There are 12 manufacturer-installed D-cell batteries to supply power to the sensor.

The internal batteries are electrically divided into a 12 V main battery pack and a 6 V isolated battery pack. The main battery pack supplies power to the sensor and the isolated battery pack supplies power to the sensing element when the sensor is in a low power "standby" mode.

SeapHOx: SBE-37-SMP-ODO integrated with SeaFET V2

SBE-37-SMP-ODO batteries

The SBE-37-SMP-ODO attached to the SeaFET uses lithium batteries that ship separately and must be installed before use if the SeaFET is not set up to supply power to the SBE-37-SMP-ODO.

Power options during deployment

Power can be supplied to the SeapHOx from either the SeaFET internal batteries or an external power source. The sensor will use an external source when the voltage is at or above 9 volts. The user can configure the SeaFET to supply power to the SBE-37-SMP-ODO. For maximum lifetime of the SeaFET batteries, install new lithium batteries in the SBE-37-SMP-ODO and configure the SeapHOx without a power supply to the SBE-37-SMP-ODO.

NOTICE

Make sure that the SeapHOx is submerged in water before operation to prevent damage to the pump. The pump always operates when the SeapHOx takes a measurement. Before a deployment, set the start time to occur after the sensor is submerged. The SeapHOx does not use a minimum conductivity value for the pump to operate.

Do the steps below to make sure the sensor operates correctly before further setup and deployment. Use the manufacturer-supplied UCI software to set up and configure the sensor and to transmit data.

1. Connect the sensor and the PC.
   - SeaFET standalone: connect the data I/O cable to the PC.
   - SeapHOx: Make sure that the Y-cable is installed and connects the SeaFET and the SBE-37-SMP-ODO. Connect the I/O cable to the Y-cable and the PC.
2. Get the software from the manufacturer's website or the manufacturer-supplied USB drive or CD.
3. Install the appropriate software.
   a. For Windows®: Double-click on the file with ".exe" appended to the name.
   b. For Mac OS X®: Double-click on the file with ".pkg" appended to the name. Make sure that the default "Install for all users on this computer" is selected as the destination for the installed software. If "Install for me only" or "Install on a specific disk" is selected, the software will not connect to the sensor.
4. Push **Run** in the new window.
   The setup wizard starts.
5. Follow the on-screen instructions to install the software.
6. Push **Connect** in the Dashboard area.
7. If necessary, change the "Instrument Type" to the connected sensor.
8. Put a check in the "Try All Baud Rates" box.
   The software automatically finds the correct baud rate.
9. Select the **UCI** menu, then *Preferences*.
10. Go to the *General* tab and push **Browse** to find or make the *Default Data Directory* on the PC.
    Data from the sensor is saved here.
11. Optional: save data directly to the PC.
    a. Go to the **View** menu and select *Data Collection*.
    b. Push "**Collection Options**" to see details in this tab.
    c. Push **Browse** to change the directory to which data is saved on the PC.
    d. Push **Start**.
12. Push **OK**.
13. Push **Apply** to store the settings in the sensor.
14. Push **Start** in the Dashboard area.
    The sensor operates and collects data.
15. Look at the data in the *Time Series* graph. The user can look at data in real-time for each sensor that has power supplied, is connected and is in communication with the software.
    - Put a check in the box next to "Time Axis" to push **Zoom In** and **Zoom Out** to change the scale of time.
    - Put a check in the box next to "Range Axis" to push **Zoom In** and **Zoom Out** to change the scale of the data.

- To move the data in any direction, push the "Ctrl" key on the PC keyboard and the left button of the mouse pointer at the same time.
- To select a specific part of the data to zoom in on, pull the mouse pointer diagonally.
- Push **Auto Range** to see the data for each selected parameter. The software adjusts the scale so that the data will always show.
- Push **Default Ranges** to go back to the manufacturer-set default scale for each parameter.
- Put a check in the box next to "Show Data Points" to see the value of the collected data when the mouse moves over each point.
- Push **Select Sensors To Display** to change the parameters to look at in the *Time Series* graph.

16. Push **Stop**. The "Connection Mode" shows "Setup."

4.1 Batteries

4.1.1 Alkaline batteries

Twelve D-cell alkaline batteries are installed in the SeaFET by the manufacturer. The user should verify that the batteries are installed correctly and supply the specified voltage. Refer to Remove and replace alkaline batteries on page 32 for details about how to change the batteries when necessary.

4.1.2 Lithium batteries

NOTICE

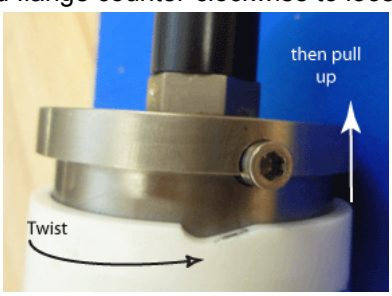
Use only the batteries recommended by the manufacturer as replacements. Do not mix chemistries, V-Ah, or new and used batteries.

The manufacturer ships the twelve lithium batteries for the SBE-37-SMP-ODO separately. Do the steps below to install or replace the batteries. See also the "how to" video on the manufacturer's website to do this procedure.

Table 2 Recommended lithium battery brands

SAFT LS-14500 (included)	3.6 V, 2.6 Ah
Tadiran TL-4903	3.6 V, 2.4 Ah
Electrochem BCX85 series	3.9 V, 2.0 Ah

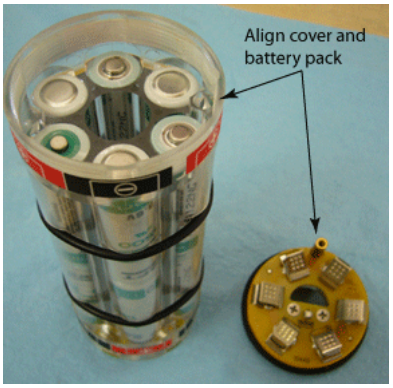
1. Make sure that the end flange and pressure housing are dry.
2. Use a 9/64" hex key to remove the two screws on the sides of the pressure housing.
3. Install these two screws into the sides of the end flange to start to loosen the end flange.
4. Turn the end flange counter-clockwise to loosen it from the pressure housing.



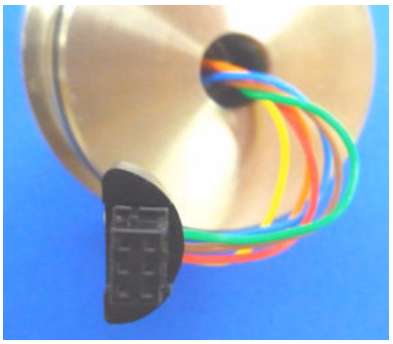
5. Pull gently to disconnect the battery wires in the end flange from the battery pack.
6. Use a lint-free tissue to remove any water from the O-ring surfaces inside the pressure housing and end flange.

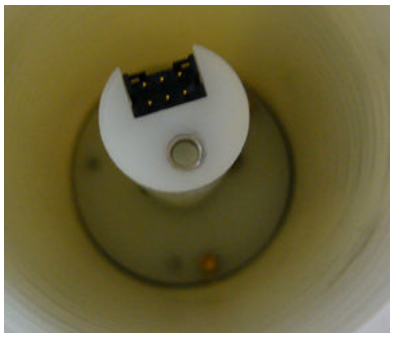
7. Use a 7/64" hex key to loosen the captured screw in the battery cover plate.
8. Remove the battery pack from the pressure housing.
9. Turn the yellow cover plate counterclockwise to remove it from the battery pack body.
10. Move each of the two O-rings on the outside of the battery holder from the grooves. It makes it easier to remove or insert batteries.

11. Examine the O-rings and surfaces for dirt, cuts, or other damage. Clean or replace as necessary.
12. If necessary, remove the batteries in the pack.
13. Insert new batteries.
    Make sure to alternate the positive (+) and the negative (-) ends on the batteries to agree with the labels on the pack as they are installed.
14. Move the O-rings back into the grooves.
15. Align the pin on the yellow battery cover with the post hole in the battery pack assembly.



