# SEA·BIRD SCIENTIFIC

# User manual

# SUNA V2
## Submersible Ultraviolet Nitrate Analyzer

| Document No. | SUNA180725 |
|---|---|
| Release Date: | 2018-07-26 |
| Version: | F |

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# Section 1    Specifications

## 1.1  Mechanical

|  | SUNA with optional wiper | | Standard SUNA | |
|---|---|---|---|---|
| Rated depth | 100 m | | 500 m | |
| Weight (in air) | 4.8 kg | | 3.9 kg | |
| Pathlength | 10 mm | 5 mm | 10 mm | 5 mm |
| Length | 58.8 cm | 58.3 cm | 55.1 cm | 54.6 cm |
| Displacement | 2077 cm³ | 2073 cm³ | 1692 cm³ | 1688 cm³ |
| Diameter | 6.3 cm | | | |
| Material | Titanium (acetal wiper) | | | |
| Temperature range, operation | 0–35 °C | | | |
| Temperature range, dry storage | -20–50 °C | | | |

### 1.1.1  Bulkhead connector

| Contact | Standard | Optional (USB/SDI-12) | MCBH-8-MP |
|---|---|---|---|
| 1 | Voltage in 8–18 VDC (15 VDC for sensors with wiper) | | |
| 2 | Ground | | |
| 3 | — | USB 5 V power | |
| 4 | — | SDI-12 | |
| 5 | RS232 TX | RS232 TX/USB D+ | |
| 6 | RS232 RX | RS232 RX/USB D- | |
| 7 | — | Analog V out | |
| 8 | — | Analog current out | |



## 1.2  Electrical

| Input | 8–18 VDC |
|---|---|
| Input, sensor with wiper | 8–15 VDC |
| Current draw, operation | ~625 mA at 12 V (nominal) |
| Current draw, supervised low power (periodic mode) | < 30 µA |
| Current draw, processor low power (controlled mode) | < 3 mA |
| Current draw, standby (SDI-12 mode) | ~20 mA at 12 V |
| Baud rate | 57600 (9600, 19200, 38400, 115200 available) |
| Communication interface | RS232 (USB and SDI-12 optional) |
| Data storage | 2 GB (optional) |

## 1.3 Optical

| | |
|---|---|
| Spectral range | 190–370 nm |
| Light source | UV deuterium lamp |
| Light source lifetime | 900 hrs |

## 1.4 Analytical

This sensor is designed to measure the concentration of nitrate ions in water. Measurements are in units of micro molar (µM). This is converted into mg/L, and also digital output. Note that 1 µM nitrogen = 0.014007 mg/L nitrogen.

### 1.4.1 Nitrate measurement accuracy

**Table 1  5 mm pathlength**

| Concentration range | Class-based fresh water | Fresh water | Seawater |
|---|---|---|---|
| Best | 0.063 mgN/L (4.5 µM) | 0.056 mgN/L (4 µM) | 0.056 mgN/L (4 µM) |
| up to 1000 µM (14 mgN/L) | 20% | 10% | 10% |
| up to 2000 µM (28 mgN/L) | 25% | 15% | 15% |
| up to 3000 µM (42 mgN/L) | 25% | 15% | 15% |
| up to 4000 µM (56 mgN/L) | 25% | N/A | N/A |

**Table 2  10 mm pathlength**

| Concentration range | Class-based fresh water | Fresh water | Seawater |
|---|---|---|---|
| Best | 0.035 mgN/L (2.5 µM) | 0.028 mgN/L (2 µM) | 0.028 mgN/L (2 µM) |
| up to 1000 µM (14 mgN/L) | 20% | 10% | 10% |
| up to 2000 µM (28 mgN/L) | 25% | 15% | 15% |
| up to 3000 µM (42 mgN/L) | 30% | 20% | 20% |
| up to 4000 µM (56 mgN/L) | N/A | N/A | N/A |

The specified accuracy is best accuracy or a percentage, whichever is more.

- A sensor-specific calibration uses extinction coefficients from the sensor itself.
- A class-based calibration uses extinction coefficients that are the average of many sensors.

### 1.4.2 Nitrate measurement precision
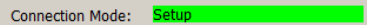
| Processing configuration | Seawater or fresh water with T-S correction | Seawater (0–40 psu) |
|---|---|---|
| Short-term precision (3 sigma) and limit of detection | 0.3 µM (0.004 mgN/L) | 2.4 µM (0.034 mgN/L) |
| Change ("drift") per hour of lamp time | < 0.3 µM (< 0.004 mgN/L) | < 1.0 µM (< 0.014 mgN/L) |
| Limit of quantification | 1.0 µM (0.014 mgN/L) | 8.0 µM (0.112 mgN/L) |

# Section 2    Set up sensor and verify operation

## 2.1  Install and start software

The manufacturer-supplied UCI software communicates with a number of sensors. Refer to the manufacturer's website for the current list of sensors that use this software.

1.  Get the software from the manufacturer's website or the manufacturer-supplied CD.
2.  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 USB will not connect to the sensor.
3.  Push **Run** in the new window.
    The setup wizard starts.
4.  Follow the on-screen instructions to install the software.
5.  Connect the cable to the bulkhead connector on the sensor and to the PC.
6.  If necessary, start the software.
7.  Push **Connect** in the Dashboard area.
8.  If necessary, change the "Instrument Type" to the connected sensor.
9.  Put a check in the "Try All Baud Rates" box.
    The software automatically finds the correct baud rate.
10. If necessary, select the communication port.
11. Push **Connect**.
    The "Connection Mode" shows "Transition" on a yellow background, and then shows "Setup" on a green background.



12. Select the **UCI** menu, then *Preferences*.
13. 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. Note that the UCI software can be started by a double-click on a ".sbsdat" filetype.
14. Push **OK**.

## 2.2  Verify sensor operation

Do the steps below to make sure that the sensor operates, collects, and transfers data with the settings selected by the user before further setup and deployment.

1.  Connect the cable to the bulkhead connector on the sensor and to the PC.
2.  Connect the USB or RS232 cable to the PC.
    For RS232: connect the power connectors on the cable to a 8–15 VDC power supply.
    For USB: a DC power supply is only necessary for data collection. If the sensor is equipped with internal memory, the file system will show as a USB mass storage device on the PC.
3.  If necessary, start the software.
4.  RS232: turn on the power supply.
5.  Push **Connect** in the Dashboard area.
6.  If necessary, change the "Instrument Type" to the connected sensor.
7.  Put a check in the "Try All Baud Rates" box.
    The software automatically finds the correct baud rate.

8. If necessary, select the communication port.

9. Push **Connect**.
   The "Connection Mode" shows "Transition" on a yellow background, and then shows "Setup" on a green background.

   | Connection Mode: | Setup |

10. Select the **UCI** menu, then *Preferences*.

11. 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. Note that the UCI software can be started by a double-click on a ".sbsdat" filetype.
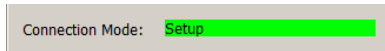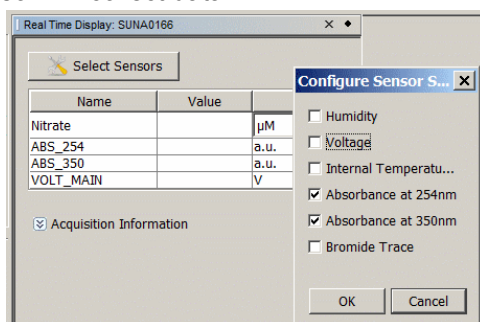
12. Push **OK**.

## 2.3  Verify sensor collects data

1. Push **Start** in the Dashboard area.
   The "Connection Mode" shows "Acquisition."

   - Push **OK** so that the software shows "Temporarily enabling Transmit Real Time Setting...". The software shows the data as it is collected in the *Time Series* tab.
   - The **Expected Data Start** window shows "You will see data in approximately 103 seconds" and shows an indication of time left. This lets the sensor become stable before it starts to collect data.

2. From the **View** menu, select the options to see the data:

   - *Real Time Data*—Put a check in each box next to each parameter for which the sensor will collect data.

   | Real Time Display: SUNA0166 | | | Configure Sensor S... |
   | --- | --- | --- | --- |
   | Select Sensors | | | ☐ Humidity |
   | Name | Value | | ☐ Voltage |
   | Nitrate | | µM | ☐ Internal Temperatu... |
   | ABS_254 | | a.u. | ☑ Absorbance at 254nm |
   | ABS_350 | | a.u. | ☑ Absorbance at 350nm |
   | VOLT_MAIN | | V | ☐ Bromide Trace |
   | Acquisition Information | | | OK   Cancel |

   - *Data Logging*—Push **Start Log** to save the collected data to the PC.

   | Data Logging: SUNA0166 × |
   | --- |
   | Frames Logged: 0  Log Timer: ○ Start Log |
   | Logging Options |
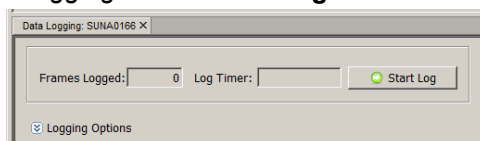
   - *Time Series*, *Spectra*, and *Total Absorbance* graphs.

3. Put a check in the box next to any additional parameters, so that they will show in the *Time Series* graph.
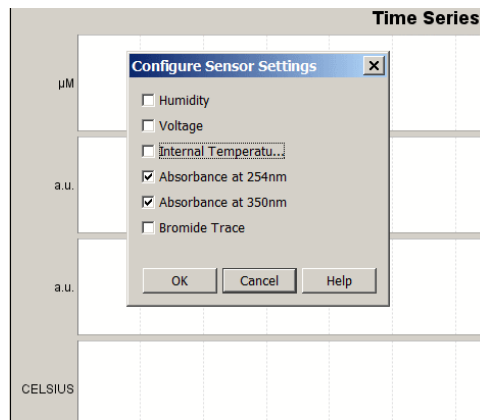
4. Look at the data in the *Time Series* graph. The user can look at data in real-time for each sensor that has power supplied, is connected and is in communication with the software.

   • 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 (refer to the arrow in the graph below).
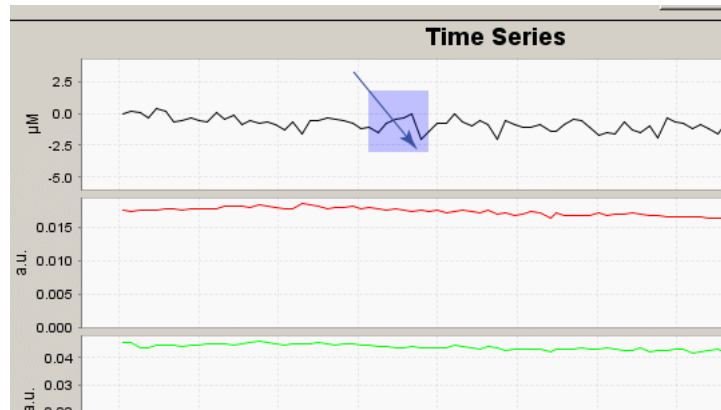


   • Push **Auto Range** to see the data for each selected parameter. The software adjusts the scale so that the data will always show.
   • Push **Default Ranges** to go back to the manufacturer-set default scale for each parameter.
   • Put a check in the box next to "Show Data Points" to see the value 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.

5. Let the sensor or sensors collect data for approximately 5 minutes.

## 2.3.1 Monitor data in spectra graph

The *Spectra* graph shows both the dark and light data in raw counts.
The dark counts are from thermal noise. The light counts are the measured output minus the dark counts.

The measured spectrum is always flat below 200 nm, and then has four or five peaks. The peaks are approximately 25 nm apart in the lower wavelength range and up to 50 nm apart in the upper range.
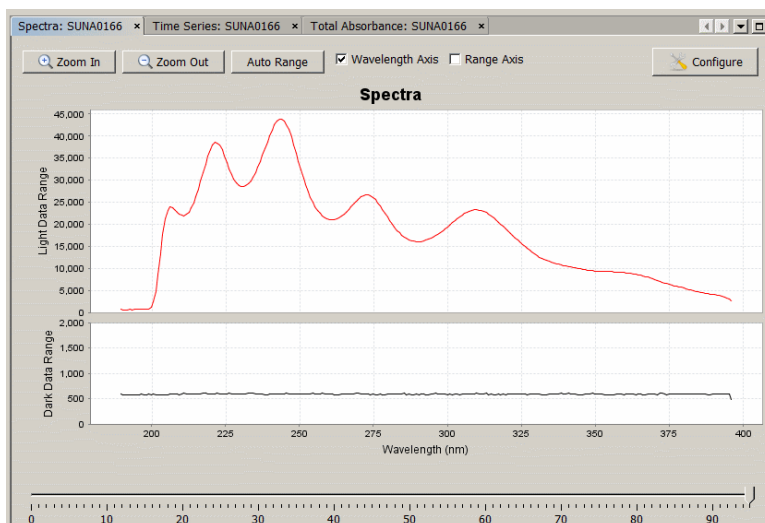


### 2.3.2 Monitor data in time series graph

The *Time Series* graph shows the nitrate concentration and any selected optional values. Use this graph to replay data that is stored in the sensor.



