User manual

SeaOWL UV-A

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Table of Contents

Section 1 Safety information

Please read this entire manual before this equipment is unpacked, set up, or operated. Pay attention to all danger, warning, and caution statements. Failure to do so could result in serious injury to the operator or damage to the equipment.

DANGER

Indicates a potentially or imminently hazardous situation which, if not avoided, will result in death or serious injury.

WARNING

Indicates a potentially or imminently hazardous situation which, if not avoided, could result in death or serious injury.

CAUTION

Indicates a potentially hazardous situation that may result in minor or moderate injury.

NOTICE

Indicates a situation which, if not avoided, may cause damage to equipment. Information that requires special emphasis.

1.1 Hazard information

WARNING

This product can expose the user to chemicals with silica, crystalline (airborne particles of respirable size), which is known to the State of California to cause cancer and birth defects or other reproductive harm. For more information, go to www.P65Warnings.ca.gov.

WARNING

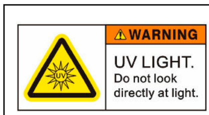
Sensors that use ultraviolet light sources (< 400 nm): Do not look directly at a UV light source when it is on. It can cause damage to the eyes. Keep products that have UV light sources away from children, pets, and other living organisms. Wear polycarbonate UV-resistant safety glasses to protect the eyes when a UV light is on.

NOTICE

The manufacturer is not responsible for any damages due to misapplication of misuse of this product including, without limitation, direct, incidental and consequential damages, and disclaims such damages to the full extent permitted under applicable law. The user is solely responsible to identify critical application risks and install appropriate mechanisms to protect process during a possible equipment malfunction.

1.2 Equipment labels

Read all labels and tags attached to the equipment. Personal injury or damage to the equipment could occur if not observed. A symbol on the equipment is referenced in the manual with a precautionary statement.

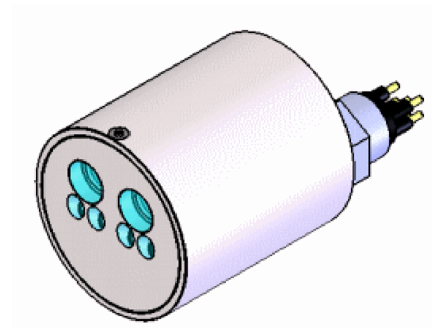
	Do not look directly at a UV light source when it is on. It can cause damage to the eyes. Keep products that have UV light sources away from children, pets, and other living organisms. Wear polycarbonate UV-resistant safety glasses to protect the eyes when a UV light is on.

	EFUP e: No hazardous material exists over the threshold of GB/T 26572-2011 standard, China's Requirements for Concentration Limits for Certain Hazardous Substances in Electrical and Electronic Products. This product should be recycled after its environmentally friendly use period.

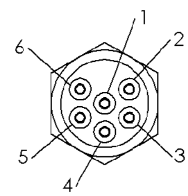
	Electrical equipment marked with this symbol may not be disposed of in European domestic or public disposal systems. Return old or end-of-life equipment to the manufacturer at no charge to the user.

Section 2 Specifications

2.1 Mechanical

Diameter	5.66 cm	
Length	6.35 cm	
Depth rating	2000 m	
Temperature range	-2–38 °C	
Storage temperature range	-20–50 °C	
Weight in air	0.44 kg	
Displacement	160 ml	
Pressure housing	Titanium 6Al-4V	

2.1.1 Bulkhead connector

Contact	Function	MCBH6MP connector
1	Ground	
2	RS232 RX	
3	Reserved	
4	Voltage in	
5	RS232 TX	
6	Reserved	

2.2 Electrical

Input	7–15 VDC
Current draw	81 mA (peak: up to 100 mA)
Linearity	99%

2.3 Communications

Sample rate	1 Hz
RS232 output rate	19200 baud
Output resolution	14 bit *(Multistage digitization sends continuous output from 0–160,000 counts.)*