16. Align the "D"-shaped part of the battery pack with the pins on the shaft.
17. Slowly move the assembly onto the housing. Push gently to connect the battery assembly with the circuit board in the pressure housing.
18. Use a 7/64" hex key to tighten the captured screw on the yellow battery cover onto the shaft in the pressure housing.
19. **Important**! Remember to attach the Molex connector on the end flange to the connector on the top of the guide pylon in the pressure housing.





20. Examine the O-rings on the end flange. They must be pristine, with no lint or scratches or chips.
    - Apply a small quantity of Parker Super O Lube® to any new O-rings.
21. Align the end flange holes with the holes in the pressure housing.
22. Carefully push the end flange into the pressure housing.
    It may help to rotate the end flange so that the wires do not bend too much.
23. If necessary, use a 9/64" hex key to remove the two screws from the end flange.
24. Use a 9/64" hex key to install the two screws into the pressure housing of the sensor again.

NOTICE

Make sure that the screw-in boss seal is tightened or the sensor will flood and void the warranty.

SeapHOx:

The SBE-37-SMP-ODO has an internal pump that operates for one second each time the sensor collects a sample. The internal pump has several advantages over sensors without pumps:

- The pump flushes the water from the flow path after each sample and quickly moves a new sample into the flow path so that conductivity and oxygen measurements are more accurate.
- Water does not flow freely through the flow path so it stays saturated with the anti-fouling chemicals.
- The optical DO sensor is integrated in the flow path for better correlation with the CTD measurement.

The user can operate the sensor in one of several modes:

Autonomous operation

- Operates at user-selected intervals (120–21600 seconds).
- Transmits data in engineering units.
- Operation sequence:

  1. The pump operates
  2. The sensor makes one measurement
  3. The pump stops
  4. The data is stored internally in the SeaFET
  5. The sensor goes into a low power mode until the next sample is collected.

Polled operation

- Polled data collection is useful when the sensor is integrated with satellite, radio, or wire telemetry equipment.
- Operation sequence:

  1. The pump operates on command
  2. The sensor makes one measurement
  3. The pump stops

4. The sensor sends the data to the controller
5. The sensor goes into a low power mode until the next command to operate.

SeaFET V2

The standalone SeaFET operates continuously user-selected intervals from 6 to 21600 seconds. Data is transmitted in engineering units.

5.1 Deployment orientation

When deployed as a stand-alone sensor, the orientation of the SeaFET should be based on the deployment site conditions. Light exposure to the ISFET could cause errors in the data, so in high-sun areas, it is best to deploy the sensor with the wet cap pointed down. Errors in data can also occur from bubbles that collect on the sensing elements. In areas where there are many bubbles, deploy the SeaFET with the wet cap pointed up or horizontally.

The SeapHOX should always be deployed with the wet cap pointed up.

5.2 Configure sensor with deployment wizard

The deployment wizard in the UCI software makes it easy to set up and configure the sensor for a specific deployment.
With the sensor connected to a power supply (or internal batteries if so equipped) and a PC that has the UCI software installed, start the software, turn on the power supply, start communication with the sensor and push **Deployment Wizard** in the Dashboard.

Autonomous operation mode

1. Push **Synchronize SeaFET clock to computer**. The sensor and the PC show the same time. Put a check in the box to erase all of the data stored in the sensor and set the event counter to 0 when the deployment starts.
2. Set the date and time for the sensor to start data collection.
3. Transmission: put a check in the box to send collected data in real time to a connected controller. Data is still stored in the sensor if this box does not have a check in it.
4. **Pump Settings**: put a check in the box to enable operation of an external pump. Values can be between 0–255. If set to 0, the pump will operate continuously.
5. Calculate **Battery Endurance**. This calculation uses an estimate of the voltage of new batteries. It does not measure voltage directly.
   a. Enter the temperature of the water in which the sensor will be deployed.
   b. Enter the sample interval (40–21600).
6. Make a deployment report to see sensor statistics, calibration values, and settings.

Polled (controlled) operation mode

1. Push **Synchronize SeaFET clock to computer**. The sensor and the PC show the same time. Put a check in the box to erase all of the data stored in the sensor and set the event counter to 0 when the deployment starts.
2. Current Output Format shows the order of the data values from the sensor.
3. Calculate **Battery Endurance**. This calculation uses an estimate of the voltage of new batteries. It does not measure voltage directly.
   a. Enter the temperature of the water in which the sensor will be deployed.
   b. Enter the polled interval (1–86400).
4. Make a deployment report to see sensor statistics, calibration values, and settings.

5.3 Remove wet cap

Just before deployment, remove the wet cap and install the anti-fouling guard or the wet cap and flow cells.

1. If necessary, unplug the cable from the sensor.
2. Remove the two plastic plugs from the wet cap. Keep them for future use.
3. Put the sensor over a sink or bucket and empty the solution of seawater from the wet cap.
4. Put the sensor upright again.
5. Use a 5/32" hex key to remove the three 10-32 x 5/8" socket head cap screws from the wet cap. Keep the screws to use with the anti-fouling guard.
6. Remove the wet cap. Keep the O-ring for future use.
7. Use a clean dry cloth to clean the sensor and the wet cap of any seawater.
8. Make sure to keep the wet cap, O-rings and plastic plugs for future use.

5.3.1 Attach anti-fouling guard and deployment cable

NOTICE

Make sure that the screw-in boss seal is tightened or the sensor will flood and void the warranty.

1. Put the sensor on a flat surface with the external reference electrode end flange face up.
2. Install the anti-fouling guard over the ISFET and external reference electrode.
   - Use a 5/32" hex key to tighten the three 10-32 x 5/8" socket head cap screws that secured the wet cap. Make sure to tighten completely.
3. If necessary, connect the deployment cable. If the sensor is to be deployed autonomously, attach the dummy plug and lock collar onto the connector.
4. Make sure the pressure plug is fully seated.

5.4 Real-time data collection

Real-time data collection is only possible when the sensor is configured to output data with every sample collected. Go to **Sensor**, *SeaFET*, *SeaFET Settings* to change this setting to transmit data in real-time under the *Data* tab.

5.4.1 Start data collection

1. Make sure that the sensor has power supplied and is connected to the software.
2. Make sure that there is a check in the box at "Transmit Data in Real Time."
3. Make sure that the "Output Format" is as selected.
4. Push **Start**.

5.4.2 Look at collected data

The user can monitor data in the *Real Time Data* or the *Time Series* graph. Information about the data, such as error statistics, shows in the *Acquisition Monitor*, and the collected data is saved to a file on the sensor.

1. The *Real Time* display is continuously updated to show the most recent data collected by the sensor.
2. Look at the data in the *Time Series* graph. The user can look at data in real-time for each sensor that has power supplied, is connected and is in communication with the software.
   - Put a check in the box next to "Time Axis" to push **Zoom In** and **Zoom Out** to change the scale of time.
   - Put a check in the box next to "Range Axis" to push **Zoom In** and **Zoom Out** to change the scale of the data.
   - To move the data in any direction, push the "Ctrl" key on the PC keyboard and the left button of the mouse pointer at the same time.
   - To select a specific part of the data to zoom in on, pull the mouse pointer diagonally.
   - Push **Auto Range** to see the data for each selected parameter. The software adjusts the scale so that the data will always show.
   - Push **Default Ranges** to go back to the manufacturer-set default scale for each parameter.
   - Put a check in the box next to "Show Data Points" to see the value of the collected data when the mouse moves over each point.
   - Push **Select Sensors To Display** to change the parameters to look at in the *Time Series* graph.
3. Select the **View** menu, then *Acquisition Monitor* (or push **Error Details** on the *Real Time Data* window. Use this window to see when and why there are errors in the data.

5.4.3 Save real-time data

The sensor has sufficient internal memory to save months of data.

1. Make sure that the sensor is connected to the software.
2. Push **Start**.
3. From the main menu, select **View**, then *Data Collection*.
4. Push **Start**.
   The PC starts to save the data collected by the sensor.
   - To enable "Auto Save Duration," put a check in the box and specify a time to stop the data from being saved.
   - To enable "Repeat Auto Save after Interval," put a check in the box and specify a time interval after which the data will be saved.
5. To stop data from being saved to the PC, push **Stop**.

5.4.4 Configure data file headers

The user can add custom headers to data files in addition to the default OPERATOR, EXPERIMENT, and COMMENT static headers.