1. Put a check in the box next to either or both the "Time Axis" or the "Range Axis" to enable the **Zoom In** or **Zoom Out** options.
2. Push **Select Sensors** either in the *Spectra* graph or in the *Real Time Display* tab to select the parameters to see on the graph.
3. Push **Configure** to put a limit on or to remove the limit to the "Graph History."

### 2.3.3 Monitor data in absorbance graph

The *Total Absorbance* graph shows the calculated absorbance from 210 to 370 nm. This graph is an alternative to the *Spectra* graph. The absorbance graph should be flat when a sample of DI water is collected. The absorbance increases as absorbing species such as nitrate and bromide are added to samples.
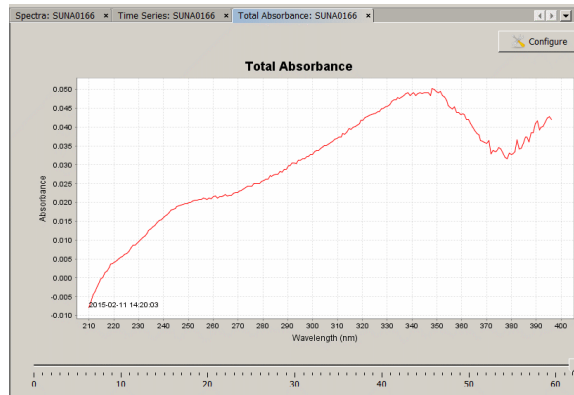
If necessary, push **Stop**.

## 2.4 Verify sensor transfers data

> **⚠ C A U T I O N**
>
> Use only the batteries recommended by the manufacturer as replacements. Do not mix new and used cells or chemistries.

If the sensor is equipped with internal memory, the collected data is saved in the sensor.

**1.** Push **Transfer Files** in the SUNA Dashboard area.
The files saved by the sensor show on the right side of the new **File Manager** window.
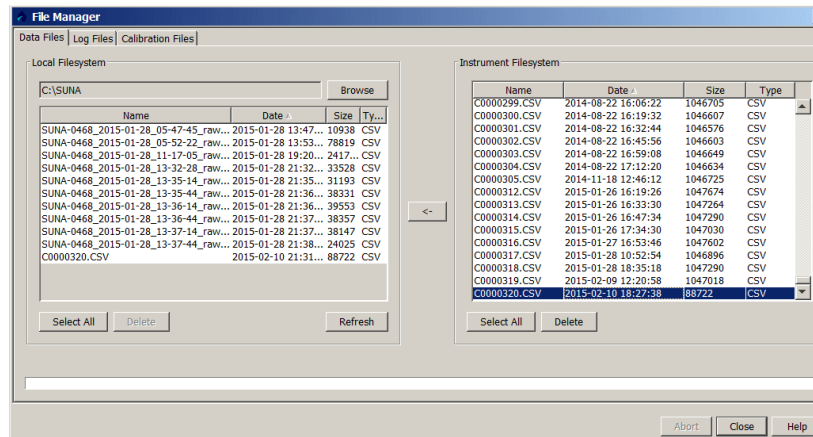


**2.** Select one or more files to copy to the PC.
The manufacturer recommends that the user use a USB connection to move the files because it is much faster.

**3.** Push the **<-** arrow to start the move.
The status shows at the bottom of the **File Manager** window.

**4.** Open the file on the PC to make sure it has all of the collected data.

# Section 3 Deployment and recovery

## 3.1 Attach sensor to cage

The sensor can be attached to a cage or pipe for deployment. Make sure that the sensor is attached correctly or the sensor may be damaged. The manufacturer recommends that the sensor operates in a horizontal orientation with the optical area pointed down to reduce the collection of sediment and bio-fouling.

If the sensor has a wiper—

- Do not use the wiper as a handle.
- Do not attach the sensor to a cage or pipe at the wiper.
- Do not let the wiper touch any part of a cage or pipe.

1. Use cradle clamps to attach the sensor to a flat surface such as a cage.
2. Make sure that both ends of the sensor are attached to a cage or pipe. Do not leave one end unattached, such as at the end of a pipe.
3. The user can attach the sensor to a cage with hose clamps:

    - Put several layers of electrical tape around the sensor to protect the pressure housing.
    - Put clamps over the electrical tape.
4. The user can deploy the sensor in an autonomous or a logger-controlled mode.

## 3.2 Deployment wizard

The deployment wizard makes it easy to set up the sensor for a specific deployment.

1. Select the **Operational Mode**. Push **Next**.
2. Select the **General Settings**.

    a. Select "Frame Based Operation" or "Time Based Operation."
    b. Enter a value between 1–65535 for the "Frame Cycle."
    c. Enter a value between 1–200 for the "Number of Measurements to Average."
    d. If the sensor has a wiper: put a check in the box at "Wiper Settings" to enable the wiper.
    e. Select the "Logging Level." "INFO" is the default. Refer to the Message logging tab on page 26 for details about the levels.
    f. Push **Next**.
3. Select the **Data Settings**.

    a. Select the "Transmitted Frame Format." FULL_ASCII" is the default.
    b. Select the "Log File Creation Method." "Daily" is the default. The other options are to make a log file for each deployment or to limit the log file size to a specified number of MB.
    c. Push **Next**.
4. Select whether the sensor will be deployed in fresh water or seawater. Push **Next**.
5. Make a **Deployment Report** for a record of the settings stored in the sensor.

# Section 4    Data retrieval and analysis

## 4.1  Options to process data

Go to the **Data** menu to select how data is processed.

- Use *Reprocess Data* to apply a different calibration or other setting to saved data.
- Use *Replay Logged Data* to show a graph of saved data.
- Use *Convert APF Data* to convert APF data from the from binary to full_ASCII so data can be re-processed (2000 m sensor only.)
- Use *Compare Calibration* to compare two calibrations from the same sensor.

The SUNA uses the files below to process data:

- The .xml instrument package file. For Windows, this is C:\Users\%USERNAME\My Documents\Sea-BirdScientific\SUNA. For Mac OS X, this is /Users/Home/Sea-BirdScientific/SUNA.
- The raw data file to process.
- The calibration file for the sensor.

### 4.1.1  Convert SUNA raw data

The Convert SUNA raw data function has been replaced with "Export Logged Data" in the software. Go to the **Data** menu and select *Export Logged Data* to transfer the data from the SUNA. Refer to Export logged data on page 16 for details.

### 4.1.2  Reprocess SUNA data

The user may find that it helps to use the *Reprocess Data* option under some conditions.

- The settings for the sensor were incorrect. Use the "Reprocess" option to correct for this, such as when a sensor was deployed in seawater, but set up for fresh water.
- The data that is collected has changed over an extended deployment. Data is processed with an updated reference spectrum file, and compared to the original reference.
- Water temperature and salinity data are collected. These can be put together with the spectral data from the sensor to get more accurate nitrate data (Sakamoto et al. 2009).

Note that the data files collected with SDI-12 (standard sensor) do not contain spectral data and cannot be reprocessed.

1. If necessary, start the software and supply power to the sensor.
2. Go to the **Data** menu, then select *SUNA*, then *Reprocess Data*.
   The Reprocessing Dashboard shows.
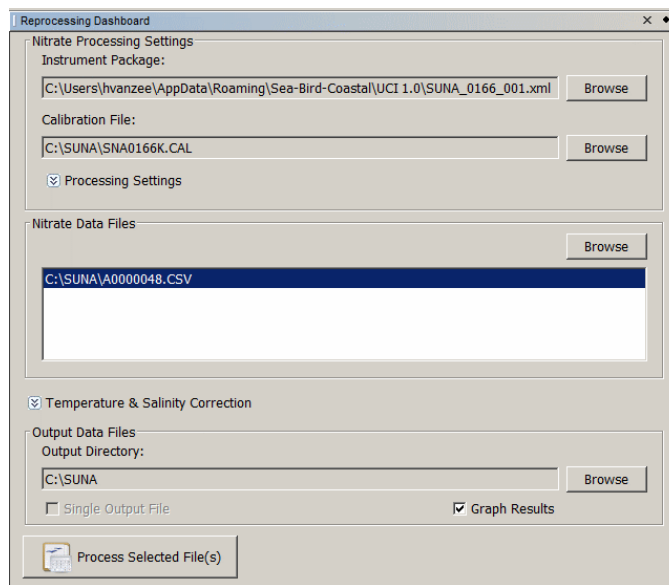
3. Push **Browse** to find the package file, the reference file, and the data file. All are required to reprocess the data.

   - "Instrument Package File" is an .xml file that describes the data from the sensor.
   - "Calibration File" is for the reference spectrum and the extinction coefficients of the chemical species. Use the calibration file that matches the time during which data was collected. Calibration files are stored in the sensor unless the user erases them.
   - "Nitrate Data Files" will show in the dashboard and the user can select some or all to process. Spectral data, which is recorded in full ASCII, full and reduced binary, and APF frames, is required to process nitrate data. Use the reduced binary and APF frames to reprocess data from seawater deployments. Note that the APF frames only let the user reprocess data that was collected with the "integration time adjustment" turned off.

4. The user can change the "Output Directory" if necessary.

5. The reprocess operation will be faster if there is no check in the "Graph Results" box.

6. Push **Process Selected File(s)**.
   The software starts to reprocess the data.

7. Open the files on the PC.

### 4.1.2.1 Nitrate reprocessing details

Settings in "Processing Settings" and the "Temperature & Salinity Correction" areas do not show until selected by the user. The user can change these settings as necessary to get better quality data.

**Processing settings**
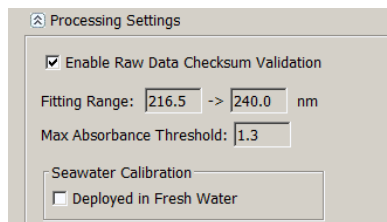


- The default "Enable Raw Data Checksum Validation" is on, with a check in the box. If it is turned off, raw data can be processed even when the checksum values have changed after data is collected.

- The default "Fitting Range" is 216.5–240 nm. If the wavelength is shorter, seawater typically causes extinction, and a poor signal-to-noise ratio. If the wavelength is longer non-characterized materials can be absorbed, which causes a bias in the processed concentrations.
- The default "Max Absorbance Threshold" is 1.3. The precision of the measured absorbance starts to decline at this value. At 2.5 absorbance units, the precision is at the "noise floor." The precision of the processed data is better when the low-quality parts of the "fitting range" are not processed.
- The default Seawater Calibration has no check in the box at "Deployed in Fresh Water." Put a check in this box if the sensor was calibrated for seawater but deployed in fresh water. Data that was collected in seawater with a check in the "Deployed in Fresh Water" box gives incorrect nitrate concentrations.

**Temperature and salinity correction**

Seawater has a temperature-dependent absorption rate. Make sure to consider this so that imprecision does not affect the nitrate concentration that is measured. To mitigate this effect, use the sample temperature and salinity values in the nitrate calculation in the host software for post-processing. Note that spectra and related temperature and salinity data is necessary. The temperature-salinity correction comes from MBARI (cf. Carole M. Sakamoto, Kenneth S. Johnson, and Luke Coletti, Limnol. Oceanogr.: Methods 7, 2009.)

"Temperature and Salinity Correction" is available if the sensor is calibrated for seawater and water temperature and salinity data ("T-S data") are collected. This data can come from frames if the sensor operates in APF mode (SUNA V2 deep only), or from an external file.