2.4 Optical

Parameter	Wavelength EX/EM	Range, Sensitivity
Chlorophyll (Chl)	470/695 nm	0.005–250, 0.005 µg/L
Fluorescent Dissolved Organic Matter (FDOM)	370/460 nm	0.03–900, 0.03 ppb QSDE
Backscattering	700 nm	0–0.04 m^{-1} sr^{-1}, 1E-06 m^{-1} sr^{-1}

Crude oil limit of detection, sensitivity	< 80, 3 ppb

Section 3 Operation and maintenance

3.1 Verify operation

⚠ WARNING

fDOM sensors use an ultraviolet LED light source. Do not look directly at a UV LED when it is on. It can cause damage to the eyes. Keep products that have UV LEDs away from children, pets, and other living organisms. Wear polycarbonate UV-resistant safety glasses to protect the eyes when a UV LED is on.

NOTICE

Do not supply more than 15 VDC to the sensor. More than 15 VDC will cause damage.

Make sure that the sensor operates before further setup and deployment.

1. Connect the sensor to a PC that has a terminal program such as Tera Term or HyperTerminal® installed. Refer to Get and install terminal program on page 11 for instructions to get, install, and use a terminal program.
2. Remove the cap that protects the sensor's optical face.
3. Connect the sensor to a regulated power supply set at 12 VDC.
4. Turn on the power supply.
   The sensor comes on.
5. Start the terminal program on the PC.
6. Select the appropriate "COM Port" in the terminal program.
7. Select the correct serial port settings in the terminal program.
   - baud rate: 19200
   - stop bits: 1
   - data bits: 8
   - flow control: none
   - parity: none.

   Data shows in the terminal window.
8. Look at the data. The default from the manufacturer is sequence 3. Refer to Output sequence description on page 14 for details.
9. To stop the data, select **File**, then *Disconnect* (Tera Term).
   The data stops.
10. To close the program, select **File**, then *Exit*.

3.2 Set up for deployment

1. Refer to the previous section to make sure that the sensor operates correctly.
2. If necessary, remove the protective cap from the sensor.
3. Use an external power supply to supply power to the sensor for deployment.

3.3 Sensor maintenance

NOTICE

Do not use acetone or other solvents to clean any part of the sensor.

1. After each cast or exposure to natural water, flush the sensor with clean fresh water.
2. Use soapy water to clean any grease or oil on the optical face of the sensor. The optical face of the sensor is made of material (titanium, optical epoxy, and glass) that scratches easily and can be damaged if an abrasive cleaner is used.
3. Dry the sensor with a clean soft cloth.

3.3.1 Clean bulkhead connectors

NOTICE

Do not use WD-40® or petroleum-based lubricant 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.

Use silicone-based lubricants only.

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 failure of the bulkhead connector.

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. Do not use too much lubricant, as that will prevent a good seal.

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

Section 4 Reference

4.1 Delivered items

- the sensor
- a lock collar (not applicable for SLC)
- a plastic protective cover for the optical face
- the CD, with:
  - this user manual
  - the characterization/calibration page for the sensor.

4.2 Calibration

The manufacturer calibrates all scattering sensors to make sure that the data that is collected meets the specifications for the sensor. This information is on the sensor-specific calibration page that comes with the sensor.

4.3 Characterization

The manufacturer uses a fluorescent material to characterize all fluorescence sensors to make sure that the data that is collected meets the specifications of the sensor. This information is on the sensor-specific characterization page that comes with the sensor.

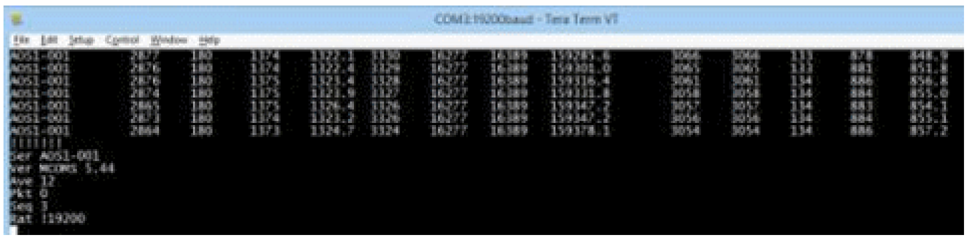
4.4 Terminal program operation

4.4.1 Get and install terminal program

Get and install a terminal communications program to communicate between the PC and the sensor. The steps below refer to Tera Term, an open-source terminal emulator program, but the set up and protocols are similar for other terminal communications programs.