1. Select the **Sensor** menu, then *Advanced*, then *Data File Header*.
2. Push **Add.**
3. Double-click the HEADER_ID row to enter a custom header.
4. Push **OK**.
5. To remove a custom header, select the row to remove and push **Remove**.
6. Put a check in the "Prompt" box so that the software will ask for input of the header record values whenever data collection is started.

5.5 Recover sensor from deployment

NOTICE

Do not let the sensing elements get dry. If the sensor will not be deployed immediately, put the wet cap in place and fill with clean seawater.

NOTICE

Do not leave the sensor in direct sun. Heat over 35 °C can cause damage to the sensor.

NOTICE

Do not let the potassium chloride (KCl) gel or the wet cap filling solution freeze. This will damage the DuraFET and void the warranty.

When the sensor is removed from the water after a deployment:

1. Use the software to turn off the sensor.
2. Immediately remove the anti-fouling guard and attach the wet cap filled with clean seawater, or, if deployed with the flow cells, make sure there is seawater in the wet cap and plug the cells to keep fresh water away from the sensing elements.
3. Disconnect the deployment Y-cable.
4. Flush the bulkhead connector, end flanges, and pressure housing with fresh water.
5. Completely dry the bulkhead connectors, then attach the dummy plugs.
6. Attach the dummy plug and lock collar to the bulkhead connector.

Section 6 Transmit and process data

Data that is collected and stored by sensors must be transmitted to a PC to be processed into a human-readable format. The data in an .sbsdat file is binary. When you use the software to transmit the data, it is converted to a human-readable comma-separated value (.csv) file.

1. Push **Transmit Data** in the Dashboard area.
   The **Transmit Data** window shows.
   - Information in the Memory Summary lets the user see the available data storage in the sensor.
     - "Bytes" is the amount of memory in use.
     - "Samples" is the number of samples the sensor has collected and stored.
     - "Free Samples" is the number of samples the sensor can store.
     - "Sample Length" is sensor-specific and shows the length of each data record that the sensor stores.
2. In the "Transmit Type" drop-down menu in the Data Transmit Options area, select either "All Data" or "Block size (bytes)."
   - "All Data": all data stored in the sensor is transmitted to the PC in both .csv and .sbsdat file types.
   - "Sample Number Range": a user-specified range of samples. Select the specific samples in the Sample Number Range area.
3. In the Data Transmit area, the software automatically selects the fastest baud rate to use to transmit data, which is 115200.
   The software temporarily increases the sensor's baud rate to upload data more quickly. After the transmission is complete, the software changes the baud rate to the default for the connected sensor.
4. In the CSV Format Options area, specify either the "UTC" or "Local" time stamp.
5. In the Output CSV Data File area, type a new file name or use the automatically generated file name.
6. Push **Transmit**.
   - The data is copied to the PC.
   - The software uploads a raw **.sbsdat** file and automatically converts the data to a readable **.csv** file type.
   - The **Transmit Progress** window shows the status of the file transmission and conversion.
   - The default is a check in the boxes for "Display Data when Conversion Completed" and "Close this Dialog when Conversion Completed."

6.1 SeaFET V2 output formats

Default output format

OutputFormat=1 is data in decimal format, converted to engineering units. Order in which the parameters show in the output:

```
FrameSync,DateTime (UTC+00:00), Sample Number(#),Error
Flags(#),External pH (pH), Internal pH(pH),External pH(Volt),
Internal pH(Volt), pH Temperature(Celsius), Relative Humidity(%),
Int Temperature(Celsius)
```

Example output:

```
SEAFET02001,08/12/2020 10:36:34, 5,0000, 7.8625, 7.8485,
-0.858358, -0.900168, 8.8229, -0.6, 11.4
```

Note: values for salinity, sound velocity, specific conductivity, and sample number are not sent, even if the settings shows these as "on."

Output format used by manufacturer

OutputFormat=0 is raw data in decimal format. Order in which the parameters show in the output:

```
FrameSync,timestamp, data error flag, temperature, Vrs_ext,
Vrs_int, pH temperature, Vk, Ib, Ik, internal relative humidity
```

Example output:

```
SEAFET02001, 2020-08-12T10:37:34, 0000, 5508600, 5368310, 1934305,
5846369, 8380847, 8385742, 21600, 2784
```

6.2 SeapHOx V2 output formats

OutputFormat=1 is data in decimal format, converted to engineering units.

```
FrameSync, DateTime(UTC+00:00), Sample Number(#), Error Flags(#),
Temperature(Celsius), External pH(pH), Internal pH(pH), External
pH(Volt), Internal pH(Volt), pH Temperature(Celsius),
Pressure(Decibar), Salinity(psu), Conductivity(S/m), Oxygen(ml/L),
Relative Humidity(%), Int Temperature(Celsius)
```

Example output:

```
SSPHOX02001,08/12/2020 12:26:54, 4, 0000, 5.3506, 7.9147, 7.8729,
-0.857475, -0.900347, 8.6681, 0.061, 33.7431, 3.26786, 6.889,
-0.5, 14.5
```

Note: values for salinity, sound velocity, specific conductivity, and sample number are not sent, even if the settings shows these as "on."

OutputFormat=0 is raw data in decimal format, for use by the manufacturer.

```
FrameSync, timestamp, data error flag, temperature, Vrs_ext,
Vrs_int, pH temperature, Vk, Ib, Ik, pressure, pressure
temperature, conductivity, oxygen phase, oxygen temperature,
internal relative humidity, internal temperature
```

Example output:

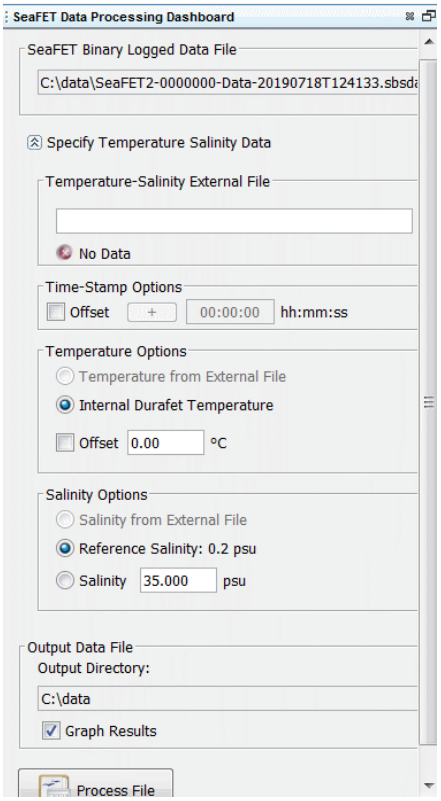
```
SSPHOX02001,2020-08-12T12:26:54, 0000, 473323, 5511401, 5367544,
1939590, 5881506, 8380553, 8386979, 525104, 1211, 5764.621,
19.227, 1.011338, 22864, 2864
```

6.3 Process data with temperature and salinity corrections

FrameSync	DateTime (UTC-07:00)	Sample Number	Error Flags (#)	External pH, pH	Internal pH, pH	External pH, V	Internal pH, V	pH Temp, C	Relative Humidity, %	Internal Temp, C
SEAFET00460	12/12/2019 12:14	1	0	5.0443	3.4901	-1.01045	-1.14948	22.0552	7.2	22.6
SEAFET00460	12/12/2019 12:15	2	0	5.0443	3.4898	-1.01045	-1.1495	22.0598	7.3	22.6
SEAFET00460	12/12/2019 12:16	3	0	5.0438	3.4899	-1.01048	-1.1495	22.063	7.3	22.7
SEAFET00460	12/12/2019 12:17	4	0	5.0442	3.4902	-1.01046	-1.14949	22.0674	7.2	22.6

After the data is transmitted to the PC and converted to a .csv file type, it can be further processed with temperature and salinity corrections.