1. The default "Activate Temperature & Salinity Correction" has no check in the box. Put a check in this box to add T-S data correction information.
2. Select either "CTD Data from SUNA APF Mode Frames" or "Data from External File" to get T-S data from an external file. The required ASCII format is "YYYY-MM-DD hh:mm:ss, Temperature (c), Salinity (PSU)" e.g. 2012-11-10 90:08:06,12.3,34.567.
3. Push **Browse** to find the file. For "External Files": at the bottom of the new window choose either "Sea-Bird CNV Data File" or "CSV Data File" in the "Files of type:" area. Push **Open**. A green check will show in the T-S Correction area of the software when the data is loaded.
4. The data files must have the same time stamp if more than one is selected. If necessary, put a value in the "Time Offset" area to align the time stamps.
5. Put a check in either the "Single Output File" box or the "Graph Results" box in the Output Data Files area of the dashboard.

   - If the user processes more than one file, the output can be directed to a single file of output. Otherwise, each file that is input to process will have one file of output.

6. Push **Process Selected File(s)**.

   - A graph of the processed data shows in the Reprocessed Nitrate Graph. The upper area shows how the chemical species combine to show measured absorbance. The lower area shows a timeline of the original and reprocessed nitrate concentrations. Use the slider under the timeline to select one measurement and see the concentration to the left.

### 4.1.3   Replay SUNA data

Use **Replay Logged Data** to see the data that has been saved on the PC.
The SUNA uses the files below to process data:

- The .xml instrument package file. For Windows, this is C:\Users\%USERNAME\My Documents\Sea-Bird-Scientific\SUNA. For Mac OS X, this is /Users/Home/Sea-Bird-Scientific/SUNA.
- The raw data file to process.
- The calibration file for the sensor.

1. Push **Replay Logged Data**.
2. If necessary, push **Browse** to find the .xml "Instrument Package File" that is saved on the PC. A typical file is "SUNA_*xxx*_001.xml, where *xxx* is the serial number of the sensor.
3. Push **Browse** to find the "SUNA Raw Data File" to replay the data that is saved on the PC.
4. Push **Browse** to find the current "SUNA Calibration File" on the PC. A typical file is SUNA_*xxxn*.CAL, where *xxx* is the serial number of the sensor, and *n* is the calibration version.
5. Push **Finish**.
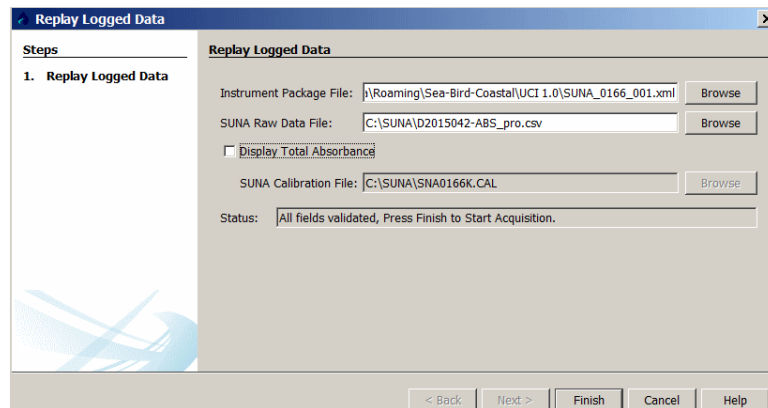


The saved data shows in the *Time Series* tab.

## 4.2   Export logged data

Export the data stored in the sensor to either a comma-separated file or a Microsoft® Excel file with a local or UTC time stamp.

1. From the **Data** menu, select *Export Logged Data*.
2. Push **Browse** to find the file to export.
3. Select a file from the list.
   - Select "SUNA Logged Data File" in the "Files of Type" to see the **.csv** and **.bin** files that show for SUNA, **or**
   - Select "Instrument Logged Data File" in the "Files of Type" to see the **.sbsdat** file that shows for all other supported sensors.
4. Push **Open**
5. Push **Next**.
   The output format shows (all sensors but SUNA).
6. Push **Next**.
7. Select the Export Options, the Format Options, and the Exported Data Output File location.

The data is stored in the directory selected in "Exported Data Output File" area.

8.  Push **Finish**.

## 4.3  Replay data from multiple sensors

The software lets the user replay data that has been saved on the PC from each supported sensor. The user can select up to 12 parameters to replay.

1.  Go to the **Data** menu, then *Replay Logged Data*.
2.  Go to the area of the first supported sensor and push **Browse** to go to the .csv file-type.
3.  Select the file, then push **Open**.
4.  Push **Select Sensors for Display**.
5.  Put a check in the box of each parameter to look at in the *Time Series* graph.
6.  Push **OK**.

# Section 5    Maintenance

## 5.1  Sensor maintenance

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### ⚠ **W A R N I N G**

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If the user thinks that a sensor has water in the pressure housing: Disconnect the sensor from any power supply. Put on safety glasses and make sure that the sensor is pointed away from the body. Use the purge port (if the sensor is so equipped), or very SLOWLY loosen the bulkhead connector to allow the pressure to escape.

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Although the sensor is built for deployment in severe conditions, it is important to clean the sensor after each deployment and weekly (if deployed frequently) or monthly to prevent fouling. After every deployment, make sure to:

1. Attach a clean and lubricated dummy plug and a lock collar to the sensor.
2. Rinse the sensor with fresh clean water.
3. Flush the optical area with fresh clean water.
4. Dry the sensor.
   Use a soft towel or blow with air.
5. Put the sensor in the manufacturer-supplied case for transport or storage.

## 5.2  Maintenance for bulkhead connectors and cables

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### ⚠ **W A R N I N G**

</div>

If the user thinks that a sensor has water in the pressure housing: Disconnect the sensor from any power supply. Put on safety glasses and make sure that the sensor is pointed away from the body. Use the purge port (if the sensor is so equipped), or very SLOWLY loosen the bulkhead connector to allow the pressure to escape.

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### *N O T I C E*

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Connectors that have corrosion can cause a loss of data and increase the costs for service.

- Connectors that have corrosion can cause irreparable damage to the sensor.
- Do not use cleaners that contain petroleum or ketones.
- Do not use the cable to lift the sensor. The cable, cable splices, and bulkhead connectors can be damaged.
- Attach cleaned and lubricated dummy connectors to the sensor immediately after each deployment to prevent the bulkhead connector from damage.
- Do not connect or disconnect connectors under water.

</div>

Examine, clean, and lubricate bulkhead connectors each time they are connected. Connectors that are not lubricated cause wear and tear on the rubber that seals the connector contacts.

1. Clean the connector contacts with isopropyl alcohol. Apply as a spray or with a nylon brush or lint-free swabs or wipes.
2. Flush the contacts with de-ionized or distilled water. Use a wash bottle with a nozzle to flush inside the sockets.
3. Shake the socket ends and wipe the pins of the connectors to remove water.
4. Examine the sockets and the rubber on the pins to make sure there are no problems.

   a. Use a flashlight and magnifying glass.
   b. Look for cracks, frayed scores, and delamination of the rubber on the pins and inside the sockets.

**Table 3  Examples of damaged connectors**



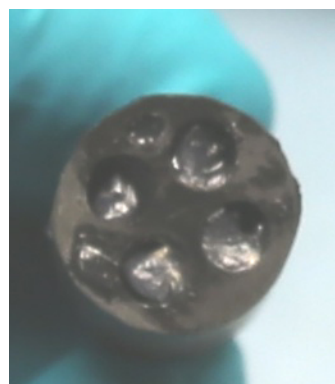| Corroded connector | Damaged contact | Damaged socket face |

5. Use a finger to place a small quantity, approximately 1.5 cm in diameter of Dow Corning® 4 Electrical Insulating Compound on the socket end of the connector.

**Table 4  Lubricant on connector sockets**



Lubricant on socket end of the connector                Lubricant pushed into the sockets of the connector

6. Use a finger to push as much of the lubricant as possible into the sockets.
7. Connect the connectors.
   There should be a small quantity of lubricant pushed to the sides of the connectors.
8. Clean the unwanted lubricant from the sides of the connectors.
   The connectors are now lubricated and the connection is waterproof.

## 5.3  Update reference spectrum

The user needs to update the reference spectrum of the SUNA at regular intervals so that the data that the sensor collects is accurate. It may also be necessary to update the firmware, although that is not required very frequently.

A calibration file contains the data required to convert a spectral measurement into a nitrate concentration. The calibration data are the wavelengths of the spectrum, the extinction coefficients of chemical species and a reference spectrum relative to which the measurement is interpreted. The sensor can store many calibration files, but only the active file has a green background. Push **Transfer Files** > *File Manager*, then select the *Calibration Files* tab to see the list of calibration files stored in the sensor.

Make sure to clean the sensor and the sensor windows at regular intervals and before and after every deployment. Monitor the spectral intensity of the lamp. Although the intensity will decrease over time, make sure there are no sudden changes.

**Necessary supplies:**

- Power supply
- PC with software
- Connector cable for sensor–PC–power supply
- Clean de-ionized (DI) water
- Lint-free tissues
- Cotton swabs
- Isopropyl alcohol (IPA)
- Parafilm® wrap

Notes

- Use only lint-free tissues, OPTO-WIPES™, or cotton swabs to clean the optical windows.
- Use the software to update the reference spectrum.
- Use only clean DI water that has been stored in clean glassware.
- Use Parafilm® wrap to capture DI water in the optical area of the sensor. Do not use cups, a bucket, or a tank to collect a reference sample.

**1.** Clean the sensor:

    **a.** Flush the sensor and the optical area with clean water to remove debris and saltwater.

    **b.** Clean the metal parts external to the optical area so that the Parafilm® will seal.

    **c.** Std. SUNA only: If the sensor is equipped with a wiper, carefully move it away from the optical area.

**Figure 1  Parafilm® to be wound around optical area**



**2.** Cut and stretch a length of approximately 40 cm (16 in.) of Parafilm®.

**3.** Wind several layers of the Parafilm® around the metal near the optical area.

**Figure 2  Parafilm® on optical area**



**4.** Break a small hole in the top of the Parafilm® and fill the optical area with DI water.

**Figure 3  Optical area filled with DI water**



5.  Supply power to the sensor and start the software if necessary.

6.  Make sure that the sensor operates in Continuous mode: push **Settings**, then in the *General* tab, select "Continuous" for the "Operational Mode."

7.  Push **Start**.

    • Push **Start Logging to File** to save approximately one minute of data to the PC.

8.  Push **Stop**.
    The sensor stops data collection.

9.  Open the data file on the PC and calculate the average measurement value.
    This is a "dirty" measurement to record the value when there are biofouling and blockages in the optical area.

10. Remove the Parafilm® and drain the water from the optical area.

11. Clean the optical area:

    a.  Use DI water or IPA and cotton swabs and lint-free tissues to clean the windows.
    b.  Use vinegar to clean debris such as barnacles. Be careful that the windows do not get scratches.

12. Flush the optical area with DI water to remove any remaining IPA or vinegar.

13. Wind Parafilm® around the metal near the optical area.

14. Break a small hole in the top of the Parafilm® and fill the optical area with fresh DI water.

15. Supply power to the sensor and start the software if necessary.

16. Push **Reference Update**.
    The "Reference Update Wizard" shows.

17. Fill the sample volume with distilled water. Refer to the hardware user manual for details.

18. Make sure the "Operational Mode" is set to "Continuous," then push **Next**.

19. The sensor starts to collect data. This will take approximately 30 seconds.

20. Push **Next**.

21. Look at the graph to see the change between reference spectra.

22. Push **Next**.

23. Push **Browse** to select a directory in which to save the Calibration Report.

24. Optional: write a comment.

25. Put a check in the "View" box to automatically open the new report.

26. Put a check in the "View" box to automatically open the new calibration file.

27. Push **Finish**.
    The software makes a report and a calibration file.

## 5.4 Compare reference spectrum files

Compare the change between two reference spectrum files. The amount of change is related to the time interval between the updates and the amount of lamp use during that time.

Note that this procedure is done automatically by the software when the user updates the reference spectrum for the sensor. Refer to Update reference for more information.

1. From the Data menu, select *SUNA*, then *Compare Calibration*.

2. Push **Browse** to find the first calibration, or reference file, to compare.

3. Push **Browse** to find the second file to compare. Note that the files must be from the same sensor.

4. Push **Compare**.
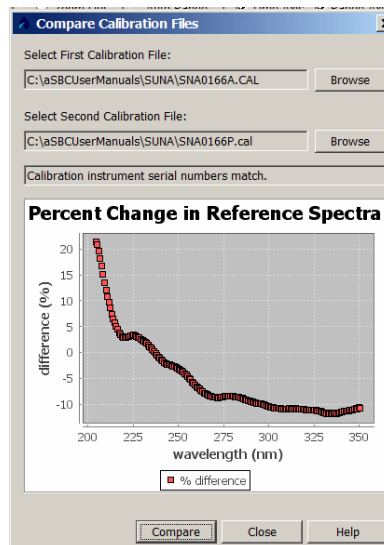


A typical update interval of 3–6 months with no more than 100 hours of lamp use should cause a change of no more than 10% in the 215–240 nm interval.

