Underwater Bioluminescence Assessment Tool (UBAT)

Hardware User's Guide

This user's guide is an evolving document. If you find sections that are unclear or missing information, please let us know. Please check our website periodically for updates.

WET Labs, Inc.
PO Box 518
Philomath, OR 97370
541-929-5650
fax: 541-929-5277
www.wetlabs.com

Warranty

This unit is guaranteed against defects in materials and workmanship for one year from the original date of purchase. Warranty is void if the factory determines the unit has been abused or neglected beyond the normal wear and tear of field deployment, or if the pressure housing has been opened by the customer.

To return the instrument, contact WET Labs for a Return Merchandise Authorization (RMA) and ship in the original container. WET Labs is not responsible for damage to instruments during the return shipment to the factory. In honoring this warranty, WET Labs will supply all replacement parts and labor, and pay for return via 3rd-day air shipping.

Shipping Requirements

1. Please retain the original shipping material. We design the container to meet stringent shipping and insurance requirements, and to fully protect the UBAT.

2. To avoid additional repackaging charges, return the instrument in the original box (or other WET Labs-approved container), using the custom-cut packing foam and anti-static bag.

3. If you use an alternative container, fully surround the instrument with at least 2 inches of foam (NOT bubble wrap or Styrofoam "peanuts").

4. Clearly mark the RMA number on the outside of your shipping container and on all packing lists.

5. Return instruments using 3rd-day air shipping or better: do **not** ship via ground.

Attention!

Return Policy for Instruments with Anti-fouling Treatment

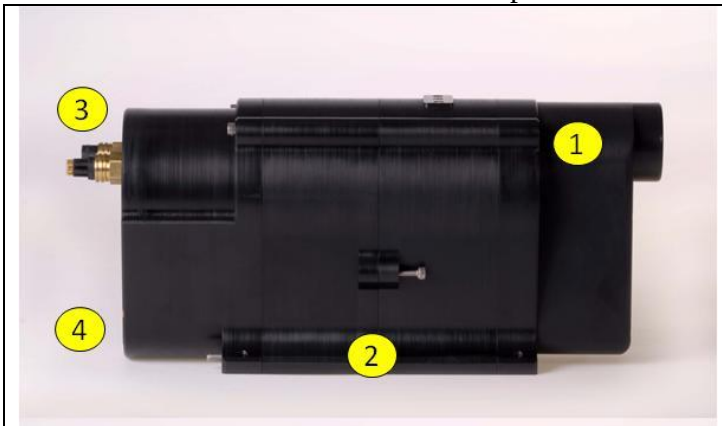
WET Labs cannot accept instruments for servicing or repair that have been treated with anti-fouling compounds, such as marine anti-fouling paint. These products present a handling hazard to our technicians and can damage our laboratory equipment. You must scrape, sand, or otherwise remove all traces of anti-fouling treatment. Also, please note that chemical strippers are likely to damage the instrument housing.

1. Instrument Description

The Underwater Bioluminescence Assessment Tool (UBAT) is designed to provide measurement of mechanically stimulated bioluminescence potential (photons s^{-1} l^{-1}). UBAT is a small, light-weight bioluminescence sensor designed for deployment on multiple platforms such as ship-board profiles, Autonomous Underwater Vehicles (AUVs) and long-term deployment on moorings. The UBAT measurement system, specifically the Photomultiplier Tube (PMT) and flow meter, are calibrated to NIST traceable standards.

Please refer to the UBAT page on the WET Labs website for the most complete and updated information, including links to live data, our latest test results, papers, FAQ's, and recommended procedures.

Description of UBAT components



UBAT (external view):

1. Front—intake section with internal S-shaped light baffle
2. Midsection—mounting platform
3. Back—6-pin and 3-socket MCBH connectors
4. Back—exhaust

UBAT (internal view):

5. calibration/validation port
6. detection chamber interior
7. guide pins
8. jack screw
9. flow impeller (pump impeller not shown)
10. exhaust, showing the front of the 3-turn helical light baffle
11. 6-pin MCBH connector
12. clear PMT faceplate, with arrow to the PMT baffle
13. electronics housing

1.1 Instrument Function

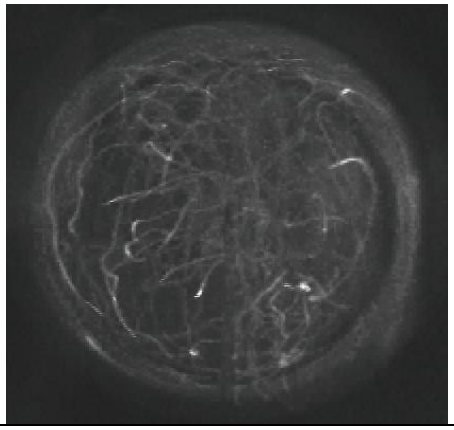
UBAT uses an internal pump to provide the mechanical stimulation necessary to obtain maximum bioluminescence potential from bioluminescent organisms entrained in the flow. Water is entrained into an S-shaped intake that acts as a light baffle and is designed to prevent pre-stimulation of organisms as they travel to the detection chamber (Figure 1, external view).