1. Select the **Data** menu, then *SeaFET*, and *SeaFET Data Processing*. The *Dashboard* shows.



2. In the "SeaFET Binary Logged Data File" area, select a data file that was transmitted to the PC.
   It has a .sbsdat file type.
3. Select "Specify Temperature Salinity Data" to see the options for temperature and salinity.
4. If an external temperature-salinity file is available:
   a. Enter the file name in the "Temperature-Salinity External File" area.
   b. Select "Temperature from External File" in the "Temperature Options" area.
   c. Select "Salinity from External File" in the "Salinity Options" area.
5. If there is no external temperature-salinity file available, use the internal temperature value stored in the sensor, and a static salinity value.
6. Put a check in the "Offset" box and enter the time in the "Time-Stamp Options" area for the software to calculate the offset.
7. Select the "Output Directory" for the processed data.
8. Push **Process File**.

6.4 Export data to .csv or MS Excel format

Data from the sensor can be saved to either a comma-separated (.csv) file or a Microsoft® Excel file with a local or UTC time stamp. Use the software to transmit data from the sensor and then export that data to a human-readable format.

1. From the **Data** menu, select *Export Stored Data*.
2. Push **Browse** to find the file to export.
3. Select the file from the list.
4. Push **Open**.
5. Push **Next**. The current output format shows (all sensors but SUNA).

6. Push **Next**. Select the options for the file to export:
   a. Select either "Excel Workbook" or "Comma Separated Values" in Export File Format.
   b. Select the filters to apply to the data in Export Samples QAQC Filter (ECO V2 only.)
   c. Select either the "UTC" or "Local" time stamp in Format Options.
7. Push **Browse** to select the directory in which the exported data will be saved.
8. Push **Finish**.

6.5 Show data from the sensor

1. Go to the **Data** menu and select the applicable sensor.
2. Push **Show Data from Sensor**.
3. Select the data file to look at.
4. Push **Open**. The data shows in the *Time Series* graph.

6.6 Erase data stored in sensor

Sensors will append data as it is collected. If the memory is full, new data is saved over the oldest data and will continue to do that until the memory is erased. This operation erases all data stored in the sensor. It is not possible to select which data to erase.

1. Select the **Sensor** menu item.
2. Select the connected sensor.
3. Select *Advanced*.
4. Select *Erase Data*.
5. Push **OK**.
6. Push **OK** when the status in *Clear Data Progress* is 100%.

NOTICE

When sensor is not in use, make sure that the wet cap is in place and is filled with clean seawater. Do not put the sensing elements in fresh water: it may cause data to be unstable and damage to the sensor.

NOTICE

Do not leave the sensor in direct sun. Heat over 35 °C can cause damage to the sensor.

NOTICE

Do not touch the sensing elements. They are sensitive to electrostatic discharge (ESD).

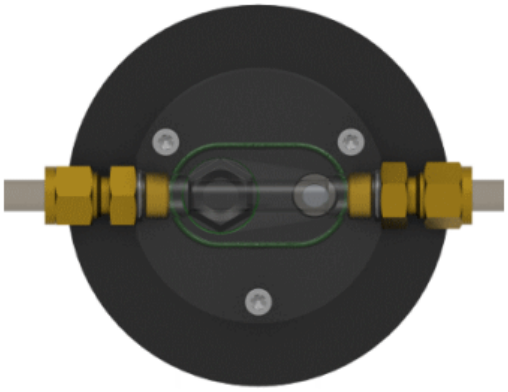
NOTICE

Use only the batteries recommended by the manufacturer as replacements. Do not mix chemistries, V-Ah, or new and used batteries.

7.1 Remove or attach wet cap

Make sure that the wet cap is filled with clean seawater during storage. The sensing element and reference electrodes **must** be kept wet with either the anti-fouling guard or the wet cap, even if the sensor is out of service for a few minutes.

1. Put the sensor on a flat surface.
2. To remove the wet cap:
   a. Use a flat blade screwdriver to loosen one of the large red plastic plugs on the wet cap.
   b. Turn the sensor so that the seawater in the cap drains out.
   c. Use a 5/32" hex key to remove the three 10-32 x 5/8" socket head cap screws that secure the wet cap to the end flange. Keep the screws.
3. To remove the anti-fouling guard:
   a. Use a 5/32" hex key to remove the three 10-32 x 5/8" socket head cap screws. Keep the screws.
   b. Remove the anti-fouling guard from the sensor.
4. To attach the wet cap:
   a. Put the wet cap O-ring into the groove at the bottom of the cap. Make sure that the O-ring is not twisted or pinched. Do not use O-ring grease near the sensing element and reference electrode.
   b. Put the wet cap over the element and electrode. Make sure that the O-ring touches the face of the end flange.
   c. Use the three 10-32 x 5/8" socket head cap screws to secure the wet cap to the end flange.
   d. If necessary, remove the one of the plugs and fill the wet cap with clean seawater.
   e. Replace the plug. If the cap is too full, the extra seawater will be pushed out when the plug is tight. Do NOT overtighten.
5. If the wet cap will be used as a flow cell, make sure it is installed in the orientation below so that sufficient water flows through the sensing elements.



7.2 Clean electrode surfaces

Clean the electrode surfaces after a deployment and before the sensor is put in storage. Clean both the external and internal reference electrodes.

1. Remove the wet cap or anti-fouling guard that is attached to the sensor.
2. Flush the internal and external references with warm tap water, clean seawater, or high-purity isopropyl alcohol (90% or higher) to remove particulates.
3. Use a lint-free swab and tissue to carefully scrub away any fouling.
4. Clean around the base of the internal reference.
5. Use a lint-free tissue to carefully dry the area.
6. To remove other types of fouling:
   - Oily deposits: use a household cleaner such as Joy® or Windex® or a laboratory soap such as Sparkleen® or Detergent 8®.
   - Mineral deposits: use diluted hydrochloric acid.
7. Rinse thoroughly with clean seawater or tap water.
8. Use lint-free wipes or cotton swabs to gently dry the sensing elements.
   The internal reference electrode should be shiny when it is clean.
9. Replace and fill the wet cap. Refer to Remove or attach wet cap on page 29 for details.

7.3 Clean flow paths

⚠CAUTION

Wear latex gloves, a lab coat, and safety glasses. Wash hands after use.

NOTICE

Do not use Triton® X-100 for long periods of time. Long exposure to Triton® X-100 causes damage to the sensor membrane and changes the calibration of the sensor.

NOTICE

Never put undiluted Triton® X-100 or bleach into the sensor.

Clean the flow path at regular intervals so that the sensor continues to collect accurate data.

Supplies:

- 500 ml bottle of DI water
- container for waste water
- container for sensor.
- De-ionized or distilled water. If unavailable, use fresh tap water, used with Triton® X-100 or bleach. Do not use shipboard fresh water because it can have traces of oil in it.
- Triton® X-100 mixed 1000:1—The manufacturer supplies Triton® X-100 with each sensor. Triton® X-100 is octyl phenol ethoxylate, a mild, non-ionic detergent. Make sure that any alternative detergent that is used is scientific grade, with no colors, perfumes, glycerins, lotions, etc.
- Bleach mixed 50:1—Household bleach is usually 4–7% (40,000–70,000 ppm) sodium hypochlorite with stabilizers.
- Manufacturer-supplied tubing and syringe to clean the plumbing.

Use warm 30 °C (86 °F) water and 1% Triton® X-100 to flush the flow path.

It may be necessary to do these steps up to five times to clean the flow path.

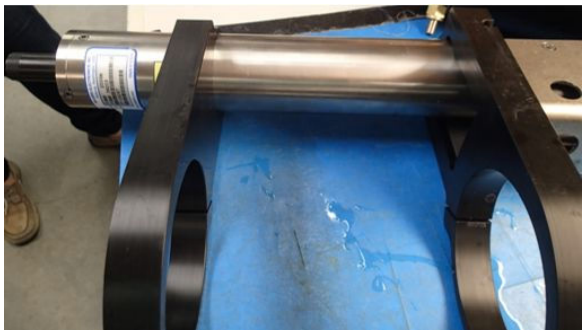
If there is bio-fouling on the sensor it may be necessary to fill the flow path with DI water for approximately 12 hours to loosen debris.

Make sure to remove the anti-fouling assembly if necessary.