Below 215 nm, larger relative changes are normal.

Above 240 nm, the change is smaller than at the 215–240 nm range.

If there is a large change, do several reference updates 12–24 hours apart to monitor the stability of the reference spectrum.

## 5.5 Update SUNA firmware

At regular intervals, make sure that the current firmware is installed in the sensor.

1. Go to the manufacturer's web site to get the current firmware for the sensor.

2. Save the firmware to the PC.
   The firmware is an ".sfw" file.

3. Make sure that the sensor is connected to the PC and a power supply.

4. Push **Connect**.

5. Go to the **Sensor** menu and select *SUNA*, then *Advanced*, then *Upload Firmware File*.
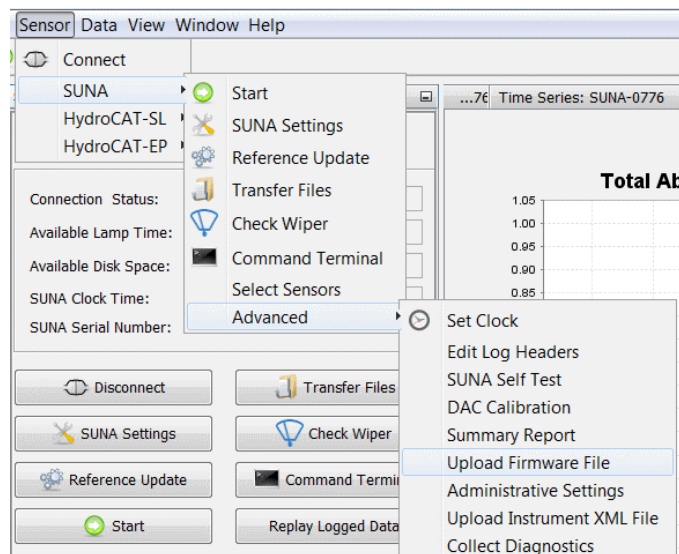
6.  Push **Browse** to find the firmware file that is saved on the PC.

7.  Push **Open**.

8.  Push **Upload**.
    It takes approximately 2 minutes for the software to be updated. The software disconnects the sensor.

# Section 6    Reference

## 6.1  Software settings

This section has information about configuration values and modes of operation that apply to all deployments.

### 6.1.1  UCI menu

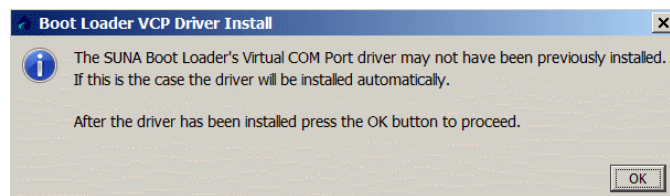The user can set up the way the that the software saves information about the operation of the sensor and change the way that the data looks from the *Preferences* menu.

#### 6.1.1.1  General tab

- "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 that the data is stored in every time the software starts.
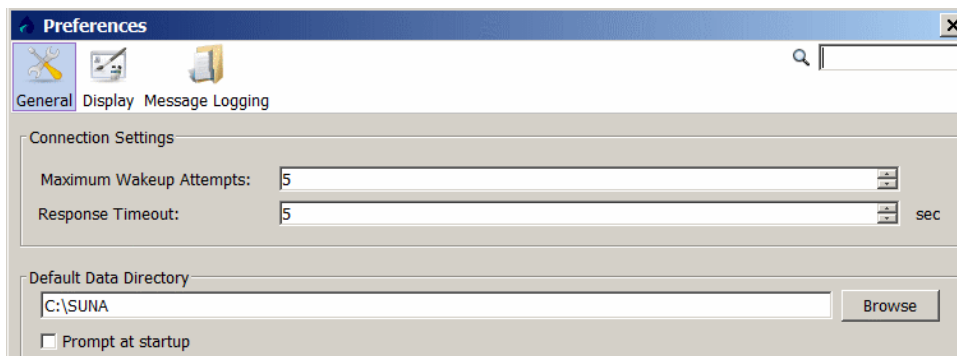


#### 6.1.1.2  Display tab

*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 <u>Performance Optimization Settings</u> area of the *Display* tab.
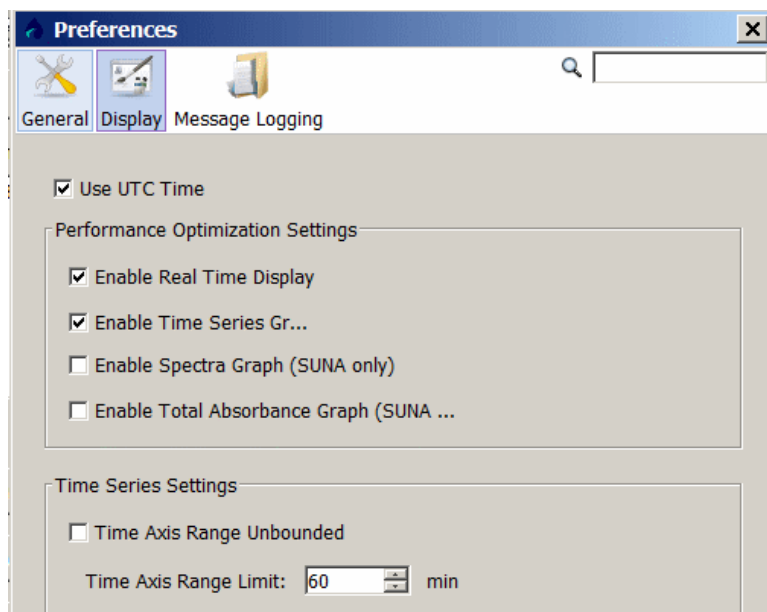
- RS232 only: "Enable Real Time Display"—Put a check in this box to see the data as it is collected in either the software, or if deployed, a terminal program.
- "Enable Time Series Graph"—Put a check in this box to see user-selected data. Remove the check in the box to so that the graph is disabled 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 data in spectra graph on page 7for details.
- SUNA only: "Enable Total Absorbance Graph"—Put a check in this box to see the calculated absorbance. Refer to Monitor data in absorbance graph on page 8 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.

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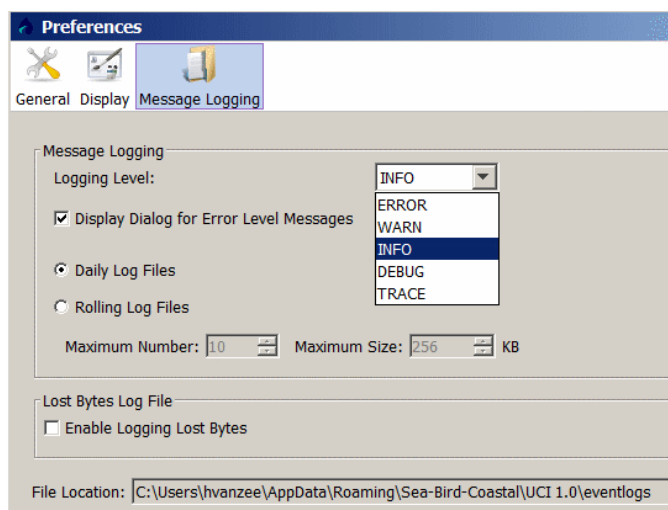
When the "Display Dialog for Error Level Messages" box has a check in it, the software saves one of five levels of error messages.

- **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 Log Files"—all messages from a single day are saved in one file.

"Rolling Log 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.

"Enable Logging 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.

## 6.1.2  Communication

Go to the *Telemetry* tab in **SUNA Settings** to set up communication and data file types.
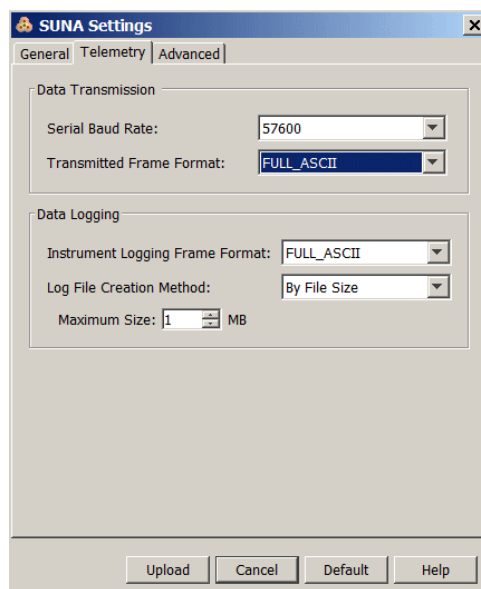


The default serial baud rate is 57600. Others are available.

The default for "Transmitted Frame Format" and "Instrument Logging Frame Format" is "FULL_ASCII."

- **FULL_ASCII**—Contains all collected data in comma-separated fields. The file extension is **.csv**. The frame size is typically 1600–1800 bytes. Use this format so that data can be reprocessed.
- **NONE**—For "Transmitted Frame Format" data output is turned off. For "Sensor Logging Frame Format" sensor data storage is turned off.

Other available formats:

- **FULL_BINARY**—Contains all collected data. The file extension is **.bin**. The frame size is 632 bytes. Use this format so that data can be reprocessed.

- **REDUCED_BINARY**—Contains data from part of the spectrum and data from some auxiliary sensors. The file extension is **.bin**.The frame size is 144 bytes. Use this format so that seawater data can be reprocessed.
- **CONCENTRATION ASCII**—Contains a time-stamp, nitrate concentration, absorbance at 254 and 300 nm and Root Mean Square Error (RMSE) to measure the quality of the data. The file extension is **.csv**.
- **APF**—Deep SUNA V2 only. Used for APEX floats. Contains the user-selected parts of the spectrum and other auxiliary sensors. The frame size is typically 300–400 bytes.

- The user can set the "Transmitted Frame Format" to "NONE" to turn off data output. This increases the rate at which data is collected, and uses 10–30% less power.
- The user can set the "Instrument Logging Frame Format" to NONE to turn off internal data collection.

The default "Log File Creation Method" is "By File Size." Others are available.

- **By File Size**—The software makes a new file when the data file in use gets to the user-selected maximum size. The file name starts with "C" ("Continuous" file).
- **By Sample Event**—The software makes a new file when data collection starts for the first time after the power has been turned off, then on. The manufacturer recommends that the user select this for testing only. Use of this setting can result in so many stored files that the sensor operates slowly or incorrectly. The file name starts with "A" ("Acquisition" file).
- **Daily**—All data that is collected during a calendar day is put into a single file. This file name is a seven-digit number that is the year and the day of the year, for example, D2015142.csv. The file name starts with "D" ("Date-stamped" file).

The default "Maximum File Size" is 2 MB when the "Mode of Operation" is set to "Continuous." It is user-selected from 1–65 MB. The "Daily" and "Sample Event" files contain all of the data that is collected during the day or during one cycle of operation.