Mechanical stimulation is provided immediately prior to entering the 0.440 l volume detection chamber by a back-EMF regulated pump impeller (Figure 1, internal view). The detection chamber, based on the design of an integration sphere, is composed of titanium dioxide and polyurethane, and is greater than 95 percent reflective from 430–700 nm. A PMT is located at the rear of the detection chamber behind a clear polyurethane faceplate that has an index of refraction similar to water (Figure 1, internal view, #12). To ensure the PMT measures integrated light flux, a light baffle is fixed in front of it.

The flow of water through the detection chamber is highly turbulent, providing multiple stimulation events as the bioluminescent organisms pass through the detection chamber.

At the exhaust side of the detection chamber a helical ramp is molded into the polyurethane PMT faceplate that guides water flow to an impeller. The exhaust is baffled from external light with a 3-turn helical insert.

Turbulent flow path of bioluminescent organisms in the detection chamber.



The UBAT PMT auto-ranges over three gain settings and can sense bioluminescence over several orders of magnitude. UBAT has three gain settings or high voltage steps (HV steps) that automatically adjust based on the amount of light detected by the system. At system start up, UBAT will use the least sensitive gain setting, HV step 1, to detect the amount of light present in the detection chamber and will auto-gain until it reaches the appropriate HV step (1, 2, or 3). During most deployments, when bioluminescence is in the low to mid range, UBAT will operate at HV 3, the most sensitive setting. Each gain is set at a factor of 10 apart.

2. Setup and Operation

WET Labs strongly recommends you verify the functionality of your meter **before** a deployment. Note that UBAT does not log data internally, therefore a computer or data logger, such as a WET Labs DH4, are required to log data.

The standard UBAT delivery package includes the following:

- UBAT meter
- Meter-specific characterization sheet
- CD (contains host software, characterization sheet, this manual)
- Validation LED light source
- Test cable
- Spare parts kit
- **Optional**: mounting bracket

2.1 Meter Setup and Functionality Check

1. Connect the UBAT to a regulated power supply at 9–18V and a host PC. WET Labs recommends using the test cable provided for pre-deployment checkout.

2. Start the UBAT host software from the CD that shipped with the meter.

3. The software will prompt you to:
   - Select the appropriate COM Port on the host PC. The software will automatically detect the meter's baud rate (19200).

   Note that it may be more convenient to copy the contents of the CD to the host computer and run UBAT Host from it.

   - If using Hyperterm:
     Baud rate = 19200, Data = 8, Parity = none, Stop = 1, Flow control = none

4. Select the Terminal output window from the software toolbar to view incoming data.

5. Supply power to the meter. There is a 15-second delay for the PMT to warm up. UBAT will start in the least sensitive PMT gain and increase its sensitivity according to light conditions. Following this, the UBAT PMT and pump turn on automatically and the sensor begins transmitting data.

6. Data output: Below is an example of one line of the UBAT's 1 Hz ASCII data stream. Note that the data is wrapped to fit on the page. Data headers are not output with the data file.

```
UBAT0006,00075,1.48E7,5.623E+07,0,11.857,0,0.581,38,44.88,4,4,3,4
,4,5,5,4,4,4,4,4,3,4,3,4,3,3,2,3,3,2,3,2,4,4,4,3,3,2,4,2,1,2,3,4,
2,2,3,5,4,3,2,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
```

UBAT Headers

Output	Column(s)	Header	Units
UBAT0006	1	UBAT SN	NA
00075	2	Record Number	NA
1.48e7	3	Calibration coefficient for HV step	photons s^{-1}
5.623e+07	4	Average Bioluminescence	photons s^{-1}
1200	5	Pump RPM	RPM
11.857	6	System Voltage	V
600	7	Flow RPM	RPM
0.581	8	HV step	V
38	9	Reserved	NA
44.88	10	Reserved	NA
4	11–70	60 Hz digitized raw A/D counts	NA

2.1.1 UBAT Photomultiplier Tube Operation

Caution

Do not apply power to UBAT while the calibration port or detection chamber are open. The PMT will be damaged.

UBAT PMT will self-protect (shut down) if the intensity of light is greater than the threshold value for the least sensitive HV step. This prevents damage to the PMT in case power is supplied to UBAT while the instrument detection chamber is open or the calibration light port is removed. However, exposure to bright light may reduce the lifetime of the PMT or damage it.