1. Attach a 10 cm length of tubing to either the intake or the exhaust port of the sensor.
2. Attach a length of tubing to the syringe.
3. Attach the syringe and tubing to either the intake or the exhaust port of the sensor.
4. Pull approximately 30 ml of cleaning solution into the syringe.
5. Attach the syringe and tubing to either the intake or the exhaust port of the sensor.
6. Push the syringe plunger to fill the sensor until 3–5 cm of solution shows in each tube.
7. Push and pull the plunger to mix the solution in the flow path. Do this 2–3 times.
8. Drain the solution from the sensor into a waste container. Push the syringe plunger to help remove all of the solution from the sensor.
9. Use the syringe to flush the flow path with DI water.
10. If the flow path is still not clean, do steps 4–9 with the bleach solution.
11. Flush the flow path with DI water.

7.4 Remove or attach mounting hardware

When an SBE-37-SMP-ODO is attached to a SeaFET it operates as a SeapHOx. There are two brackets that secure the SeaFET and the SBE-37-SMP-ODO together so that they can operate as a SeapHOx. If it is necessary to remove them, do the steps below.



1. Put the sensors on a table to remove or attach the mounting brackets.
2. Use a 3/16" hex key to loosen the screws on each bracket that secure the SeaFET.

3. Use a 5/32" hex key to remove the three screws that secure the flow cells.
4. Remove the flow cells.
5. Carefully move the SeaFET out of the brackets.
   Make sure not to scratch the housing.
6. If it is necessary to move the bracket on the SBE-37-SMP-ODO to clean the conductivity cell, use a 3/16" hex key to loosen the screws on each bracket that secure the sensor.
7. Slide the bracket out of the way.
8. To install the sensors in the brackets again:
   a. Move the brackets onto each sensor in the positions shown above.
   b. Use a 3/16" hex key to tighten each screw.
   c. Remove the two red plugs.
   d. Attach the flow cells and attach the cap again with the 5/32" screws.

7.5 Remove and replace alkaline batteries

Replace the batteries in the SeaFET when necessary. Use the sensor *Dashboard* in the software or use the magnetic switch to make sure that the batteries have sufficient power for a deployment. Refer to Lithium batteries on page 16 for details about batteries in the SBE-37-SMP-ODO.

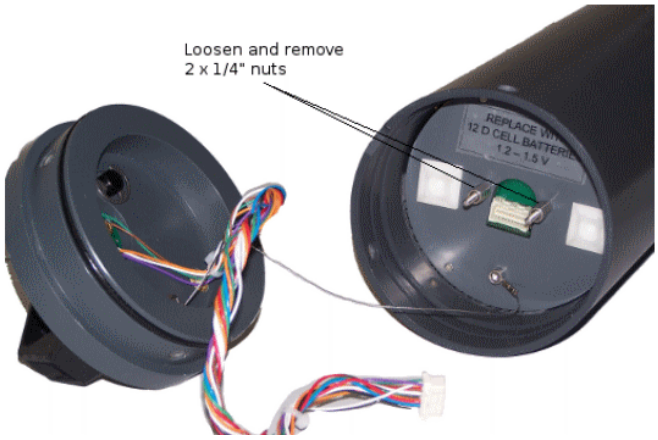
Table 3 Required tools and supplies

8/32" thumb screw	flat head screwdriver
5/32" hex wrench	2 new desiccant packs or sealable plastic bag to store the packs removed from the sensor
1/4" socket driver	12 new alkaline D-cell batteries

1. Make sure that the flow cell is attached to the sensing elements.
2. Loosen the boss seal screw.
3. Use a 5/32" hex wrench to remove the three 10-31 x 3/8" screws from the end flange.
4. Insert a flat head screwdriver into the slot between the pressure housing and the end flange.

5. Loosen the end flange with the screwdriver until the end flange can be pulled from the pressure housing with one hand.
   A safety line attaches the end flange to the battery plate to keep the battery connector wires attached.

6. Press the locking tab on the white end flange connector to disconnect and gently pull it out.
7. Remove the desiccant packs and put them in a sealed bag.
8. Remove the two ¼" nuts that hold the battery plate:



- When batteries are installed, the battery plate compresses six springs that hold the batteries. Make sure to loosen the nuts equally—loosen one a few turns, then the other—so that the battery plate does not lock.

9. Remove the batteries.
10. Follow the polarity labels and install new batteries.

- Change all of the batteries. Do not mix used and new cells.
- Do not mix battery chemistries. The manufacturer recommends industrial 1.5V alkaline D-cells.

11. Examine, clean, and if necessary, lubricate the O-rings on the end flange.
12. Examine and clean the surface on the inside of the battery compartment where the O-rings sit.
13. Replace the desiccant packs.

The old ones can be used again, but the manufacturer recommends that the user install new packs.

14. Put the battery plate into position and tighten the two nuts equally until the battery plate is flush with the white connector.
15. Connect the battery connector. Make sure that it "locks" in the receptacle.
16. Install the end flange. Make sure that the wiring is not pinched.
17. Use a 5/32" hex wrench to install the three 10-31 x 3/8" screws again.
18. Tighten the boss plug screw.

19. Connect the sensor to the software and turn on the internal batteries.
    The voltages in the sensor *Dashboard* for new batteries are 12V for the Main Battery Voltage and 6V for the Isolated Circuit Voltage. If they are not, open the sensor and correct the problem.

7.6 Remove or replace anti-fouling devices

⚠CAUTION

AF24173 Anti-fouling devices contain bis(tributyltin) oxide. Wear rubber or latex gloves and eye protection to replace these devices on the sensor. Wash hands with soap and water when finished.
Read the precautions on the product label.
It is a violation of US federal law to use this product in a manner that is inconsistent with its label.

Anti-fouling devices are installed at the intake and exhaust ports of the pump. Remove these as a first maintenance task to save the anti-fouling material for deployments.

1. Remove the four Phillips-head screws that attach the conductivity cell guard to the pressure housing.

2. Carefully remove the guard.

3. Use a toothpick to lift each of the anti-fouling devices out of their cups. If necessary, use needle-nose pliers to carefully break up the device.
4. To prepare for deployment:
   a. Insert a new anti-fouling device into each cup.

   b. Install the cap onto the cup. Do not tighten too tight.

   c. Replace the conductivity cell guard.
5. To prepare for storage:
   a. Do not insert new anti-fouling devices.
   b. Install the protective plug. Make sure to remove the plugs before the next deployment, or they will cause damage to the conductivity cells.
   c. Replace the conductivity cell guard.

7.7 Examine O-rings

NOTICE

Do not use petroleum-based lubricants on O-rings. It will cause damage to the O-rings. Damaged O-rings can cause the sensor to flood and make it unserviceable.

Examine the O-rings on the sensor every time they are exposed—on the connector end flange and other parts. O-rings must be pristine. If there is any question about whether an O-ring is clean and undamaged, replace it with a new one.

1. Dry the O-rings and O-ring grooves with a lint-free cloth or tissue.
2. Examine each O-ring to make sure there is no damage, dirt, lint or hair on it.
3. Replace an O-ring if necessary.
4. Apply a small quantity of silicone-based Parker Super O Lube® or Dow Corning® high vacuum grease to each O-ring.
   - The lubricant helps the O-ring move into its groove with no twist, which can compromise the seal.
   - Do NOT use petroleum-based lubricants on any O-ring.

7.8 Clean bulkhead connectors

NOTICE

Do not use WD-40® or petroleum-based lubricants on bulkhead connectors. It will cause damage to the rubber.
Damaged connectors can cause a loss of data and additional costs for service.
Damaged connectors can cause damage to the sensor and make it unserviceable.

Examine, clean, and lubricate bulkhead connectors at regular intervals. Connectors that are not lubricated increase the damage to the rubber that seals the connector contacts. The incorrect lubricant will cause the bulkhead connector to fail.

1. Apply isopropyl alcohol (IPA) as a spray or with a nylon brush or lint-free swab or wipes to clean the contacts.
2. Flush with additional IPA.
3. Shake the socket ends and wipe the pins of the connectors to remove the IPA.
4. Blow air into the sockets and on the pins to make sure they are dry.
5. Use a flashlight and a magnifying glass to look for:

Any corrosion.		
Cracks, scratches, or other damage on the rubber pins or in the sockets.		
Separation of the rubber from the pins.		
Swelled or bulging rubber pins.		