### 6.1.2.1 File types

The sensor uses three types of files:

- Data—either ASCII (**.csv**), or binary (**.bin**).
- Calibration—reference spectrum updates from the manufacturer (**.cal**).
- Log—information about the sensor (**.log**)

**Table 5  Information in data files**

| Column | Data type | Full ASCII | Full Binary |
|---|---|---|---|
| 1 | Date, yyyy-mm-dd | | |
| 2 | Header and serial number | N/A | |
| 3 | Date, year and day-of-year | AI7 | BS 4 |
| 4 | Time, hours of day | AF | BD 8 |
| 5 | Nitrate concentration, µM | AF | BF 4 |
| 6 | Nitrogen in nitrate, mgN/L | AF | BF 4 |
| 7 | Absorbance, 254 nm | AF | BF 4 |
| 8 | Absorbance, 350 nm | AF | BF 4 |
| 9 | Bromide trace, mg/L | AF | BF 4 |
| 10 | Spectrum average | AI | BU 2 |
| 11 | Dark value used for fit | AI | BU 2 |
| 12 | Integration time factor | AI | BU 1 |

**Table 5  Information in data files (continued)**

| 13–268 | Spectrum channels | 256 x AI | 256 x BU 2 |
|---|---|---|---|
| 269 | Internal temperature, °C | AF | BF 4 |
| 270 | Spectrometer temperature, °C | AF | BF 4 |
| 271 | Lamp temperature, °C | AF | BF 4 |
| 272 | Cumulative lamp on-time, secs | AI | BU 4 |
| 273 | Relative humidity, % | AF | BF 4 |
| 274 | Main voltage, V | AF | BF 4 |
| 275 | Lamp voltage, V | AF | BF 4 |
| 276 | Internal voltage, V | AF | BF 4 |
| 277 | Main current, mA | AF | BF 4 |
| 278 | Fit aux 1 | AF | BF 4 |
| 279 | Fit aux 2 | AF | BF 4 |
| 280 | Fit base 1 | AF | BF 4 |
| 281 | Fit base 2 | AF | BF 4 |
| 282 | Fit RMSE | AF | BF 4 |
| 283 | if CTD: Time, secs | AI | BU 4 |
| 284 | if CTD: Salinity, PSU | AF | BF 4 |
| 285 | if CTD: Temperature, °C | AF | BF 4 |
| 286 | if CTD: Pressure, dBar | AF | BF 4 |
| 287 | Check sum | AI | BU 1 |
|  | Terminator | <CR><LF> | — |

## 6.1.3  Continuous and fixed-time operation

The sensor must regularly collect a dark spectrum measurement so that it has a baseline correction for changes in time or "drift" in the output of the spectrometer.

The user can set up the sensor to collect a dark spectrum measurement on a time-based or measurement-based schedule. A typical setup is a 1-second dark spectrum measurement for each 20–30 seconds (20–30 measurements) of the light spectrum.

### 6.1.4  Periodic operation

Use the software to see and change the settings for this mode of operation.



1.  Select a "Sample Interval" from the drop-down menu.
2.  Look at the "Offset" value. An offset value of 300 (5 min) changes the start time by five minutes, for example, from 06:00 to 06:05.
3.  The "Light Frames" value is **0–255**.

Data is collected for either a user-selected quantity of time or a user-selected number of measurements.

*Note: "Periodic" and "Autonomous" are both terms for the same mode of operation.*

### 6.1.5  Logger-controlled operation

Use the software to see and change the settings for this mode of operation.
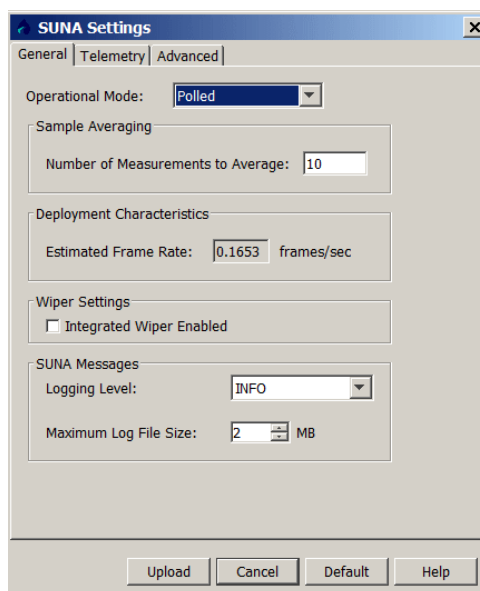
Use the commands below to communicate with the sensor in RS232.

| Command | Result |
|---------|--------|
| Start | Start continuous data collection. |
| $ | Stops the sensor data collection. |
| Measure N | The sensor gets "n" light data frames. If "n" is zero, the sensor gets one dark data frame. |
| Timed N | The sensor gets light data frames for "n" seconds. |
| CTD | The sensor sends CTD data to be corrected for temperature and salinity. The sensor must be set up to do the correction and to process it. |
| Status | Print the status of the sensor. |
| Sleep | The sensor goes to low power standby mode. |

Data files are saved in "FULL_ASCII."

*Note: "Polled" and "Logger-controlled" are both terms for the same mode of operation.*

## 6.1.6  Analog operation

Sensors can be optionally equipped with analog output capabilities so that the sensor can work with analog input data collection systems such as the Sea-Bird CTD profiler. A standard application integrates the voltage signal into the auxiliary port of a CTD to get a profile of conductivity, temperature, and nitrate vs. depth.

To find out if a sensor has analog output, go to the **Sensor** menu, then *Advanced*. The DAC calibration function is available if the sensor has analog output.

The sensor gives voltage and current output of the calculated nitrate values. A 12-bit digital-to-analog converter (DAC) is used to give a voltage range of 0.095–4.095. A 16-bit DAC gives a current range of 4–20 mA.

The sensor has two configuration values: DAC minimum nitrate and DAC maximum nitrate that are the lowest and highest values for voltage and current output. Nitrate values lower than the minimum or higher than the maximum are calculated:

$$V = V_{min} + [(V_{max} - V_{min}) / (DAC_{max} - DAC_{min})] \times (C_{nitrate} - DAC_{min})$$

$$I = I_{min} + [(I_{max} - I_{min}) / (DAC_{max} - DAC_{min})] \times (C_{nitrate} - DAC_{min})$$

*where*—

| $C_{nitrate}$ | Nitrate concentration |
|---------------|----------------------|
| $DAC_{min}$ | Nitrate concentration at minimum voltage and current |

| $DAC_{max}$ | Nitrate concentration at maximum voltage and current |
|---|---|
| V | Generated voltage |
| $V_{min}$ | Minimum voltage, 0.095 V |
| $V_{max}$ | Maximum voltage, 4.095 V |
| I | Generated current |
| $I_{min}$ | Minimum current, 4 mA |
| $I_{max}$ | Maximum current, 20 mA |

**Calculate nitrate concentration from voltage and current**

The inverse voltage and current calculations are shown below.

$C_{nitrate} = DAC_{min} + [(DAC_{max} - DAC_{min}) / (V_{max} - V_{min})] \times (V - V_{min})$ *and*

$C_{nitrate} = DAC_{min} + [(DAC_{max} - DAC_{min} / (I_{max} - I_{min})] \times (I - I_{min})$

These equations can also be written as:

$C_{nitrate} = A_0 + A_1 \times V$, *and*

$C_{nitrate} = B_0 + B_1 \times I$

*where—*

| $A_1 = (DAC_{max} - DAC_{min}) / (V_{max} - V_{min})$ | is the voltage scale coefficient |
|---|---|
| $A_0 = DAC_{min} - A_1 \times V_{min}$ | is the voltage offset coefficient |
| $B_1 = (DAC_{max} - DAC_{min}) / (I_{max} - I_{min})$ | is the current scale coefficient |
| $B_0 = DAC_{min} - B_1 \times I_{min}$ | is the current offset coefficient |

**Calibrate the sensor in-system**

The voltage and current values in a deployed system may be different from the nominal values and should be used instead.

1. Use a Y-cable to connect the sensor to the data collection device and a PC.
2. Select the **Sensor** menu, then *Advanced*, then *DAC Calibration*. Push Low, then High, to get the analog output for the lower, then upper values of the nitrate DAC range.
3. Use these values to calculate the in-system scale and offset coefficients.

| $A_1 = (DAC_{max} - DAC_{min}) / (V_{high} - V_{low})$ | is the in-system calibrated voltage scale coefficient |
|---|---|
| $A_0 = DAC_{min} - A_1 \times V_{low}$ | is the in-system calibrated voltage offset coefficient |
| $B_1 = (DAC_{max} - DAC_{min}) / (I_{high} - I_{low})$ | is the in-system calibrated current scale coefficient |
| $B_0 = DAC_{min} - B_1 \times I_{low}$ | is the in-system calibrated current offset coefficient |

## 6.1.7   Other general settings



Sample Averaging, Deployment Characteristics—The average of the number of frames selected. The higher the value, the more time it takes to make a measurement. The "Estimated Frame Rate" is directly related to the "Number of Measurements per Frame." The manufacturer recommends a value of 10–15 as the "Number of Measurements per Frame" to increase precision in a stable water sample. Use a lower value for unstable water samples.

Wiper Settings—If the sensor is equipped with a wiper, the user can put a check in this box so that the wiper will operate before each measurement.

SUNA Messages—The sensor gives information about the sensor operation and collected data. The default is "Info."

*   "Error" gives the least information.
*   "Debug" and "Trace" give the most information and are used only for troubleshooting.

Set the "Maximum Log File Size" to "0" to turn off the messages.

***Options to monitor data***

The user can select additional parameters to look at from the *Real Time Display* tab in the main window of the software. Push **Select Sensors** and put a check in the box next to the parameter to measure.



## 6.1.8   Data acquisition monitor

The software monitors the data collected by the sensor and shows any errors in this window. The error counters are reset each time the sensor starts a new data collection file. All information is transmitted during data collection, in real-time.

To see this tab, go to the **View** menu and select *Acquisition Monitor*.

- Frame Id—the unique frame number.
- Read—The number of frames accepted.
- Errors—The number of frames discarded.
- Checksum Errors—There may be a problem with the data that is transmitted. Examine the cabling and connectors. If the value in such is frame is wrong, it is discarded. If the collected data is saved to the internal memory of the sensor, that data is correct and can be copied to the PC at a later time.
- Counter, Status, and Fitting Errors—always zero.

## 6.2  SDI-12 operation

*Note: SDI-12 operation is not available on SUNA V2 deep sensors.*

The manufacturer-set address of the SDI-12 is numerical value 48 (ASCII character 0). The SDI controller uses this address to interface with the sensor in an SDI-12 mode of operation. The user can change this value in the SDI controller.

*Note: "Polled" and "Logger-controlled" are both terms for the same mode of operation. The sensor supports all basic SDI-12 commands. Refer to the SDI-12 specification at www.sdi-12.org for details of the command protocol. For any command not described below, the sensor will respond according to the SDI-12 v1.3 specification.*

*Definitions:*

- "a" is the SDI-12 address of the sensor (default is "0")
- <CRC> is the 3-character Cyclic Redundancy Check
- <CR> is a Carriage Return character
- <LF> is a Line Feed character

| Acknowledge Active (a!) | |
| --- | --- |
| Response | a<CR><LF> |
| Purpose | verifies the SDI-12 address |
| Example | address = 0 |
| | SDI recorder sends 0! |
| | sensor sends 0<CR><LF> |

| Address query (?!) | |
| --- | --- |
| Response | a<CR><LF> |
| Purpose | shows the SDI-12 address |
| Example | address = a |
| | SDI recorder sends ?! |
| | sensor sends a<CR><LF> |

| Change address (aAb!) | |
|---|---|
| Response | b<CR><LF> |
| Purpose | changes SDI-12 address to "b". The default address is 0. |
| Example | address = 0 |
| | SDI recorder sends 0A1! |
| | sensor sends 1<CR><LF> |
| | address now = 1 |

| Verify (V!) | |
|---|---|
| Response | attn<CR><LF> |
| Purpose | The sensor always responds with a0000<CR><LF> . No diagnostic information is supported. |

| Send identification (aI!) ("a, capital I, !) | |
|---|---|
| Response | allccccccccmmmmmmvvvxxxxxxxxxx<CR><LF> |
| | a = sensor address |
| | ll (lowercase "L") = 2-character SDI-12 version. For example, "13" for version 1.3 |
| | cccccccc = 8-character manufacturer identification. For example, "SATLANTC" |
| | mmmmmm = 6-character sensor model. For example, "SUNA" |
| | vvv = 3-character sensor version. For example, "v2" |
| | xxxxxxxxxxxxx = up to 13-character optional field. Format: F<MAJOR>.<MINOR>.<PATCH> Used for firmware by the manufacturer. |
| Example | 013SATLANTC SUNA v2 0002F2.1.2<CR><LF> |

| Start Measurement (aM!) Start Measurement and Request CRC (aMC!) Start Concurrent Measurement (aC!) Start Concurrent Measurement and Request CRC (aCC!) | |
|---|---|
| Response | atttn<CR><LF> atttnn<CR><LF> |
| Purpose | starts a measurement. starts a concurrent measurement. |
| Notes | a = address = (0–9) |
| | ttt = measurement time in seconds. The sensor typically responds in less than 30 seconds. |
| | n or nn. The number of measurement values the sensor makes and returns after subsequent Send Data commands. Value = 4. |
| Example | 00104<CR><LF> measurement 001004<CR><LF> concurrent measurement |
| | The sensor reports that 10 seconds are required to do the measurement. Typically it will complete sooner and send a service request to the controller. |
| | In subsequent data commands, the four values are— nitrate concentration µM nitrogen in nitrate concentration mgN/L light spectrum average dark spectrum average |