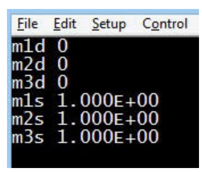
1. Do the steps on the web site www.ayera.com/teraterm/download.cfm to get the software.
   - **a.** Enter the required information on the web site.
   - **b.** Select "Save As" to save the software to a user-selected location on the PC.
   - **c.** Right-click on the .zip file and select "Extract all..."
2. Go to the extracted files and double-click on the ttermpro.exe file.
3. Push **Run**.
4. Push **OK** in the **Tera Term: New connection** window.
5. In the **Tera Term Web 3.1 - COMx VT** window, go to **Setup**, then *Serial port....*
   - Port: user-selected COM x
   - Baud rate: 19200
   - Data: 8 bit
   - Parity: none
   - Stop: 1 bit
   - Flow control: none
   - Transmit delay, msec/char: 2
   - Transmit delay, 50 msec/line
6. Push **OK**.
7. To view commands as they are entered, go to the **Setup** menu, then *Terminal...* and put a check in the box next to "Local echo."
8. To save this setup, go to the **Setup** menu, then *Save setup....*

9. Enter a new "File name," or push **Save** to save the default "teraterm.ini" setup file name.
10. Connect the sensor to a power supply set at 12 VDC and PC.
    Refer to Verify operation on page 7 for details.
11. Make sure that the terminal program is open.
12. Turn the power supply on.
    The sensor automatically starts to collect and show data.
13. Enter ! ! ! ! ! to stop the sensor.
    The menu of the sensor shows below the collected data.



- ser: serial number of the sensor
- ver: version of installed firmware
- ave: the number of measurements that are averaged to make up one row of data.
- seq: the manufacturer-set sequence in which data is output.
- rat: baud rate

14. Enter **$cal** to see the calibration settings that are saved in the sensor.



15. Enter **$run** to start the sensor.
    The sensor collects and shows data.
16. Find the offset, or dark counts value of the sensor for data correction.

4.4.1.1 Find sensor offset value

Use the power supply that the sensor will use for deployment to find the offset value of the sensor output. It is possible that the offset given by the manufacturer is different because the sensor is very sensitive in terms of both input and output.

1. Cover the detectors on the optical face of the sensor with Scotch 33™ electrical tape. Make sure that the tape does not cover any part of the LED optical bore holes.

2. If necessary, connect the sensor to the PC and power supply and start the terminal program.

3. Turn the power supply on.
4. Enter **$run**, then push **Enter** to start the sensor operation. Let the sensor operate for approximately 60 seconds.

5. Enter **! ! ! ! !** to stop the sensor.
6. Calculate the average each of column 4, 8, then 13.
   These averages are the offset ("dark counts") values to use for chlorophyll, scattering, and FDOM or 532 nm scattering.
7. Save these values to use when the data from a deployment is processed.
8. Remove the electrical tape from the optical face of the sensor.
9. Use a lint-free wipe and isopropyl alcohol to gently clean any remaining adhesive from the optical face.
   The sensor is ready to deploy.

4.4.2 Common terminal program commands

Command	Parameters	Description
!!!!!	none	Stops the data collected by the sensor. Lets the user to enter setup values. If the sensor is in a low-power mode, turn the power supply off for one minute, then turn the power on and push the "!" key 5 or more times.
$ave	1–255	The number of measurements that make up each row of collected data.
$mnu	—	Prints the menu of setup values to the PC screen.
$pkt	0–65535	Sets the number of rows of data that are collected between the specified time intervals.
$rls	none	Gets the settings from the flash memory.
$run	—	Uses the current setup values to operate.
$sto	—	Saves the desired setup values to the flash memory.