The UBAT is equipped with two purge ports at the top of the sensor that allow bubbles to float free of the detection chamber, and are J-shaped to baffle the direct light from entering the detection chamber. Under normal conditions, the optical sensor is not sensitive to external light sources. However, if there is direct overhead light or bright sunlight, baseline values may be elevated.

2.1.2 Motor Operation

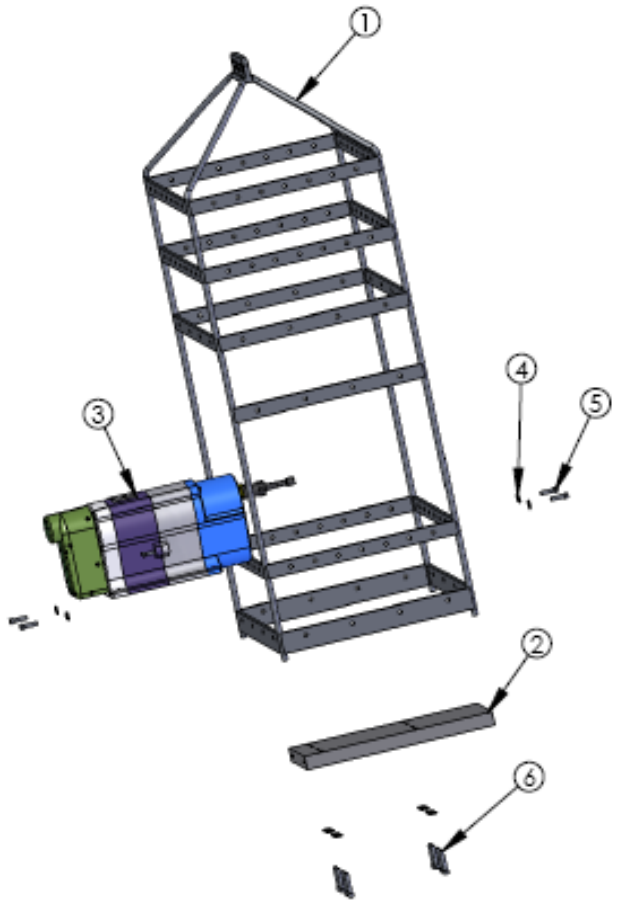
The motor will start automatically after 9–18V power is applied to UBAT. The pump motor is optimized for use in water; however if the pump fails to turn on at initial power up, the control electronics will give the pump a command to turn on once per second until it is successful. WET Labs recommends that if UBAT is powered on while it is out of the water, the pump should be powered off to preserve its functional life. Pump and flow RPM are measured by UBAT and are output as a column in the ASCII data stream. Although the exact values differ between UBAT instruments, the expected pump and flow RPM should be approximately 1200 RPM for the pump and 600 RPM for the flow meter. The average flow rate of UBAT is 0.330 ± 0.05 l s^{-1}.

Recommendation

Make sure the pump is OFF while operating UBAT out of water to preserve pump life.

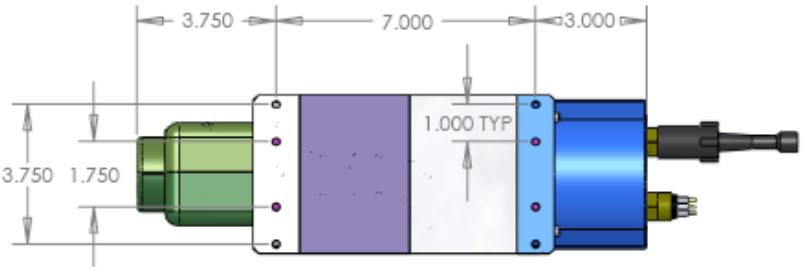
2.2 Mounting UBAT for Deployment

WET Labs recommends a horizontal mounting orientation, such as on a platform mounted on an optical cage. This orientation allows air to escape from the detection chamber via the purge ports located at the top of the sensor. To ensure appropriate flow rates for UBAT, prevent any obstruction within 6 inches of the intake or exhaust. Mounting brackets are sold separately for use with WET Labs standard optical cage.



UBAT IOP cage assembly and horizontal mounting platform components:

1. UBAT-IOP profile cage
2. UBAT cage mount
3. UBAT
4. 0.25 washer
5. 0.25-20 x 1.00 socket head cap screws (SHCS), stainless
6. 0.25-20 x 1.50 SHCS, stainless



UBAT mounting platform with location of mounting holes.