6. Use a silicone-based lubricant on each of the contacts of the bulkhead connector. The manufacturer recommends any of the products listed below.
   - 3M™ Spray Silicone Lubricant (3M ID# 62-4678-4930-3). Make sure to let it dry.
   - Dow Corning Molykote® III Compound (DC III)
   - Dow Corning High Vacuum Grease® (DC 976 V)
   - Dow Corning 4 Electrical Insulating Compound® (DC 4)
   - Dow Corning Molykote 44 High Temperature Grease® (DC 44)

Use a finger to put a small quantity (approximately 1 cm in diameter) of silicone grease on the socket end of the connector and push as much of the lubricant as possible into each socket.

7. Connect the connectors.
8. Use a lint-free wipe to clean any unwanted lubricant from the sides of the connectors.

7.9 Prepare sensor for storage

7.9.1 CTD storage

When the plumbing is clean, the sensor can be prepared for storage:

- Make sure the anti-fouling devices are not installed.
- Make sure there is a dummy plug and lock collar attached to the bulkhead connector.

For short-term storage up to a week, make sure to put the manufacturer-supplied colored plugs on the intake and exhaust plumbing ports.

For long term storage:

- Attach one end of a Tygon hose section to the exhaust port, and the other end to the intake port to isolate the conductivity cell plumbing.
- Attach the yellow protective label over the intake and exhaust ports.

7.9.2 pH sensor storage

Fill the storage cap with seawater and make sure DD-size batteries are installed. This will keep the bias and conditioning of the electrode. Make sure that new batteries are installed before the next deployment.

7.10 Calibration

The manufacturer calibrates every sensor to known conditions and measures the response of the sensor. Calibration coefficients are calculated and are used to get engineering units.

7.10.1 Manufacturer pH calibration

NOTICE

The manufacturer recommends that the user return the sensor annually for calibration to make sure it gives the highest level of accuracy for both pH calculation and re-processed data. The external reference electrode is replaced as needed.

Calibration coefficients are stored in the sensor and are used with an on-board temperature measurement and the user-selectable salinity constant to calculate pH from the cell voltage potentials. The calculated pH value shows in each data frame sent from the sensor.

Calibration coefficients are written to the header section of every raw .sbsdat data file that uploaded from the sensor. The software uses these coefficients to re-process data.

7.10.2 Verify calibration

NOTICE

Do not use NIST-type buffers with the sensor to check accuracy. The chemistry of those buffers is not appropriate for marine pH measurements and can damage the external reference electrode.

The manufacturer recommends that the user monitor the accuracy of the calibration at regular intervals. Compare the calculated pH values with independent pH data that is collected just before and after a deployment, either in situ or from direct measurements of a primary standard under temperature-controlled conditions.

One procedure for pre- and post-deployment checks is to start with a sample of known pH and salinity (TRIS buffered synthetic seawater or other certified reference material). The sensors require 20–40 psu.

1. Fill the flow cell with the sample. Close the opening and update the stored salinity value with the sample salinity value: in the software, go to **Sensor**, *SeaFET*, *SeaFET Settings*, then *Processing* to enter the updated sample salinity value.
2. Make sure the sensor and a bottle of the additional sample is at a constant temperature in a bath (e.g. overnight).
3. Flush the flow cell with the sample and then fill the flow cell. Return the sensor to the bath. Record data until the values are stable and similar to the expected values. Do not leave the standard TRIS recipe (it has no bromine) in the flow cell for extended periods of time because it will start to change the chemistry of the external reference electrode and void the calibration.

Section 8 Reference

8.1 Terminal program setup and use

If necessary, use a terminal program to set up and operate the sensor.

1. Use the test cable to connect the sensor to the PC and a 12V power supply.
2. Start a terminal emulator program such as HyperTerminal® or Tera Term.
3. Select "Serial" for the type of connection.
4. Set up the connection at 19200 (default), 8 bits, no parity, 1 stop bit, flow control: none.

8.2 Terminal commands

This is a reference for advanced users. The values of these commands are stored in the sensor until the user changes them. Notes about terminal commands are listed below.

- Commands are not case-sensitive. Use "Enter" to store a command.
- The sensor sends an error message if a command is invalid.
- The argument Y and 1 are both "Yes" and N and 0 are both "No." For example, OutputSal=y and OutputSal=1 are equivalent.
- If there is no communication with the sensor for 2 minutes, it goes into a low power mode. Use "Enter" to start communication again.
- Push the "Esc" key, then "Enter" to stop the sensor as it sends data.
- If the user sent StartNow (autonomous mode) and the sensor is in operation or in standby, the user can use the Status commands, TS, TPS, SL, QS, and Stop. For example, if the user sends a DS to see status data, the sensor completes the current measurement and then responds to the command. If OutputExecuted=Y, the sensor will send "executing" messages until the measurement is complete.
- If the user sent StartLater (autonomous mode) and the sensor is operation or in standby, the user can use the Status commands, TS, TPS, SL, QS, and Stop. To send other commands, enter the Stop command, then enter any other commands, and send StartLater again.

Status

GetCD	show configuration
GetSD	show status
GetCC	show calibration coefficients
GetEC	show event counter
ResetEC	reset event counter
GetHD	show hardware
Help	shows list of available commands
DS	show status and configuration
DC	show calibration coefficients

General setup

DateTime=x	set clock. Format is mmddyyyyhhmmss
BaudRate=x	RS232 rates. Default is 19200. 600*, 1200*, 2400*, 4800, 9600, 19200, 38400, 57600, 115200. *available only if no oxygen sensor is installed.
OutputExecutedTag=x	x=Y: show XML executing and executed tags. x=N: do not show

TxRealTime=x	x=Y: send real-time data during autonomous operation or in serial line sync mode. x=N: do not send
QS	puts sensor in low power ("quiescent") state. Sensor continues to take measurements and store data.
OutputFormat=x	x=0: send raw decimal data. x=1: send converted decimal data.
Initlogging	resets the memory pointer to sample number 0. Makes all memory available for storage. Send command twice to confirm.
*Default	reset user settings back to the defaults as shipped from the manufacturer
SampleInterval=x	x=interval in seconds between samples (6–21600) when command is sent with StartNow or StartLater.

Data collection

StartNow	start data collection now
StartLater	start data collection at a specified time in the future
StartDateTime=	mmddyyyyhhmmss is format for delayed data collection start time
Stop	stop data collection, or wait to start data collection if StartLater was sent
SL	sends as output the last sample stored in the buffer
TS	take sample, store data in buffer, send data, leave power on
TPS	operate pump, collect data once, send data in the current specified format
TSS	take sample, store in buffer and in flash memory, send as output. Valid only if usepump=Y or in SeapHOx™ mode.
TPSS	operate pump, collect a sample, store in buffer and in flash memory, send as output. Valid only if usepump=Y or in SeapHOx™ mode.
Getsamples:b,e	upload converted data, where b=start sample number, and e=end sample number. Total must be less than 5000.
Recoversamples	restore the stored sample number. Use to restore the sample number after the "initlogging" command is sent but before any new data is collected.
ReferenceSalinity=x	sets the salinity value in psu that is used in calculations

Pump setup

MinCondFreq=x	minimum conductivity frequency for pump to operate, Hz
PreFlush=x	time, in seconds, for pump to operate before the first measurement. Default is 300. Range 300–600. If autonomous operation starts with StartNow, the pre-flush starts immediately. If autonomous operation starts with StartLater, the pre-flush starts *x* seconds before scheduled start time.
PreFlushStartTIme=x	set mmddyyyyhhmmss for controlled ("polled") data collection set 0 to disable the pre-flush for controlled data collection
OxNTau=x	pump operation time multiplier. Default is 7.0. Range 0–100.0.
PumpTime=x	time the pump operates for each measurement, when oxygen sensor is installed. Range 0–550.
PumpOn	start pump. Pump will stop after 2 minutes without communication or when PumpOff is sent.
PumpOff	stop pump, if started with PumpOn.