4.4.3 SeaOWL-specific terminal commands

Command	Parameters	Description
$cal	none	Shows the calibration settings.
$m1d	0–127	Parameter 1, dark count value to calculate the data collected in engineering units.
$m2d	0–127	Parameter 2, dark count value to calculate the data collected in engineering units.
$m3d	0–127	Parameter 3, dark count value to calculate the data collected in engineering units.
$osd	0–3	Shows the output sequence for the selected value. These values agree with the meta data shown with $mdl.
$ose	0–3	Starts the output sequence entry mode for the selected value. Enter data by line number: $nn<space>value<enter> *where***nn** is the field number and **value** is the related output field that shows in that field. Start the sequence input with the delimiter $00 and end it with $99.
$rat	2400–230400	Baud rate for communication. An invalid baud rate defaults to 19200. It shows as 19201 so that the user knows the baud rate in use by the software.

$rfd	none	Loads the original setup from the manufacturer.
$rls	none	Loads the original settings from the flash memory.
$seq	0–3	Selects on of the pre-defined sequences to use for data collection.

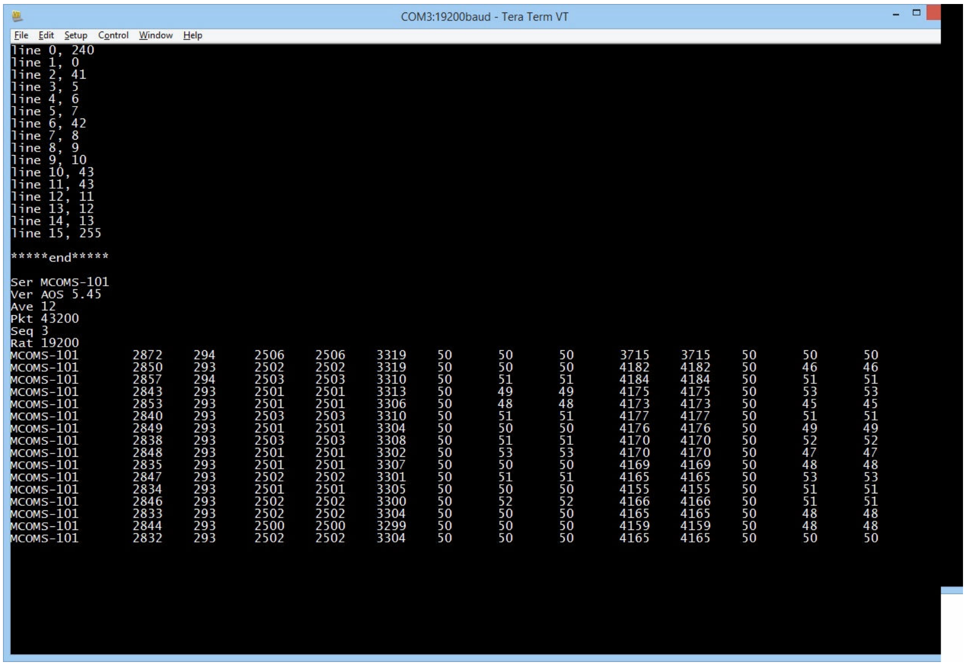
4.5 Output sequence description

The sensor has four different "sequences" of data output that are user-selectable. The default from the manufacturer is sequence 3.
Refer to the table below for details about the variable output fields.

Value	Output
0	serial number
3	dummy date, 99/99/99
4	dummy time, 99:99:99
5	chlorophyll high-gain raw counts
6	chlorophyll low-gain raw counts
7	chlorophyll reported output
8	bb 700 high-gain raw counts
9	bb 700 low-gain raw counts
10	bb 700 reported output
11	FDOM high-gain raw counts
12	FDOM low-gain raw counts
13	FDOM reported output
14	internal thermistor counts
15	chlorophyll low-gain dark counts for engineering calculation
16	bb 700 low-gain dark counts for engineering calculation
17	FDOM low-gain dark counts for engineering calculation
18	numeric part of serial number
19	chlorophyll scale factor for engineering calculation
20	bb 700 scale factor for engineering calculation
21	FDOM scale factor for engineering calculation
22	chlorophyll high-gain dark counts for engineering calculation
23	bb 700 high-gain dark counts for engineering calculation
24	FDOM high-gain dark counts for engineering calculation
27	engineering output, chlorophyll
29	engineering output, bb 700
32	engineering output, FDOM
41	LED 1, chlorophyll forward voltage
42	LED 2, backscatter 700 nm forward voltage
43	LED 3, FDOM or backscatter 532 nm forward voltage
44	LED 4, FDOM or backscatter 532 nm forward voltage (LEDs 3 and 4 report the same values)