Mounting UBAT vertically creates a challenge for air to purge from the detection chamber. Do not use hose clamps directly on the external housing of the UBAT. Hose-clamp mounting brackets are available separately from WET Labs. If your deployment requires that UBAT be used on an inline system or with an alternative mounting orientation, contact WET Labs, Inc.

2.3 Recording Data

UBAT does not log data internally, therefore either a host computer with a terminal emulator program such as HyperTerm or the software included with UBAT is required to log data. The WET Labs graphic user interface and control software for UBAT provides a data viewing window, data logging and validation tracking. Using the UBAT software, data can be saved continuously with automatic file naming. Refer to the software user's guide for more information. If UBAT is part of an instrument package a data logger, such as a WET Labs DH4 can be used.

2.4 Troubleshooting

Pump and flow RPM can be used for troubleshooting. For example, if the pump RPM reads zero or the flow RPM is zero or significantly lower than expected values (~600 RPM), the motor may not be powered on or functioning properly. This can occur when there is an obstruction at the intake. To verify there is no obstruction, disassembly of the UBAT sections may be required (see section 7). To test for motor functionality, cycle the power to UBAT. Listen to see if the pump turns on (wait 1 minute between powering the UBAT off and on). The pump motor should turn on automatically after power up. In case of a complete motor failure the motor can be replaced. Please contact WET Labs for more information.

3. Parts Reference

3.1 Equipment Delivered

Qty	Item	P/N
1	6-socket dummy plug	EXA-KX0038
1	Lock collar	EXA-KX0025
1	3-pin dummy plug	EXA-KX0006
1	Lock collar	EXA-KX0025
1	Test cable	CXA-KX0115
1	Validation LED light source	B0A-530402

3.2 Spare Parts Kit

Qty	Item	P/N
1	Pigtail, 6-socket	EXA-KX0018
1	Lock collar	EXA-KX0025
1	6-socket dummy plug	EXA-KX0038
1	6-pin dummy plug	EXA-KX0183
3	4-40 x 0.250 Flat Head Phillips Screw (FHPS), 18-8SS	G0X-SX0040
3	6-32 x 0.375 FHPS 18-8SS	GXA-SX0162
2	0.25-20 x 1.0, Socket Head Cap Screw (SHCS), 316SS	G0X-SX0050
2	0.25-20 x 4.5 SHCS, 18-8	G0X-SX0033
2	0.25-20 x 7.5 SHCS, 18-8	MAA-906091
2	4-40 X 0.5 FHPS 18-8SS	G0X-SX0041

3.3 Optional Mounting Kit

Qty	Item	P/N
4	0.25-20 x 1.00 SHCS, 316SS	G0X-SX0050
8	0.25-20 x 1.50 SHCS, 316SS	G0X-000032
12	0.25, washer, steel, zinc plated	G0X-SX0043
1	UBAT IOP profiler cage mount	M0X-899401

4. Specifications

Electrical

Connector	MCBH-6-MP (power); MCBH-3-FS (LED)
Output	RS-232
Input	9–18 VDC
Current draw	600 mA (typical)
Sample rate	60 Hz sampling rate with 1 Hz data output rate
Digital output signal	RS-232
Digital output resolution	16 bit
Baud rate	19200

Data

Bioluminescence units	Photons L^{-1} s^{-1}

Mechanical

Pressure housing	Acetyl copolymer plastic
Housing dimensions	34.93 x 10.80 x 16.83 cm
Intake dimensions	3.81 cm ID; 5.08 cm OD
Weight in air	5.10 kg
Weight in water	1.64 kg
*Detection chamber**	Molded acrylic and titanium dioxide (> 95% reflectance between 430–700 nm) —*Light-baffled air-bleed ports located at top of the detection chamber exhaust any air*
Flow rate	0.330 ± 0.05 L s^{-1}
Chamber volume	0.440 L

Environmental

Depth rating	600 m
Range	4–38 deg C

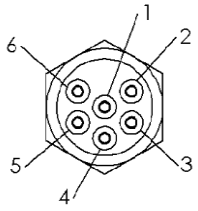
Optical

Detectors	Photomultiplier Tube
Detection range	$1.50e^{7}$ – $6.7e^{13}$ Photons s^{-1}

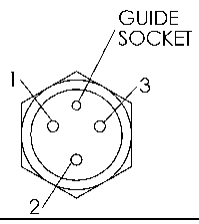
**Light-baffled air-bleed ports located at top of the detection chamber exhaust any air.*

4.1 Connector Pin-outs

Pin	Function
1	Ground
2	RS-232 (RX from host)
3	NC
4	V +
5	RS-232 (TX to host)
6	NC



Socket	Function
1	Ground
2	NC
3	Power



5. Data Processing

WET Labs provides both the PMT and flow meter calibration coefficients on the UBAT characterization sheet that is shipped with the sensor.