| Additional Measurement (aM1!) | |
|---|---|
| Additional Measurement and Request CRC (aMC1!) | |
| Additional Concurrent Measurement (aC1!) | |
| Additional Concurrent Measurement and Request CRC (aCC1!) | |
| Response | atttn<CR><LF><br>atttnn<CR><LF> |
| Purpose | starts a measurement.<br>starts a concurrent measurement. |
| Notes | a = address = (0–9) |
| | ttt = measurement time in seconds. The sensor typically responds in less than 30 seconds. |
| | n or nn. The number of measurement values the sensor makes and returns after subsequent Send Data commands. Value = 7. |
| Example | 00067<CR><LF> measurement<br>000607<CR><LF> concurrent measurement<br>*where 00067 is the address (0), the measurement time (006), and the number of measurements (7).* |
| Example output from the controller: | |
| 00M1!<br>0D0!<br>0D1! | 00067 <CR><LF><br>0+22.7+22.5+141779+46.8<CR><LF><br>0+12.0+5.0+14.0<CR><LF> |
| | Example output from the controller for the seven values—<br>*Example output values in parentheses:*<br>lamp temperature, °C (22.7)<br>spectrometer temperature, °C (22.5)<br>lamp time, seconds (141779)<br>relative humidity, % (46.8)<br>internal voltage, V (12.0)<br>regulated voltage, V (5.0)<br>supplied voltage, V (14.0) |

| Additional Measurements (aM2!) | |
|---|---|
| Additional Measurements and Request CRC (aMC2!) | |
| Additional Concurrent Measurement (aC2!) | |
| Additional Concurrent Measurement and Request CRC (aCC2!) | |
| Response | atttn<CR><LF><br>atttnn<CR><LF> |
| Purpose | starts a measurement.<br>starts a concurrent measurement. |
| Notes | ttt = measurement time in seconds. The sensor typically responds in less than 30 seconds. |
| | n or nn. The number of measurement values the sensor makes and returns after subsequent Send Data commands. Value = 7. |
| Example | 00099<CR><LF> measurement<br>000913<CR><LF> concurrent measurement |

| Example output from the controller: | |
|---|---|
| 00M2!<br>0D0!<br>0D1!<br>0D2! | 00099 <CR><LF><br>0+3.26+0.0457+15501+721<CR><LF><br>0+2015033+20.57608<CR><LF><br>0+0.132+0.0672+0<CR><LF> |
| | Example output from the output for the nine (or 13 for concurrent) values—<br>*Example output values in parentheses:*<br>nitrate concentration, μM (3.26)<br>nitrogen in nitrate concentration, mgN/L (0.0457)<br>light spectrum average (15501)<br>dark spectrum average (721)<br>measurement date (2015033)<br>measurement time (20.57608)<br>absorbance at 254 nm (0.132)<br>absorbance at 350 nm (0.672)<br>bromide trace (0)<br>lamp temperature, °C (concurrent measurement only)<br>spectrometer temperature, °C (concurrent measurement only)<br>relative humidity, % (concurrent measurement only)<br>rmse of nitrate processing (concurrent measurement only) |

| Additional Measurements (aM3–aM9!)<br>Additional Measurements and Request CRC (aMC3!–aMC9!) | |
|---|---|
| Additional Concurrent Measurement (aC3!–aC9!) | |
| Additional Concurrent Measurement and Request CRC (aCC3!–aCC9!) | |
| Response | atttn<CR><LF><br>atttnn<CR><LF> |
| Purpose | starts a measurement.<br>starts a concurrent measurement. |
| Notes | The sensor supports 2 additional measurements.<br>ttt = 000<br>n = 0<br>nn = 00 |

"Send Data" commands that come after the aM! or aMC! commands:

| Send Data (aD0!–aD9!) | |
|---|---|
| Response | a<values><CR><LF><br>a<values><CRC><CR><LF> |
| Purpose | sends data to the SDI controller after a measurement or verification command. The response depends on the previous measurement command. |
| Note | after the M! or C! command the sensor responds with nitrate concentration in two units, and the light and dark spectrum average. |
| Example | 0+1039.040+14.8434+22799+671<CR><LF> |
| Note | after the MC! or CC! command the sensor responds the same as M! or C! but with a CRC value attached. |
| Example | 0+1038.188+14.8350+22683+672NtW<CR><LF> |
| Note | after the MC! or CC! command the sensor responds to the aD0! command temperature in two units, lamp time, and humidity. |

| Example | 0+33.188+23.500+3356+23.2AsF<CR><LF> |
| --- | --- |
| Note | The sensor responds to the aD1! command with three voltage units. |
| Example | 0+11.92+5.43+13.68<CR><LF> |
| | after the MC1! command the sensor responds as in the M!! command, but with a CRC value attached. |
| Example | 0+33.813+23.500+3356+23.2AsF<CR><LF><br>followed by: 0+11.92+5.43+13.62EyF<CR><LF> |
| | The response to the aC1!, aCC1!, aM2!, aMC2!, aC2!, aCC2! commands is similar. |

| Continuous Measurement (aR0!–aR9!)<br>Continuous Measurement and Request CRC (aRC0!–aRC9!) | |
| --- | --- |
| Response | a<values><CR><LF> or a<values><CRC><CR><LF> |
| note | the Continuous Measurement command is not supported due to the limited life of the lamp. The sensor reports a0<CR><LF> or a0<CRC><CR><LF> |

## 6.3 Terminal program

The user can communicate with the sensor through the manufacturer-supplied software, or by use of a terminal program through the serial port on a PC. Examples of terminal programs include PuTTY, Tera Term, and Bray.

When power is supplied to the sensor, the sensor goes into a low-power "standby" mode. Any activity on the input line puts the sensor to the "SUNA>" command interface within three seconds. The sensor returns to low-power standby after a user-selected period of time with no communication.

1.  Connect the serial cable to the sensor and the PC.
2.  Connect the serial cable to an 8–15 VDC, 1 A minimum, power supply.
3.  Start a terminal program.

    a.  Set up the communication values if necessary: 8 bit, no parity, 1 stop bit, no flow control.
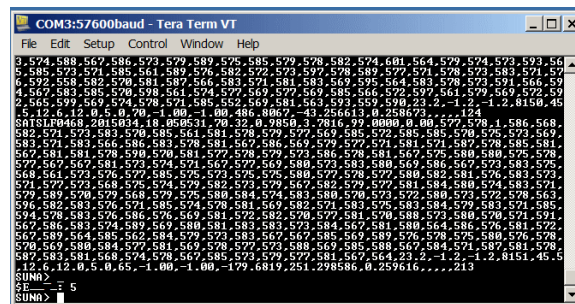
    

    b.  Go to **Setup**, then *Serial Port*.
    c.  If necessary, change the baud rate to 57600. Push **OK**.
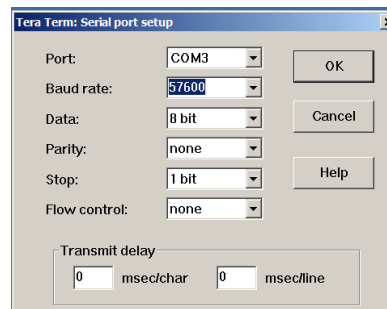
**4.** Turn on the power supply.

**5.** Send one or more "$" commands to the sensor to see a prompt at the command line. The sensor shows "SUNA>" when it is ready to accept commands.

**6.** Type "get opermode" to see the current mode of operation for the sensor. The default value is Fixed Time. It shows as "fixedtime." Refer to Data collection setup values on page 39 for other values for modes of operation.

**Table 6  Status commands**

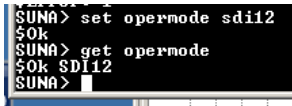| Description | Command | Result |
|---|---|---|
| Selftest | selftest | Makes sure the sensor operates correctly, does measurements, and sends those measurements as the last line of output.<br>$Ok—the sensor operates correctly.<br>!—A sensor component did not operate correctly.<br>$Error—A sensor component did not pass the test. |
| Used lamp time | get lamptime | The total time the lamp has operated, in seconds. |
| Current configuration | get config | The sensor shows the current setup configuration. |
| Get mode of operation | get opermode | The sensor shows the current mode of operation. |
| Set mode of operation | set opermode | Changes the mode of operation |

**7.** To change the mode of operation to SDI-12:

**a.** Make sure that the sensor is so equipped. Type "getopermodesdi12brd" The response is "available." If the response is "missing", the sensor is not equipped with SDI-12.

**b.** Type "set opermode sdi12" to change the mode of operation to SDI-12.



**c.** Type "get opermode" to make sure that the sensor is in SDI-12 mode.

**8.** Use the SDI-12 controller to communicate with the sensor when it is in SDI-12 mode.

## 6.3.1  Input-output configuration values

| Parameter | Possible values | Default value | Short name |
|---|---|---|---|
| Baud rate | 9600, 19200, 38400, 57600, 115200 | 57600 | baudrate |
| Message level | Error, Warn, Info, Debug | Info | msglevel |
| Message file size (MB) | 0–65 | 2 | msgfsize |
| Data file size (MB) | 1–65 | 5 | datfsize |
| Log file type | acquisition, continuous, daily | acquisition | logftype |
| Acquisition file duration (min) | 0–1440 | 60 | afiledur |
| Data wavelength, low (nm) | 210–350 | 217 | wdat_low |
| Data wavelength, high (nm) | 210–350 | 250 | wdat_hgh |

## 6.3.2  Data collection setup values

| Parameter | Possible values | Default value | Short name |
|---|---|---|---|
| Operation mode | continuous, fixedtime, periodic, polled, SDI12 | fixedtime | opermode |
| Operation control | duration, samples | samples | operctrl |
| Countdown (sec) | 0–3600 | 3 | countdwn |

| Fixed time duration (sec) | 1–1000000 | 10 | fixddura |
|---|---|---|---|
| Periodic interval | 1, 2, 5, 6, 10, 15, 20, 30 (min); 1, 2, 3, 4, 6, 8, 12, 24 (hr) | 1 hr | perdival |
| Periodic offset (sec) | any value | 0 | perdoffs |
| Periodic duration (sec) | 0–255 | 10 | perddura |
| Periodic samples (# light frames) | 0–255 | 10 | perdsmpl |
| Polled timeout (sec) | 0–65535 | 10 | polltout |
| Skip sleep at startup | on, off | off | skpsleep |
| Lamp stability time (ds) ? | 0–255 | 5 | stbltime |
| Lamp switch-off temperature (°C) | * (see note below) | 35 | lamptoff |
| Spectrometer integration period (msec) | 5–60000 | N/A | spintper |
| Dark averages | 1–200 | 1 | drkavers |
| Light averages | 1–200 | 1 | lgtavers |
| Dark samples | 1–65535 | 1 | drksmpls |
| Light samples | 1–65535 | 10 | lgtsmpls |
| Dark duration (sec) | 1–65535 | 10 | drkdurat |
| Light duration (sec) | 1–65535 | 120 | lgtdurat |
| External device | none, wiper | none | exdevtyp |
| Ext. dev. pre-run time (sec) | 1–120 | 0 | exdevper |
| Ext. dev. during collection | on, off | off | exdevrun |
| Ext. dev. minimum interval | 1–1440 | 60 | exdvival |

*Periodic Mode of Operation*: When power is supplied to the sensor, the sensor goes to a low-power standby mode. Any activity on the input line puts the sensor to the "SUNA>" command interface within three seconds. The sensor returns to low-power standby after a user-selected period of time with no communication.

*Continuous Mode of Operation*: Data is collected continuously and autonomously when power is supplied to the sensor. Data collection stops when the user removes power or enters a "$" character.

*Fixed-time Mode of Operation*: data collection occurs for the time set up by the user. When that time is completed, the sensor enters a low-power standby.

*Polled Mode of Operation*: the sensor is in low power standby mode until there is activity on the input line. The sensor initializes in 3–4 seconds, then displays a "CMD?" prompt to show that is it is ready to receive commands from the controller. The "timeout" value controls the length of time the sensor is in standby mode before it returns to low power standby mode.

For best accuracy, regular dark measurements are necessary to compensate for the change in temperature. Select a dark-to-light data collection rate based on either the number of samples or the duration.