240	printf tab
241	putchar 0x09 (tab)
255	printf/n (carriage return line feed)

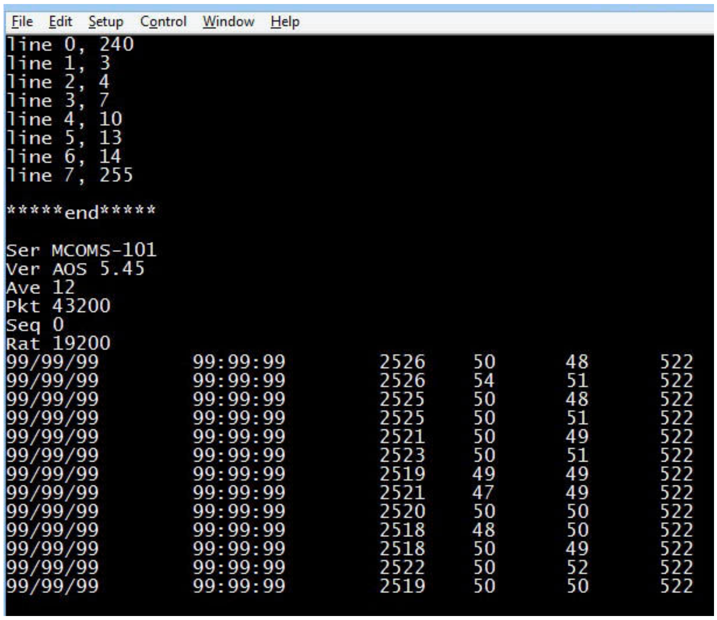
Figure 1 Manufacturer-set sequence 3



All relevant data shows. This sequence lets the manufacturer troubleshoot any issues with the data.

Column	Output
1	sensor serial number
2	chlorophyll LED forward voltage
3	chlorophyll low-gain raw counts
4	chlorophyll high-gain raw counts
5	chlorophyll reported output
6	bb 700 LED forward voltage
7	bb 700 low-gain raw counts
8	bb 700 high-gain raw counts
9	bb 700 reported output
10	FDOM LED1 forward voltage
11	FDOM LED2 forward voltage
12	FDOM low-gain raw counts
13	FDOM high-gain raw counts
14	FDOM reported output

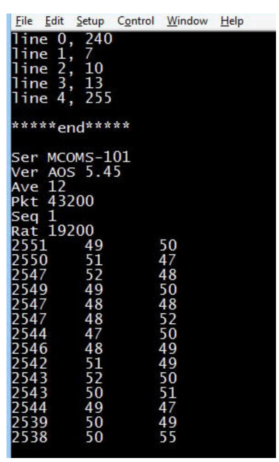
Figure 2 Example of user-set sequence 0



This data is almost the same as the ECO Triplet-w, without the date and time information.

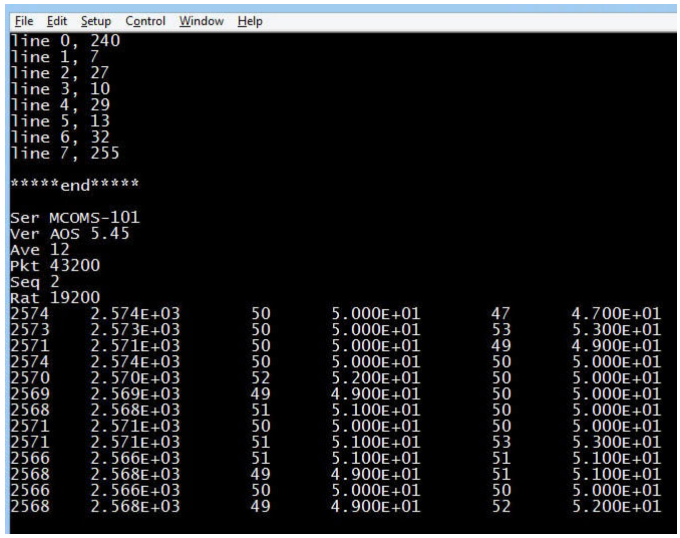
Column	Output
1	date placeholder
2	time placeholder
3	chlorophyll reported output
4	bb 700 reported output
5	FDOM reported output
5	thermistor