Although data is recorded immediately following applied power, the first 5 data records should be ignored. During this period, the system is stabilizing.

5.1 Applying Calibration Coefficients

Bioluminescence potential is represented in units photons s^{-1} l^{-1}. Therefore, post-processing of UBAT data is required.

1. *Convert flow rate (RPM) to flow rate (l s^{-1})*

The flow rate of UBAT is determined at WET Labs using a specially designed raceway flume equipped with a NIST traceable flow meter. The calibration coefficient determined is specific to each UBAT and is provided by WET Labs on the calibration sheet.

Flow rate (l s^{-1}) = Flow (RPM) * Flow rate calibration coefficient

2. *Calculate bioluminescence potential (photons s^{-1} l^{-1})*

UBAT internally computes average bioluminescence (photons s^{-1}) and applies the necessary calibration coefficients. Prior to shipment, UBAT is calibrated with a NIST-traceable light standard. Calibration coefficients are held in the UBAT memory and output as part of the data stream. The coefficients output are for reference only, to track changes in the gain setting, and should not be applied again during post-processing.

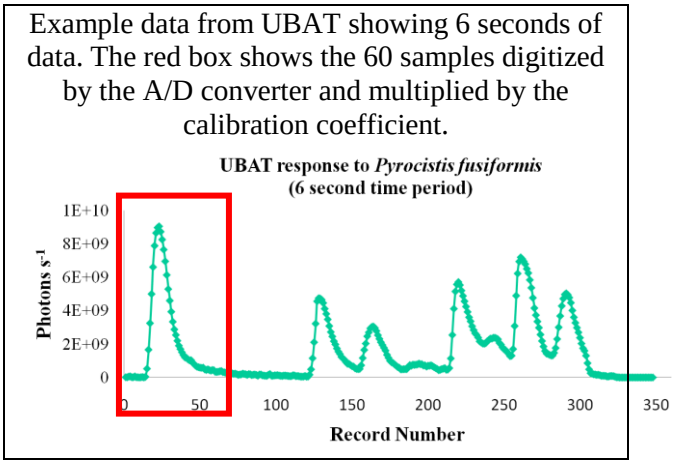
Average bioluminescence (photons s^{-1}) is output every second, in column 4. To obtain bioluminescence potential (photons s^{-1} l^{-1}), divide the average bioluminescence (photons s^{-1}) by the calculated flow rate (l s^{-1}). The time components cancel because both are rate measurements. However, because UBAT internally calculates and outputs average bioluminescence at 1 Hz, the time component of the data output rate (s^{-1}) is reflected in the final units.

Bioluminescence potential (photons s^{-1} l^{-1}) =

$$\frac{\text{Bioluminescence (photons } s^{-1})}{\text{Flow rate (l } s^{-1})}$$

5.2 Analysis of Flash Kinetics

Using the output calibration coefficients and the raw data records 1–60, UBAT is capable of measuring the short time scale evolution of the bioluminescence signal, which is important for analyzing the flash kinetics of bioluminescent organisms (right).



Example data from UBAT showing 6 seconds of data. The red box shows the 60 samples digitized by the A/D converter and multiplied by the calibration coefficient.

The PMT output voltage is measured directly and digitized using a 16-bit A/D converter that samples the analog signal at a rate of 60 samples per second.

Each sample from the A/D converter is output as a separate column (raw A/D counts) of the 1 Hz data stream.

The calibration coefficient for the current PMT gain setting is also output as a column of data. Therefore, the 1–60 A/D samples per second can easily be converted into bioluminescence (photons s^{-1}) using the following equation:

Bioluminescence (photons s^{-1}) =
(raw A/D count) * (PMT calibration coefficient for the current gain setting)

Thus, the user can use this information to analyze individual flashes that compose the average bioluminescence value output by UBAT at 1Hz (photons s^{-1}).

5.3 Gain Change

When UBAT changes from one gain to the next (either an increase or decrease in sensitivity), the point at which this occurs in the 1-second data stream is unknown. Therefore, to ensure data is accurately represented, the 1 second data record at the point when the calibration coefficient changed should be flagged. Following the gain change, all data records associated with the new calibration coefficient are accurate.