**Note:**
*The lamp turn-off temperature is 35 °C. The lamp should not operate at temperatures above 35 °C.*

*When the lamp reaches the turn-off temperature, the sensor overrides the user-configured mode of operation. The sensor does 5 cycles of 5-light to 5-dark sample collection, then does 1-light to 10-dark cycles until the lamp temperature is below the turn-off temperature.*

*Contact the manufacturer for information to safely change the turn-off temperature.*

## 6.4 Theory of operation

### 6.4.1 Background

The SUNA is a chemical-free nitrate sensor for fresh, brackish, and salt water. The sensor is based on the In-Situ Ultraviolet Spectroscopy (ISUS) that was developed at MBARI (cf. Kenneth S. Johnson, Luke J. Coletti, Deep-Sea Research I, 49, 2002, 1291–1305).

The sensor lights the water sample with its deuterium UV light source and measures this with its spectrometer. The difference between this measurement and a prior baseline measurement of pure water is the absorption spectrum.

Absorbance characteristics of natural water components are in the calibration file of the sensor. The Beer-Lambert law for multiple absorbers makes the relationship between the total measured absorbance and the concentrations of individual components. Based on this, the sensor gives a best estimate for the nitrate concentration with multi-variable linear regression.

If the "Integration Time Adjustment" configuration parameter is set to "On" or "Persistent," the sensor makes measurements with a spectrometer integration time that is 20 times as long as the normal integration time. This increases the signal-to-noise ratio in faint light conditions and lets the sensor operate in optically dense conditions. When the optical density decreases, the sensor goes back to the normal spectrometer integration time.

### 6.4.2 Description of nutrient units

Nutrient units express the amount of something, usually moles or mass, relative to the volume it is in. Many researchers and scientists use micromoles per liter (µM/L), a unit that is independent of mass and useful for stoichiometric calculations.

Most fresh water monitoring programs and many researchers use units of milligrams per liter. This unit is almost always expressed as milligrams of relevant atoms per liter—for example, milligrams of nitrogen (N) per liter, rather than milligrams of nitrate per liter. Although nitrate, $NO_3$, is the most prevalent form of nitrogen, this unit is frequently used as a means of easily keeping track of total nitrogen loading. Because milligrams per liter is a mass-based unit and the mass of N and $NO_3$ are different, this difference is very important to prevent mistakes. Milligrams per liter is also typically referred to as parts per million (ppm), the mass of N relative to the mass of water.

The SUNA V2 sensor measures dissolved nitrate and displays units in micromolar (µM) or milligrams of nitrogen per liter (mg/N/L). The SUNA V2 does not display milligrams of nitrate per liter (mg/L or $mgNO_3$/L ).

### 6.4.3 Nitrate concentration

Nitrate processing uses the 217–240 nm wavelength range, which is approximately 35 spectrometer channels. The precision of the nitrate concentration is related to the number of absorbers into which the measured absorbance is decomposed. High absorbance conditions introduce inaccuracies into the nitrate concentrations. Channels with an absorbance of more than 1.3 are not included in the processing. If less than approximately 10 channels remain, the sensor cannot give a nitrate concentration. The user can increase the absorbance cutoff and get decreased-accuracy nitrate concentration at higher absorbances.

### 6.4.4 Description of adaptive sampling

The SUNA V2 has a 256-channel spectrometer that integrates for a specific length of time, usually 300–500 ms, to maximize the signal while it collects data. When the sensor makes a measurement, the spectrograph collects UV light for the length of the integration period. In optically dense waters, with high turbidity or CDOM, very little UV light is transmitted through the water, so the spectrometer "sees" a much lower signal. The SUNA V2 automatically increases the integration period to compensate for the low light, so the sensor has a strong signal in extreme environmental conditions.

## 6.4.5 Sensor calibration from manufacturer

Sensors come from the manufacturer with a default class-based calibration. Sensors can have an optional sensor-specific calibration for either fresh water or seawater. The user can configure a seawater calibration for either fresh water or seawater.

The calibration file is stored in the sensor and includes the coefficients to calculate nitrate, as well as a reference spectrum. The software has a wizard to let the user update the reference spectrum at regular intervals or as necessary. This procedure adjusts the "zero" nitrate value based on a sample of pure water (ultra pure, nano pure, or DI).The user must periodically update the reference spectrum to make sure that the sensor collects accurate data because the optical components change over time..

For best performance, send the sensor back to the manufacturer annually for maintenance.

# 6.5 Interferences and mitigation

## 6.5.1 Uncharacterized species in sample

A number of substances in natural water absorb in the UV spectral range where nitrate absorbs. The spectral signature is usually different from nitrate but certain combinations of water components may cause a bias in the calculated nitrate concentrations.

If the user thinks there are significant concentrations of interfering species, do a random spectral and chemical analysis of the water sample to quantify and correct the optical interference.

## 6.5.2 Optically dense constituents

The performance of the sensor is compromised in optically dense conditions, which transmit less light than necessary for the regression analysis. As the optical density increases, the quality of the measurement (signal-to-noise) decreases. The accuracy and precision of the nitrate concentration measurements decrease as the quality of the data decreases. High optical densities are frequently caused by CDOM/turbidity in the water sample.

## 6.5.3 Identification of interfering species

The effect of turbidity and CDOM on the measured nitrate concentration was calculated in the laboratory.

| Turbidity sample | NTU per mg/L | Absorbance at 225 nm (10 mm) per mg/L | $NO_3$ change, µM, in freshwater per mg/L | $NO_3$ change, µM, in seawater per mg/L |
|---|---|---|---|---|
| Arizona Road Dust (ARD) | 1.25 | 0.0016 | < -0.002 (-2.8 **e** -5) | 0.01 (1.4 **e** -4) |
| Kaolin powder | 1.5 | 0.0085 | < 0.001 (1.4 **e** -5) | 0.02 (-2.8 **e** -4) |
| Titanium dioxide ($TiO_2$) | 15.0 | 0.0090 | < 0.001 (1.4 **e** -5) | < 0.001 (1.4 **e** -5) |

| CDOM sample | QSD per mg/L particle | Absorbance at 225 nm (10 mm) per mg/L particle | $NO_3$ change, µM, in seawater per mg/L particle | $NO_3$ change, µM, in seawater per mg/L particle |
|---|---|---|---|---|
| Pony Lake Fulvic Acid reference (1R109F) | N/A | 0.017 | 0.4 (5.6 **e** -3) | 0.6 (8.4 **e** -3) |
| Suwannee River Fulvic Acid standard (1S101F) | N/A | 0.027 | < 0.1 (1.4 **e** -3) | < 0.1 (1.4 **e** -3) |
| Pahokee Peat Humic Acid reference (1R103H-2) | 42 | 0.003 | < 0.01 (1.4 **e** -4) | < 0.1 (1.4 **e** -3) |

An interfering species causes an incorrect nitrate concentration when its spectral characteristics are almost the same as nitrate. The root mean square error (RMSE) value

is the square root of the mean of the sum of the squared differences between the measured and the fitted absorbance. The RMSE is a measure of the quality of the fit. Independent measurements of turbidity and CDOM, and an analysis of the absorption spectrum help the impact analysis.

### 6.5.4  Sensor function

The lamp and other optical components in the sensor change with time. This causes nitrate measurements to change, or "drift." Do regular updates to the reference, or baseline, spectrum to minimize this change.

The output of the lamp is related to its temperature. The manufacturer recommends that the user collect the reference (baseline) spectrum in conditions that are almost the same as a deployment.

## 6.6  CDOM absorption

**Figure 4  Fulvic acid, mg/L**
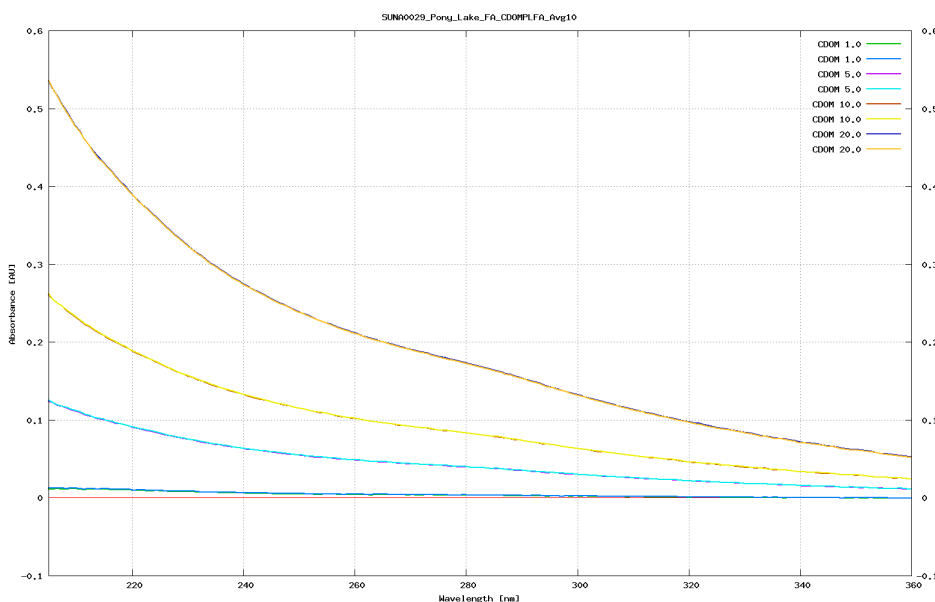


*Note that the CDOM spectral shape overlaps with the nitrate processing region.*

The model to calculate nitrate fits for four parameters: nitrate, bromide, a temperature coefficient and a linear baseline correction that accounts for all additional absorbing species. If the absorption of the sample is high (default cut-off = 1.3 AU), the model can no longer be used effectively to fit parameters or calculate nitrate concentration. The SUNA V2 data output is an RMSE parameter that indicates the quality of the fit of the models to the absorption curves.

**CDOM absorption properties**

Colored Dissolved Organic Matter (CDOM) is one of the main substance classes that absorbs in the same UV range as nitrate. (Other significant absorbers are seawater, bromide, bisulfite, and suspended particles). CDOM is a mixture of many chemicals, and changes across locations and times, usually depending on its origin. Thus, there is no universal characterization of the UV absorption of CDOM.

**CDOM impact on SUNA nitrate concentration**

The UV absorption spectra of CDOM changes across the types of CDOM. Some types of CDOM are closer in their absorption to nitrate than others. Types of CDOM that absorb similar to nitrate will cause a larger bias than those that absorb dissimilarly. Thus, the concentration of CDOM alone cannot predict the magnitude of the bias.

**Quantification and correction of CDOM impact**

Under ideal conditions, CDOM would be isolated from all other absorbers, and its absorbing properties identified in isolation. A more realistic approach is to independently find the content (nitrate, salinity, CDOM) of a number of water samples (if CDOM is stable over time), and calculate the CDOM-induced bias on the nitrate concentration.

*FDOM:* Fluorescent Dissolved Organic Matter is a subset of CDOM and can be used as a proxy (if the composition is stable over time). Most FDOM sensors use a 370 nm excitation source that targets more humic substances, and may not represent absorption in the nitrate range (~220 nm).

*Absorption:* The data output of the SUNA V2 is the absorption at 350 nm and 254 nm (A350 and A254). These wavelengths are outside the nitrate absorption range and can be used to make an estimate of the impact of CDOM. If absorption is high (>1.3 AU), the SUNA will not be able to collect adequate light to make a measurement.

*RMSE*: The root mean square error parameter from the SUNA V2 can be used to make an estimate of how well the nitrate spectral fit is. This should usually be less than 1E-3. If it is higher, there is spectral shape (likely due to CDOM) that adversely impacts the nitrate estimate.

*Pathlength:* SUNA V2 comes in both a 10 mm and a 5 mm pathlength version. Because absorbance is directly proportional to pathlength, a halved pathlength gives a tolerance of approximately twice the background absorption.

# 6.7  Optional equipment

## 6.7.1  Wiper

The wiper cleans the optical window of biological growth and particulates so that the quality of the data collected stays constant. The wiper works in all modes of operation of the sensor. The wiper operates one time before each time that data is collected.

The wiper operates at 90 degrees. Make sure the wiper can operate without any blockage. Each cycle of the wiper across the optical window takes approximately 15 seconds. There is a minimum required delay of 30 seconds between wiper cycles.

**Figure 5  SUNA with wiper**



The wiper drive shaft has a mechanism that lets the wiper be moved manually without damage. Make sure that the wiper is not bent or pushed off of its axis of rotation.