SeaFET V2 calibration coefficients

phcaldate=	sensor sends command to DO sensor and gets response
K0=	set K0 coefficient

K2=	set K2 coefficient
ReferenceSalinity=	set the salinity value to be used in calculations
tdfcaldate=	DuraFET temperature calibration date, dd-mm-yy
tdfa0=	set DuraFET thermistor temperature coefficient, A0
tdfa1=	set DuraFET thermistor temperature coefficient, A1
tdfa2=	set DuraFET thermistor temperature coefficient, A2
tdfa3=	set DuraFET thermistor temperature coefficient, A3

SeapHOx V2-specific

Resync	re-sync host SeaFET to SBE-37-SMP-ODO. Communicates with the 37 to configure the CTD and download coefficients and serial numbers from the attached SBE-37-SMP-ODO.
Send37=x	x = command for SBE37
Ctdpower=	configures the SeapHOx V2 to provide power to the attached SBE37. Power can come from internal batteries or external source. x=0: do not power the SBE37. x=1: power the SBE37.
Setoxunits=x	x=0: show oxygen units in ml/L. x=1: show oxygen units in mg/L
Usectdt=	use CTD temperature value for calculations

8.3 Polled data collection

The sensor collects data at user-specified intervals when it receives an RS232 polled sample command from an external controller. To operate the sensor manually, send any character and wait for 3 seconds for the sensor to go into Standby mode. The user has 2 minutes to send a polled sample command before the sensor returns to a low power mode. Refer to Terminal commands on page 41 for the description of the four polled sample commands.

The output from the sensor is a single frame of data. Send a polled sample command, then send the "qs" command to return the sensor to a low power mode. Otherwise the sensor will stay in Standby mode for 2 minutes and drain the batteries more quickly.

Section 9 Software reference

9.1 Sensor dashboards

The Dashboard is the main area from which to control and communicate with the sensor.

Information about the status of the sensor is contained in the upper part of the window and is updated each time the sensor is connected to the software.

Common settings

- **Connect/Disconnect** lets the user start/stop communication between the sensor and the software.
- **Start/Stop** lets the user start and stop data collection.
- **Sensor Settings** lets the user select options for a specific deployment.
- **Deployment Wizard** lets the user select a deployment mode, start time, and the parameters to measure, estimate the deployment time and data collection interval, and make a summary report of the status of the sensor.
- **Transmit Files, Data** lets the user move data saved on the sensor to a PC.
- **Show Data from Sensor** lets the user see data that was saved on a PC in a graph.
- **Command Terminal** lets the user send terminal program-level commands to the sensor.

Sensor-specific settings

- SUNA: **Reference Update** lets the user update the reference spectrum stored in the sensor so that the sensor can accurately convert a spectral measurement into nitrate concentration.
- SUNA: **Check wiper** lets the user operate the anti-fouling wiper for one cycle.
- HydroCAT, HydroCAT-EP: **Start Pumping** operates the pump for 5 minutes if the sensor is in water.
- HydroCAT, HydroCAT-EP: **Conductivity Check** lets the user verify that the conductivity value that is output by the sensor is within specification.
- HydroCAT, HydroCAT-EP: **Temperature Check** lets the user enter reference temperatures, collect data, and make new reference values.
- HydroCAT-EP: **Optics Check** lets the user verify that the optics values are within specification.
- HydroCAT-EP: **pH Calibration** lets the user verify that the pH value is within specification.
- ECO V2: **Sleep** puts the sensor in a low power mode (140µA).
- ECO V2: **Run Data Analysis** is a six-step wizard that lets the user do a QA/QC analysis of data.
- ECO V2: **Check Wiper** lets the user operate the anti-fouling wiper for one cycle.

9.2 UCI menu

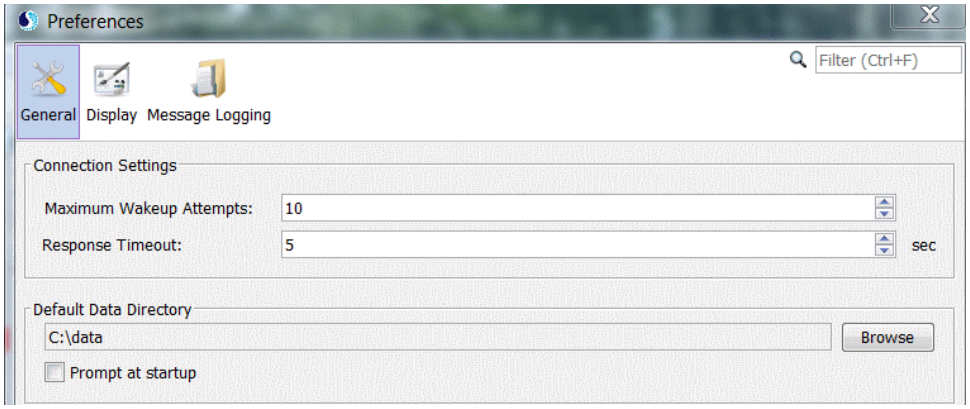
The user can set up the way that the software saves information about the operation of the sensor and change the way that the data looks from the *Preferences* menu.

9.2.1 General tab

Enter or change the directory on the PC in which data from the sensor is stored.

- "Maximum Wakeup Attempts" lets the user select the number of times the software will try to connect to a sensor. Range: 5–15.
- "Response Timeout" is the interval of time between communication between the sensor and the software. Range: 5–10.

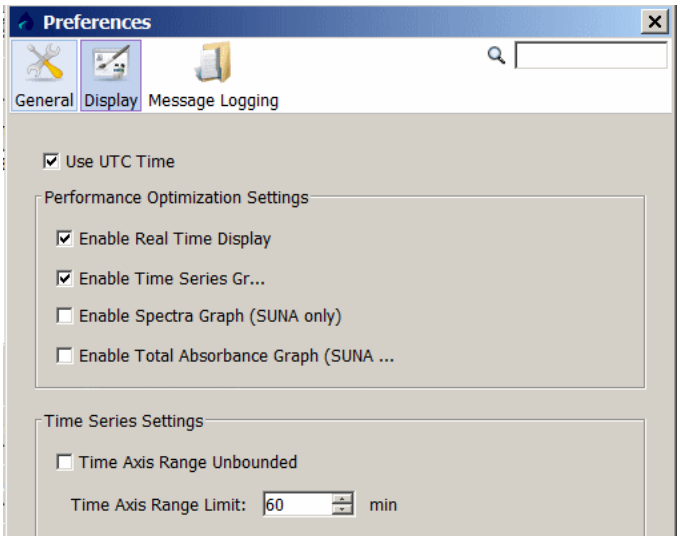
- "Default Data Directory" lets the user enter the location on the PC in which to save data from the sensor. If there is a check in the "Prompt at startup" box, the user can change the directory in which the data is stored every time the software starts.



9.2.2 Display tab

Note: *The software operates faster if the user selects less data and only one or two graphs.*

Data that is collected by the sensor shows in the user-selected graphs in the Performance Optimization Settings area of the *Display* tab.



- RS232 only: "Enable Real Time Display"—Put a check in this box to see the data as it is collected in either the software, or if deployed, a terminal program.
- "Enable Time Series Graph"—Put a check in this box to see user-selected data. Remove the check in the box to so that the graph is disabled and the data does not show.
- SUNA only: "Enable Spectra Graph"—Put a check in this box to see both dark and light data in raw counts. Refer to Monitor spectra for details.
- SUNA only: "Enable Total Absorbance Graph"—Put a check in this box to see the calculated absorbance. Refer to Monitor absorbance for details.

Time Series Settings—The default is a check in the box for continuous data collection that is not limited to a specified amount of time. Remove the check in the box to enable the "Time Axis Range Limit" of 60 minutes (default value). Only the most recent hour of data will show in the *Time Series Graph*. The user-selectable range is 1–1440 minutes.

9.2.3 Message tab

The software automatically saves files that have information about sensor use, data collection, and software operation over time. This information helps the user and Customer Support find problems and do troubleshooting.

When the "Display Dialog for Error Level Messages" box has a check in it, the software saves one of five levels of error messages.

- **INFO**—The default level. All high-level operations are saved.
- **ERROR**—Minimum level. Only errors that need to be examined by the user or Customer Support are saved.
- **WARN**—Low level. The files that are saved do not have enough information for the user to make an analysis of how the sensor is used and set up.
- **DEBUG**—High level. Used for troubleshooting. **DEBUG** and **TRACE** files are very large.
- **TRACE**—The highest level. Used only for troubleshooting.