5.4 Ambient Light

UBAT is designed to limit the effect of ambient light on bioluminescence measurements. Sections are mated using O-rings that act as a light baffle, bubble purge ports have a J-shape to reduce ambient light, and both the intake and exhaust are light-baffled. Under normal operating conditions, verify that there is no ambient light influence. Raw A/D counts should be < 1 average raw counts over a 1 minute sampling period. If values are greater, there is an intrusion of ambient light. While operating UBAT in the lab or recording a validation light value, cover the UBAT's purge ports, intake and exhaust with a black cloth or black plastic bag. This should greatly reduce the effect of ambient light on the measurement. During deployment, overhead or deck lights should be shut off to limit the effect of ambient light on measurements. If this is not possible, record the average bioluminescence (photons s^{-1}) or raw A/D values under ambient light conditions (i.e. just above water) and subtract this baseline value from surface measurements during data post-processing.

6. Calibration/Validation and Dark Counts

6.1 UBAT Validation Overview

The UBAT detection system (PMT and detection chamber) is calibrated at the factory using a NIST traceable LED light standard. The response of the PMT to the standard is determined and the HV steps are set according to the known light flux of the standard. Therefore, UBAT measurements are traceable and comparable between sensors.

To ensure that the UBAT detection system is operating within specification, a validation light standard is provided. The light flux of the validation light source is specific to each UBAT and is determined prior to leaving the factory. Its value is provided on the characterization sheet. The validation light source is intended to assist the user in tracking possible PMT degradation or a change in signal response due to biofouling. A validation measurement should be collected and recorded prior to and following each deployment as well as a record of the system dark counts. A single validation light source can be used to track multiple UBATs as long as the light flux of the validation light source is recorded for each UBAT prior to deployment.

6.2 Making a Validation Measurement

To make a validation light measurement the following equipment is required: Phillips head screw driver, black cloth or plastic garbage bag, validation light source, communications/power cable, regulated power source, host computer, UBAT host software (or terminal emulator program). Step-by-step instructions are below.

Cautions

Before opening the calibration light port, make sure that the PMT is OFF.

Prolonged exposure of the PMT to the validation light source could decrease the lifetime of the PMT or damage it.

To use the validation light source, remove the port cover located on the top of the instrument housing. Remove all 6 exterior screws. DO NOT remove the center screw, as this is holding the port plug to the port cover. Place the port cover in a safe place where the white port plug cannot be scratched or damaged. Insert the validation light standard into the calibration port of UBAT. Make sure the light source is seated properly and re-install the outer four screws that were used to hold the calibration port plug in place.

Cover the UBAT in black cloth or plastic if operating in the presence of light. Prior to making a validation measurement, power UBAT on and measure the instrument dark counts. Values should be < 1 average raw A/D counts over a 1 minute period.

Because the validation light source is on the mid- to upper end of the sensing capabilities of the UBAT, long-term exposure to light will decrease the PMT sensitivity. Therefore, the validation light source should not be left on for greater than 1 minute. If it is left on for longer periods, the lifetime of the PMT might be reduced.

1. Remove the calibration port cover (6 outer screws) using a #1 Phillips screw driver.
   Do not remove the center screw!

2. Store the port plug and screws in a safe place: damage to the plug will change the reflection characteristics of the UBAT detection chamber.

3. Insert the validation LED light source and use the 4 #6-32 x 0.375 flat head Phillips screws (FHPS) to fix it into place.

   Note that the LED light source is keyed to fit a specific orientation.

4. Plug the calibration LED light source into the 3-socket connector, located at the back of UBAT.

5. Plug 6-pin UBAT power connector to power/communications cable.

6. Launch the host or a terminal program.
   - ✓ Recommendations: Save output.

7. Provide power to UBAT.

8. Obtain dark counts (1 minute)

9. Type O (upper case "oh") to stop printing (UBAT is now ready to receive control commands).

10. Type `n` (Power validation light source ON).

11. Type P (Print data to screen). UBAT will auto-gain for the light intensity of the LED.

12. Obtain validation measurement for (1 minute)

13. Type `m` (Power validation light source OFF).

To make a manual validation measurement for each individual HV step:

1. Type `L M 1 <enter>`
   `L` = unlock, `M` = manual, `1` = change gain to HV1. (`2` = HV2, `3`=HV3).

2. Verify that the expected HV gain setting is correct by comparing the value of the calibration coefficient with that on the characterization sheet for the specific HV gain setting.

3. Repeat steps 9–13 for HV2 and 3.

7. UBAT Maintenance and Cleaning

The UBAT should be serviced following each deployment, but the frequency of service depends on deployment and use. UBAT should be rinsed with fresh water between profiles. For long-term or inline deployments, UBAT should be serviced at frequent intervals to maintain measurement accuracy. If UBAT is moored long-term in highly productive regions, more frequent servicing may be required. For long-term storage, UBAT should be disassembled, cleaned with dilute soapy water, rinsed with de-ionized water and the detection chamber and PMT faceplate dried using Kimwipes to prevent formation of water spots.