Figure 3 Example of user-set sequence 1



Column	Output
1	chlorophyll reported output
2	bb 700 reported output
3	FDOM reported output

Figure 4 Example of user-set sequence 2



Column	Output
1	chlorophyll reported output
2	chlorophyll calculated
3	bb 700 reported output
4	bb 700 calculated
5	FDOM reported output
6	FDOM, calculated

4.5.1 Change output sequence

Refer to Get and install terminal program on page 11 to set up communication with the sensor.
Use the commands below to change the output sequence.

1. **$seq 2** (change to sequence # 2. Other sequences can be selected as well.)
2. **$run** (verify that the output is correct).
3. **!!!!!** (stop the data output).
4. **$sto** (store the settings in the flash memory of the sensor).

4.5.2 Make new output sequence

NOTICE

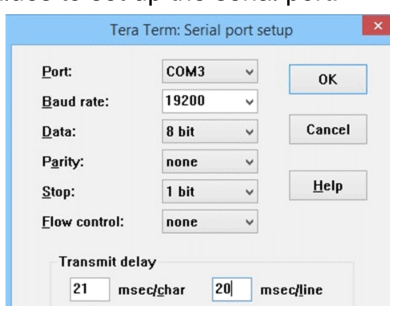
If the user changes the output string it is not possible for the manufacturer to make an analysis of sensor performance and the data that is collected by the sensor.

The user can overwrite sequences 0–2 to make a custom output sequence. The manufacturer recommends that the user does not change sequence 3.
The output columns in the image above are wrapped if there is not sufficient space on a PC screen.

1. Start a spreadsheet program such as Microsoft Excel®.
2. Make a spreadsheet that has the necessary values from columns 1 and 2 below.

$0se	1 (**must come first**)	sequence number
$0	240 (**must follow $ose**)	start print
$1	1	column 1 output = date (first column of output)
$2	2	column 2 output = time
$3	3	column 3 output = chlorophyll high-gain raw counts
$4	4	column 4 output = chlorophyll low-gain raw counts
$5	5	column 5 output = chlorophyll reported output
$6	6	column 6 output = bb 700 high-gain raw counts
$7	7	column 7 output = bb 700 low-gain raw counts s
$8	8	column 8 output = bb 700 reported output
$9	9	column 9 output = FDOM high-gain raw counts
$10	10	column 10 output = FDOM low-gain raw counts
$11	11	column 11 output = FDOM reported output
$10	255 (**required value**)	end print
$99	(**must follow "end print"**)	end sequence input
$osd	(**must follow $99**)	display (show) the sequence

3. Make sure that the sensor is on and in communication with the terminal program.
4. If necessary, start the terminal program.
5. Enter the values to set up the serial port:



6. Push **OK**.
7. Select the sequence made in Excel and copy (Ctrl-C) it.
8. Make sure that the cursor is in the terminal program and that the sensor is not in operation. and
9. Select *Paste* from the **Edit** menu.
10. Type **$sto** to store the new sequence in the sensor.
11. Type **$seq 1** to change the output of the sensor to the new sequence.
12. Type **$run** to see the output format of the data that is collected by the sensor.

4.6 Set output sequence for CTDs

The SeaOWL has been integrated with CTDs, but because of the differences in communication protocols, the user must change the output of the SeaOWL UV-A so that the two sensors can communicate. Refer to "Change variable output" section for instructions to change the sequence.