"Daily Files"—all messages from a single day are saved in one file.

"Rolling Files"—all messages are saved in one file until it is the maximum size specified by the user. The messages are then saved to a new file. The user specifies the number of files to keep. The oldest files are erased first.

"Save Lost Bytes"—if this box has a check in it, the software saves all of the unexpected output from the sensor to a file.

"File Location"—the operating system of the PC determines where these files are saved.

9.3 Sensor menu

The **Sensor** menus have options for each sensor with which the software communicates. Refer to the sections on Sensor dashboards on page 45 for more information about these items.

Advanced Sensor menu items

Common

- *Set Clock* lets the user synchronize the time between the PC and the sensor.
- *Summary Report* lets the user get a summary of the settings stored in the sensor.
- *Collect Diagnostics* is helpful for troubleshooting.

9.3.1 SeaFET, SeapHOx

- *Erase Saved Data* lets the user erase all of the data saved in the sensor.
- *Edit Data File Headers* lets the user put labels on data files.
- *Upgrade Firmware* lets the user install the latest firmware from the manufacturer.

9.4 Data menu

The **Data** menu has sensor-specific options to look at data that has been saved to a PC.

Section 10 General information

Revised editions of this user manual are on the manufacturer's website.

10.1 Warranty

Refer to the manufacturer's website for warranty information (seabird.com/warranty).

10.2 AF24173 anti-foulant device

AF24173 Anti-Foulant Devices supplied for user replacement are supplied in polyethylene bags displaying the following label:

AF24173 ANTI-FOULANT DEVICE

FOR USE ONLY WITH SEA-BIRD ELECTRONICS' CONDUCTIVITY SENSORS TO CONTROL THE GROWTH OF AQUATIC ORGANISMS WITHIN ELECTRONIC CONDUCTIVITY SENSORS.

ACTIVE INGREDIENT: Bis(tributyltin) oxide 52.1%
OTHER INGREDIENTS: 47.9%
TOTAL 100.0%

DANGER
Refer to conductivity sensor manual for the complete label and additional precautionary statements and information on the handling, storage and disposal of these devices.

Net contents: Two anti-foulant devices
Sea-Bird Electronics, Inc.
13431 NE 20th St.
Bellevue, WA 98005

EPA Registration No. 74489-1
EPA Establishment No. 74489-WA-1

AF24173 ANTI-FOULANT DEVICE

FOR USE ONLY WITH SEA-BIRD ELECTRONICS' CONDUCTIVITY SENSORS TO CONTROL THE GROWTH OF AQUATIC ORGANISMS WITHIN ELECTRONIC CONDUCTIVITY SENSORS.

ACTIVE INGREDIENT: Bis(tributyltin) oxide 52.1%

OTHER INGREDIENTS: 47.9%

TOTAL 100.0%

DANGER

See Precautionary Statements for additional information.

FIRST AID	
If in eyes	• Hold the eye open and rinse slowly and gently with water for 15–20 minutes. • Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye. • Call a poison control center or doctor for treatment advice.
If on skin or clothing	• Take off contaminated clothing. • Rinse skin immediately with plenty of water for 15–20 minutes. • Call a poison control center or doctor for treatment advice.
If swallowed	• Call poison control center or doctor immediately for treatment advice. • Have person drink several glasses of water. • Do not induce vomiting. • Do not give anything by mouth to an unconscious person.
HOT LINE NUMBER	
Note to Physician	Probable mucosal damage may contraindicate the use of gastric lavage.
Have the product container or label with you when calling a poison control center or doctor, or going for treatment. For further information, call National Pesticide Telecommunications Network (NPTN) at 1-800-858-7378.	

Net contents: Two anti-foulant devices

Sea-Bird Electronics, Inc.

13431 NE 20th St.

Bellevue, WA 98005

EPA Registration No. 74489-1

EPA Establishment No. 74489-WA-1

PRECAUTIONARY STATEMENTS
HAZARD TO HUMANS AND DOMESTIC ANIMALS

Danger:

Corrosive—Causes irreversible eye damage and skin burns. May be fatal if swallowed or absorbed through the skin. Do not get in eyes, on skin, or on clothing. Wash thoroughly with soap and water after handling and before eating, drinking, chewing gum, using tobacco, or using the toilet. Remove and wash contaminated clothing before reuse.

PERSONAL PROTECTIVE EQUIPMENT

Users must wear: protective gloves (rubber or latex), goggles or other eye protection, long-sleeved shirt, long pants, and shoes plus socks.

USER SAFETY RECOMMENDATIONS

Users should:

- Remove clothing immediately if pesticide gets inside. Then wash thoroughly and put on clean clothing.
- Follow the manufacturer's instructions for cleaning and maintaining PPE. If no such instructions for washables, use detergent and hot water. Keep and wash PPE separately from other laundry.

ENVIRONMENTAL HAZARDS

Do not discharge effluent containing this product into lakes, streams, ponds, estuaries, oceans, or other waters unless in accordance with the requirements of a National Pollutant Discharge Elimination System (NPDES) permit and the permitting authority has been notified in writing prior to discharge. Do not discharge effluent containing this product to sewer systems without previously notifying the local sewage treatment plant authority. For guidance contact your State Water Board or Regional Office of EPA. This material is toxic to fish. Do not contaminate water when cleaning equipment or disposing of equipment washwaters.

PHYSICAL OR CHEMICAL HAZARDS

Do not use or store near heat or open flame. Avoid contact with acids and oxidizers.

DIRECTIONS FOR USE

It is a violation of Federal Law to use this product in a manner inconsistent with its labeling.

For use only in Sea-Bird Electronics' conductivity sensors. Read installation instructions in the applicable Conductivity Instrument Manual.

Intended for professional use by military, government, academic, commercial, and scientific personnel.

STORAGE AND DISPOSAL

PESTICIDE STORAGE: Store in original container in a cool, dry place. Prevent exposure to heat or flame. Do not store near acids or oxidizers. Keep container tightly closed.

PESTICIDE SPILL PROCEDURE: In case of a spill, absorb spills with absorbent material. Put saturated absorbent material into a labeled container for treatment or disposal.

PESTICIDE DISPOSAL: Pesticide that cannot be used according to label instructions must be disposed of according to Federal or approved State procedures under Subtitle C of the Resource Conservation and Recovery Act.

CONTAINER HANDLING: Nonrefillable container. Do not reuse this container for any other purpose. Offer for recycling, if available.

10.3 Service and support

The manufacturer recommends that sensors be sent back to the manufacturer annually to be cleaned, calibrated, and for standard maintenance.
Refer to the website for FAQs and technical notes, or contact the manufacturer for support at support@seabird.com.

Do the steps below to send a sensor back to the manufacturer.

1. Complete the online Return Merchandise Authorization (RMA) form or contact the manufacturer.
   Note: *The manufacturer is not responsible for damage to the sensor during return shipment.*
2. Remove all batteries from the sensor, if so equipped.
3. Remove all anti-fouling treatments and devices.
   Note: *The manufacturer will not accept sensors that have been treated with anti-fouling compounds for service or repair. This includes AF 24173 devices, tri-butyl tin, marine anti-fouling paint, ablative coatings, etc.*
4. Use the sensor's original ruggedized shipping case to send the sensor back to the manufacturer.

5. Write the RMA number on the outside of the shipping case and on the packing list.
6. Use 3rd-day air to ship the sensor back to the manufacturer. Do not use ground shipping.
7. The manufacturer will supply all replacement parts and labor and pay to send the sensor back to the user via 3rd-day air shipping.

10.4 Waste electrical and electronic equipment

Electrical equipment that is marked with this symbol may not be disposed of in European public disposal systems. In conformity with EU Directive 2002/96/EC, European electrical equipment users must return old or end-of-life equipment to the manufacturer for disposal at no charge to the user. To recycle, please contact the manufacturer for instructions on how to return end-of-life equipment, manufacturer-supplied electrical accessories, and auxiliary items for proper disposal.

Sea-Bird Electronics
13431 NE 20th Street
Bellevue WA 98005 U.S.A.
(425) 643-9866