WET Labs recommends you return your UBAT annually for servicing and recalibration by our trained technicians. If the light flux of the validation LED light source measured by UBAT shows greater than 10 percent change from factory calibration values after UBAT has been cleaned, UBAT should be returned to WET Labs for servicing.

- Soft sponge
- Diluted dish soap
- Small Phillips screwdriver
- Warm tap water
- 3/16 in. ball driver
- Kimwipes
- De-ionized water
- Canned air, e.g. “Dust-Off”
- Silicon spray
- Dummy plugs (3)

Cautions

- **Do not use Scotch-Brite™ pad or similar to clean UBAT detection chamber.**
- **Do not scratch the polyurethane faceplate or detection chamber. Scratches on this surface will change the reflective properties of the detection chamber.**
- **Do not use acetone or other solvents to clean the sensor. Solvents will damage the polyurethane faceplate and detection chamber.**
- **Do not use WD-40 on the connectors.**
- **DO NOT use an automatic ball driver or manually over tighten screws. Damage to the housing may occur.**

Note that each section is mated using guide pins provided for proper orientation and an O-ring between each section that acts as a light baffle.

Caution

DO NOT unscrew the purge port plug. The electronics housing seal will be compromised.

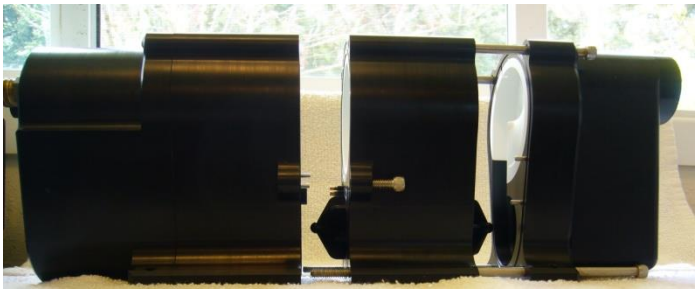
Exterior view of the front section of UBAT showing the intake and location of the four bolts that hold the unit together.

Caution

Do not remove the bolts holding the intake together.

1. Use a 3/16 in. ball driver to remove the 4 Socket Head Cap Screw (SHCS) from the meter.

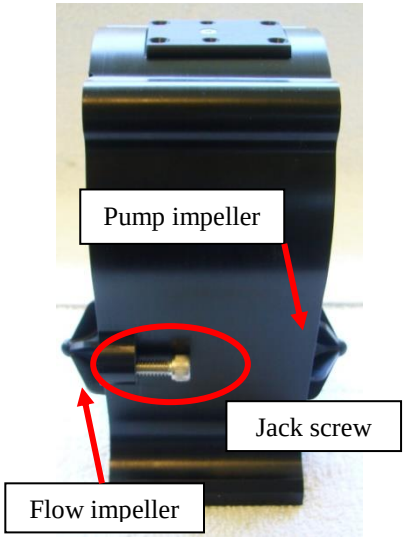
   Use jack screws located on the exterior of the mid-section to gently separate the mid- and back sections.



2. Clean the detection chamber walls and faceplate using a soft sponge and warm soapy water. Rinse thoroughly with DI water.

3. Dry with lint-free tissues, e.g. Kimwipes.

The mid-section of UBAT contains the majority of the detection chamber, motor electronics, pump and flow impellers, and the calibration/validation port.



Mid-section, side view

Mid-section, internal view

4. Secure dummy plugs on the internal connectors prior to submersion.

5. Secure dummy plugs on the external connectors prior to submersion.

6. Clean main part of detection chamber as in steps 2 and 3 above.

7. Use compressed air to dry the internal connector and apply electronics-grade silicon spray (cover the detection chamber to avoid spray of water droplets or silicon)

8. Dry with lint-free tissues.

Caution
Cover the detection chamber with a towel or lint-free tissues before drying connectors or spraying with silicon.

Caution
Do not use pliers to remove the impellers. This will damage the plastic.

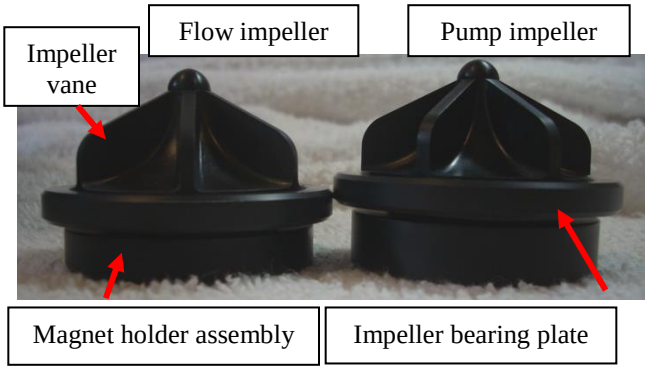
9. Remove the pump impeller from the housing by grasping two of the impeller blades and pulling it to loosen it from its magnetic coupling. If necessary you can rock the impeller back and forth to promote disengagement from the magnets.