## 6.7.2  Anti-fouling guard

Use the anti-fouling guard for moored deployments that do not use a pump. The guard is attached to the sensor by a plastic clamp. The foul guard is made of perforated copper that goes around the sample volume to prevent biofouling and lets the sample volume flush. Operate the sensor horizontally and point the sample volume area downward so that air bubbles and sediment do not collect.

**Figure 6  Copper anti-fouling guard**
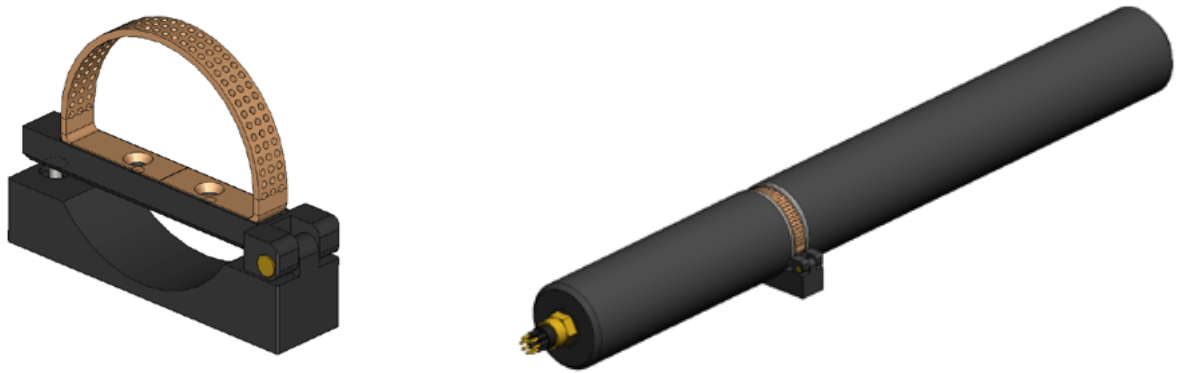


### 6.7.3  Flow cell

Use the flow cell for moored deployments that require a pump. Attach the flow cell to the sensor with the manufacturer-supplied plastic clamp. The flow cell seals against the pressure housing of the sensor so that the water from the pump flows across the optical path of the sensor. The flow cell has a copper tube on the inlet port and a plastic barbed fitting on the outlet port that connects to the pump with flexible tubing. Spare parts for the flow cell include elbow fittings so that the user can adjust the position of the sensor for deployment.

**Figure 7  SUNA flow cell**

**Reference**
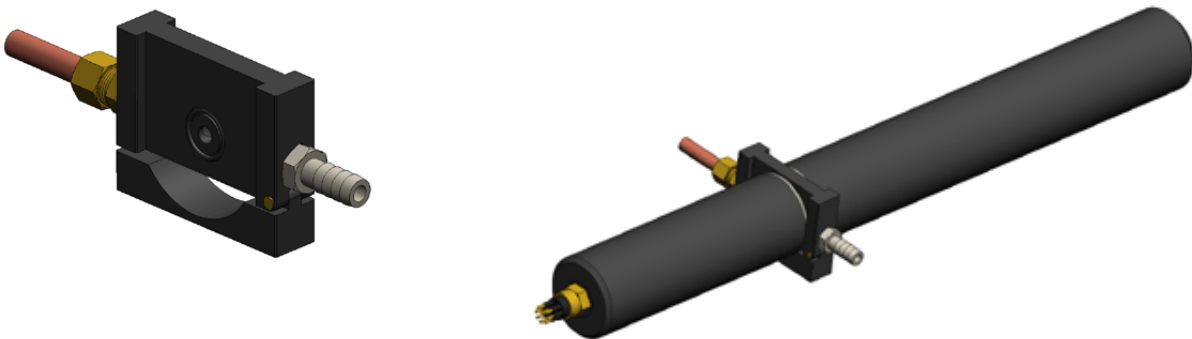
# Section 7    Troubleshooting

> ## ⚠ WARNING
>
> Nitrate sensors use an ultraviolet (UV) light. Do not look directly at a UV light when it is on. It can damage the eyes. Keep products that have UV light away from children, pets, and other living organisms. Wear polycarbonate UV-resistant safety glasses to protect the eyes when a UV light is on.

**Table 7  General**

| Possible problem | Possible solution |
|---|---|
| Sensor does not appear to be on | Make sure that the cable is connected and the power source is on. |
| | Turn the sensor off for at least 60 seconds. Turn the power on again. If the sensor still does not appear to be on, use a different cable. |
| | Make sure that the voltage supplied to the sensor is between 8–15 VDC with at least 1 amp of current. Check the cable voltage: put the leads of a DMM in DC voltage mode at contacts 1 (+) and 2 (-) of the cable to see if there is voltage. If not, use a different cable. |
| | Make sure of the mode of operation. The sensor may be in an unknown mode. Start a terminal program, supply power to the sensor, and type "$" then "Enter" three or more times. A prompt from the sensor shows. |
| | Verify the continuity of the cable. Refer to the sensor specifications for connector functions. |
| | Verify the power consumption. Use a power supply with an accurate digital current indicator.<br><br>• current > 500 mA at 12V: sensor is in data collection mode. Put a piece of white paper into the optical area and make sure that there is a blue spot. If there is not, the sensor may be in an unknown mode or there is a system failure.<br>• current > 5 mA: sensor is in "standby" mode and gives a result over the RS232 input.<br>• current >100 µA: sensor is not in operation. Contact Customer Support. |

**Table 8  Operations**

| Possible problem | Possible solution |
|---|---|
| Self-test fails for internal humidity | Monitor the sensor and do a sensor self-test at regular intervals. Make sure that the sensor is not attached to any frame so tightly that the pressure housing is out-of-round. |
| Self-test fails for low spectrum average or high dark counts | Clean the optical windows with a low-lint swab or tissue and isopropyl alcohol. The average value in DI water is within specifications shown below.<br><br>• Dark spectrum: 500–1000 counts, with a standard deviation of no more than 12 counts.<br>• Maximum light spectrum: no more than 55000, with no more than 60-count standard deviation.<br>• Average light spectrum: approximately 10000–15000 counts, with ranges to at least 20000 counts. An average value of <10000 may mean that the optical windows are dirty or stained, or that the lamp is degraded. |
| Baseline "drift" | Look to see if the lamp is degraded. Apply drift corrections if the rate is approximately 0.004 mgN/L per hour of lamp "on" time. |
| Wiper does not operate correctly | • Make sure that there is a check in the box for "Integrated Wiper Enabled" in the *General* tab of the *Settings* tab of the software.<br>• Verify the alignment of the wiper brushes and make sure that the wiper is not bent.<br>• If the wiper is from another manufacturer, check that the battery contacts are functional.<br>• Contact Customer Support for further help. |

**Table 9 Communication**

| Possible problem | Possible solution |
|---|---|
| Collected data is different from transmitted data | •    Verify the clock settings in the sensor.<br>•    Make sure that there is no extra averaging or data collection in the setup.<br>•    Verify the data output settings. |
| Problems with sensor-to-software communication | •    Make sure that the sensor–PC cable is connected correctly.<br>•    Make sure that the current software and firmware are installed. |
| Self-test fails to complete | Make sure that the sensor has an external power source; external power is necessary to turn on the lamp. |
| Data warnings and error messages | Contact Customer Support. If possible, have the information listed below:<br><br>•    screenshot of the "Application Console" of the software.<br>•    "messages.log" file—go to the **Transfer Files** window and select the *Log Files* tab. Copy the file to the PC for Customer Support. |
| Negative nitrate concentration | Clean the optical area and check the reference spectrum. Apply a new one if necessary.<br><br>•    Make sure that the sensor is in water.<br>•    Make sure that the "Deploy in Fresh Water" box has the appropriate check in it.<br>•    Verify the salinity compensation. |
| Analysis of nitrate standard shows sensor is possibly out of specification | Make sure that the nitrate standard concentrations are accurate. Make sure the dilutions were done correctly and that the standards are used within 1 week (in the lab) or before expiration (unopened standards). Verify that the standards were made in comparable units (mg/L as nitrogen or µMoles). |
| | Verify the sensor settings. Make sure that the "Deployed in Fresh Water" setting has a check in the box if the sensor operates in fresh water. |
| Poor correlation with field samples (grab samples) | Look at the sensor for fouling or lamp change ("drift"). Clean the optical windows and do a blank test.<br><br>•    Set the sensor to do a self-test. Check light:dark counts, such as high CDOM or other absorbers and other data about the sensor.<br>•    Look for matrix interferences that can cause measurement errors. Do measurements for a wider range of constituents an do possible lab matrix spikes to isolate the cause. |
| | Verify the representativeness of the data collection site. If the data from the sensor does not agree with grab samples but shows good performance, the site may not be representative of conditions, or the water is not well mixed. |
| Data collection rate is very slow | Verify that the internal memory is on. Data collection starts after approximately 5 seconds. |
| | Verify that the "adaptive integration" is on. Data collection starts after approximately 500 milliseconds (20 × "integration period"). |
| Nitrate values are not stable | •    Make sure that the optical area is not blocked with debris.<br>•    Make sure that the wiper functions correctly.<br>•    Clean and dry the optical area. |
| Nitrate value are frequently "-1" or "NAN" | Make sure that the lamp intensity is sufficient. Measure the spectrum in DI or tap water. Maximum output is > 10000. For best case, > 30000. |
| | Look at the data: if the maximum is < 1000 and the lamp intensity is sufficient, the water sample is optically dense. |
| SELFTEST alert for lamp intensity or high humidity | Does the sensor have high internal humidity? Do a "selftest":<br>if humidity is > 50%, the sensor may have a leak. Contact Customer Support.<br>if humdity is > 30%, the sensor is probably ok. Contact Customer Support. |

# 7.1 SUNA warnings and error messages

| Possible problem | Possible solution |
|---|---|
| Data warnings and error messages | Contact Customer Support. If possible, have the information listed below:<br><br>• screenshot of the "Application Console" of the software.<br>• "messages.log" file—go to the **Transfer Files** window and select the *Log Files* tab. Copy the file to the PC for Customer Support. |
| Negative nitrate concentration | Clean the optical area and check the reference spectrum. Apply a new one if necessary.<br><br>• Make sure that the sensor is in water.<br>• Make sure that the "Deploy in Fresh Water" box has the appropriate check in it.<br>• Verify the salinity compensation. |
| Analysis of nitrate standard shows sensor is possibly out of specification | Make sure that the nitrate standard concentrations are accurate. Make sure the dilutions were done correctly and that the standards are used within 1 week (in the lab) or before expiration (unopened standards). Verify that the standards were made in comparable units (mg/L as nitrogen or µMoles). |
| | Verify the sensor settings. Make sure that the "Deployed in Fresh Water" setting has a check in the box if the sensor operates in fresh water. |
| Poor correlation with field samples (grab samples) | Look at the sensor for fouling or lamp change ("drift"). Clean the optical windows and do a blank test.<br><br>• Set the sensor to do a self-test. Check light:dark counts, such as high CDOM or other absorbers and other data about the sensor.<br>• Look for matrix interferences that can cause measurement errors. Do measurements for a wider range of constituents an do possible lab matrix spikes to isolate the cause. |
| | Verify the representativeness of the data collection site. If the data from the sensor does not agree with grab samples but shows good performance, the site may not be representative of conditions, or the water is not well mixed. |
| Data collection rate is very slow | Verify that the internal memory is on. Data collection starts after approximately 5 seconds. |
| | Verify that the "adaptive integration" is on. Data collection starts after approximately 500 milliseconds (20 × "integration period"). |
| Nitrate values are not stable | • Make sure that the optical area is not blocked with debris.<br>• Make sure that the wiper functions correctly.<br>• Clean and dry the optical area. |
| Nitrate value are frequently "-1" or "NAN" | Make sure that the lamp intensity is sufficient. Measure the spectrum in DI or tap water. Maximum output is > 10000. For best case, > 30000. |
| | Look at the data: if the maximum is < 1000 and the lamp intensity is sufficient, the water sample is optically dense. |
| SELFTEST alert for lamp intensity or high humidity | Does the sensor have high internal humidity? Do a "selftest":<br>if humidity is > 50%, the sensor may have a leak. Contact Customer Support.<br>if humdity is > 30%, the sensor is probably ok. Contact Customer Support. |

**Troubleshooting**

# Section 8 General information

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

## 8.1 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.

## 8.2 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-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.

## 8.3 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.

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