- Sea-Bird 16PlusV2 and Sea-Bird 19PlusV2: Sequence = **seq 3**
- Sea-Bird 25Plus: Sequence = **seq 2**

4.7 Convert FDOM to oil equivalent

Because the signal from FDOM is ubiquitous in natural waters and overlaps with the signal from dispersed oil, the calculation of the quantity of oil in natural water must include the subtraction of a background value of FDOM.
When CTD data is available and the oil contamination is in separate water masses, a dynamic background estimate can be derived from the generally inverse relationship between salinity and FDOM. A linear regression will typically give a good fit. Use this relationship to calculate FDOM for the background values when water masses are similar. The user can calculate the FDOM in an area where there is less knowledge of the amount of oil contamination.

For an application in which the source water is constrained and the additional signal is from the substance of interest (oil), use the steps below.

1. Put black electrical tape over the optics of the sensor.
2. Operate the sensor in a container of the cleanest water available.
3. Record the output.
   This is the "dark count" value.
4. Remove the tape.
5. Operate the sensor in an uncontaminated area that is similar to the area where oil is thought to be (for example, outside of the plume, or, if an a flow-through system, where the incoming stream is not contaminated).
6. Record the output.
   This is the "background" value.
7. Calculate the apparent crude oil concentration in the "background" or uncontaminated water.
   This is the "crude oil scale factor" value. The crude oil scale factor × (background - dark counts) = background crude oil concentration.
8. Operate the sensor in the oil-contaminated water.
9. Record the output.
   This is the "gross dispersed crude oil" value.
10. Calculate the gross crude oil concentration value:
    Crude oil scale factor × (gross dispersed crude oil concentration - dark counts) = gross crude oil concentration.
11. Subtract the background:
    Crude oil concentration = gross crude oil concentration - background crude oil concentration.

4.7.1 Adjust sensor for wide temperature range

The manufacturer has tested the SeaOWL between 0 and 35 °C but the sensor can operate outside that range. The quantity of FDOM changes with the temperature: the signal decreases as the temperature of the water increases.

If the temperature will be outside the tested range for a specific application, the user can test the signal of uncontaminated water at a low temperature and at a high temperature and adjust the FDOM signal as in the example below.

1. The FDOM water in the application signal is 200 counts at 20 °C.
2. A sample of the FDOM water in the application is chilled to 10 °C; the signal is 220 counts.
3. A sample of the FDOM water in the application is warmed to 30 °C; the signal is 180 counts.
4. The change in the signal per degree is thus 2 counts.
5. Modify the crude oil equation to include the temperature adjustment:

Crude oil Scale Factor × (4000 - [200 × (2 counts/degree × 20 - Temperature)]) = crude oil

1.4 × 3800 = 5300 ppb crude oil (Dispersed Macondo Equivalent NIST SRM 2779).

Section 5 General information

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

5.1 Warranty

This sensor is warranted against defects in materials and workmanship for one year from the date of purchase. The warranty is void if the manufacturer finds the sensor was abused or neglected beyond the normal wear and tear of deployment. The manufacturer will replace or repair, as deemed necessary, any defective components. This warranty does not include shipping charges to and from the manufacturer's facility.

5.2 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-butyltin, 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.

5.3 Tera Term BSD license

Tera Term is used under a BSD open source license.

Copyright

```
This program is free software. Tera Term is licensed under BSD style license.

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including any general, special, incidental or consequential damages arising out of the use or
inability to use the program (including but not limited to loss of data or data being rendered
inaccurate or losses sustained by you or third parties or a failure of the program to operate
with any other programs).

URL: http://ttssh2.osdn.jp/
Project: http://osdn.jp/projects/ttssh2/
e-mail: yutakakn@gmail.com (Yutaka Hirata)
forum: http://www.logmett.com/forum/index.php
ML(Japanese): http://www.freeml.com/info/teraterm@freeml.com

Tera Term Pro(original): http://hp.vector.co.jp/authors/VA002416/
ANSI color change & concatenating multi-line patch: http://www.sakurachan.org/ml/teraterm/msg00264.html
IPv6 version Tera Term Pro: http://win6.jp/TeraTerm/index.html
Eterm lookfeel transparency window patch: http://www.geocities.co.jp/SiliconValley-PaloAlto/4954/av.html
Oniguruma: http://www.geocities.jp/kosako3/oniguruma/

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  URL: http://hp.vector.co.jp/authors/VA013320/
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