10. Remove the flow impeller (opposite the pump) for cleaning.

11. Clean both impeller sockets. Rinse.

12. Dry with compressed air.
13. When reinstalling the pump and flow impellers, please note that impellers are NOT interchangeable and are different sizes. The pump impeller (right) is taller than the flow impeller (left). The pump impeller is located at the intake whereas the flow impeller is located at the exhaust.

    The impellers should rotate freely when holding the impeller bearing plate and spinning the impeller vane. If not, internal damage to the rotor assembly may have occurred.



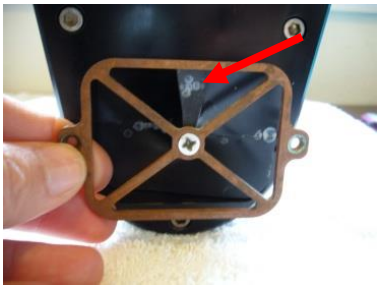
The PMT-section of UBAT contains PMT and control electronics. The motor from the mid-section is connected internally to this section by a 6-pin female MCBH connector.

14. Clean the clear polyurethane PMT faceplate with warm soapy water and a soft sponge. Rinse thoroughly with DI water.

15. Dry with lint-free tissues.

16. Clean the exhaust chamber, helical exhaust baffle and copper grid.

17. Remove the two outer Phillips FHCS holding the copper grid in place. DO NOT remove the center screw.



18. Remove the copper grid and helical exhaust baffle. When ready to re-install, ensure that the center vane is oriented facing up (shown here with red arrow).

19. Clean the helical exhaust and internal exhaust chamber. Depending on the amount of fouling, a Scotch-Brite™ may be used to clean these parts. Rinse thoroughly with DI water.

To reassemble UBAT, orient the sections using the guide pins. Pay special attention when mating the 6-contact internal MCBH connectors to ensure that the male and female connectors mate evenly. Press the sections together gently. Insert the screws into the holes on the front of the UBAT (intake section) and manually tighten using a 3/16 inch ball driver, to finger tight.

Verify system response using validation LED light source, refer to section 6.2.

Appendix A: Control Commands

UBAT comes with a graphical user interface and control software package. However, a terminal emulator program such as HyperTerminal can also be used to communicate with UBAT. Once power is applied, type O to stop printing. Type ? <enter> to obtain a list of the electronics control commands and the firmware version. Control commands for UBAT are listed below. These commands are case sensitive. To record data in HyperTerminal choose Transfer > Capture Text from the tool bar.

Electronics control commands
L - unlocks, then: M - for manual HV step 1,2, or 3 <enter>
C - store cal multiplier for HV step 1
V - store cal multiplier for HV step 2
B - store cal multiplier for HV step 3
hit the <enter> after entering values in the form 1.23E4
P - to start printing data
O - (oh) to stop printing (and pump)(PMT to standby)
g - to start pump
s - to stop pump
o - to turn on PMT 12v
i - to turn off PMT 12v
n - to turn on external cal power (12v)
m - to turn off external cal power

Appendix B: Anti-fouling Application Note

The following are suggestions, tips, and techniques that have worked for others in the oceanography community. Copper foil tape or electrical tape should be applied to the external housing to reduce fouling.

Caution

Do not tape over air-bleed holes located to the top of the detection chamber.

Adhesive-backed copper foil tape. This tape is very thin and pliable, and it's easy to apply, especially in the narrower widths. Because the polyurethane adhesive backing becomes gooey after long exposure to seawater, we first apply a layer of electrical tape to the plastic, and then apply the copper foil over the electrical tape. To remove build-up, simply unwrap the electrical tape and you're left with a fairly clean housing. The copper corrodes over time. Start with one layer of tape for every six weeks of deployment Source: www.mcmaster.com, P/N 76555A725.

Electrical tape. High quality electrical tape (i.e. 3M Scotch Super 33+) will withstand extended service in seawater, and can be removed with little or no adhesive residue. Softer types of biofoulants will peel off with the tape. Tape can be applied over irregular surfaces. It also blocks light, inhibiting growth in cavities.

Pressure washing. WET Labs does not recommend this for the sensor, as intense spray can compromise seals.

Revision History

Revision	Date	Revision Description	Originator
A	5/10/10	New document (DCR 694)	C.Orrico
B	11/9/10	Clarify validation steps (DCR 725)	C. Orrico
C	7/9/15	Update part numbers, correct # of output columns (DCN 914)	J. Pauk